United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Washington, D.C. 20240
http://www.blm.gov

TAKE PRIDE IN AMERICA

December 2010

In Reply Refer To:
1610 (300)

Dear Reader:

Attached for your review and comment is the Draft Programmatic Environmental Impact Statement (PEIS) for Solar Energy Development in Six Southwestern States. This document was prepared by the Bureau of Land Management (BLM) and the Department of Energy (DOE) as co-lead agencies. The BLM and DOE prepared this document in consultation with cooperating agencies and in accordance with the National Environmental Policy Act (NEPA) of 1969, as amended; the Council on Environmental Quality, DOE, and Department of the Interior regulations implementing NEPA (40 CFR Parts 1500-1508, 10 CFR Part 1021, 43 CFR Part 46); and the Federal Land Policy and Management Act of 1976, as amended.

The Draft PEIS assesses environmental, social, and economic impacts associated with the development and implementation of agency-specific programs and guidance that would facilitate environmentally responsible utility-scale solar energy development in six southwestern states (Arizona, California, Colorado, Nevada, New Mexico, and Utah). Through the Draft PEIS, the BLM is evaluating a new Solar Energy Program that would be applicable to utility-scale solar energy development on BLM-administered lands in the six-state area. The DOE is evaluating new program guidance relevant to DOE-supported solar projects on Federal, state, tribal, or private lands.

The BLM and DOE encourage the public to provide information and comments pertaining to the analysis presented in the Draft PEIS. The public is invited to submit their comments for consideration in identifying environmental issues, existing resource data, and industry interest with respect to utility-scale solar energy development. The BLM and DOE are particularly interested in feedback concerning the appropriateness of identifying proposed solar energy zones, or portions thereof, as priority areas for utility-scale solar energy development. The BLM and DOE are also interested in feedback concerning the categories of land to be excluded from solar energy development and on policies and required design features applicable to this development. It is possible for exclusions and policies to vary by geographic area, e.g., special recreation management areas could be excluded in some areas, but not others; sensitive species

habitat could be excluded entirely, or applications could be accepted but be required to conform to existing or new management prescriptions.

As a member of the public, your timely comments on the Draft PEIS will help formulate the Final PEIS. Comments will be accepted for ninety (90) calendar days following the Environmental Protection Agency's publication of its Notice of Availability in the *Federal Register*. The BLM and DOE can best utilize your comments and resource information submissions if received within the review period. Comments received after the end of the review period will be considered to the extent practicable.

Comments may be submitted electronically on the online comment form available at the project Web site: http://solareis.anl.gov. To facilitate analysis of comments and information submitted, we strongly encourage you to submit comments in an electronic format. Comments may also be submitted by mail to Solar Energy Draft PEIS, Argonne National Laboratory, 9700 S. Cass Avenue—EVS/240, Argonne, Illinois 60439.

Your review and comments on the content of the Draft PEIS are critical to the success of this effort. We request that your comments be as specific as possible. Comments are more helpful if they reference a section or page number of the Draft PEIS and include suggested changes, additional information sources, or alternative methodologies. Your comments will receive a response from the BLM and/or DOE. Comments containing only opinion or preferences will be considered as part of the decision-making process, but will not receive individual responses.

Before including your address, phone number, email address, or other personal identifying information in your comment, be advised that 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.

In addition to written comments, public meetings to take public comments will be announced through local media and Web sites. Public meetings are currently planned for the following locations:

Alamosa, Colorado	Las Vegas, Nevada
Barstow, California	Ontario, California
Caliente, Nevada	Palm Springs, California
Cedar City, Utah	Phoenix, Arizona
El Centro, California	Salt Lake City, Utah
Goldfield, Nevada	Tucson, Arizona
Las Cruces, New Mexico	Washington, D.C.

Copies of the Draft PEIS have been sent to affected Federal, state, and local government agencies and applicable tribal governments. Requests for additional information on the Draft Solar PEIS, including requests for copies of the document, should be directed to Linda Resseguie, BLM Washington Office, by email at linda_resseguie@blm.gov, or by telephone at 202–912–7337; or Jane Summerson, DOE Solar PEIS Document Manager, by email at

Jane.summerson@ee.doe.gov, or by telephone at 202-287-6188. You may also visit the Solar Energy Development PEIS Web site at http://solareis.anl.gov.

Thank you for your continued interest in the PEIS for Solar Energy Development in Six Southwestern States. We appreciate the information and suggestions you contribute to the NEPA and planning process.

Sincerely,

Michael D. Nedd
Assistant Director
Minerals and Realty Management

DES 10-59 • DOE/EIS-0403 December 2010

Draft Programmatic Environmental Impact Statement for

Solar Energy Development in Six Southwestern States

Volume 1
Reader's Guide, Executive Summary
Chapters 1–7, 14–16

U.S. DEPARTMENT OF ENERGY

NATIONAL SYSTEM OF PUBLIC LANDS

On the cover:
Typical Solar Fields for Various Technology Types (clockwise from upper left):
Solar Parabolic Trough (Source: Hosoya et al. 2008),
Solar Power Tower (Credit: Sandia National Laboratories. Source: NREL 2010a),
Photovoltaic (Credit: Arizona Public Service. Source: NREL 2010b), and
Dish Engine (Credit: R. Montoya. Source: Sandia National Laboratories 2008).
Reference citations are available in Chapter 1.

Background photo: Parabolic trough facility from an elevated viewpoint
(Credit: Argonne National Laboratory)

Draft Programmatic Environmental Impact Statement (PEIS) for Solar Energy Development in Six Southwestern States (DES 10-59; DOE/EIS-0403)

Responsible Agencies: The U.S. Department of the Interior (DOI) Bureau of Land Management (BLM) and the U.S. Department of Energy (DOE) are co-lead agencies. Nineteen cooperating agencies participated in the preparation of this PEIS: U.S. Department of Defense; U.S. Bureau of Reclamation; U.S. Fish and Wildlife Service; U.S. National Park Service; U.S. Environmental Protection Agency, Region 9; U.S. Army Corps of Engineers, South Pacific Division; Arizona Game and Fish Department; California Energy Commission; California Public Utilities Commission; Nevada Department of Wildlife; N-4 Grazing Board, Nevada; Utah Public Lands Policy Coordination Office; Clark County, Nevada, including Clark County Department of Aviation; Dona Ana County, New Mexico; Esmeralda County, Nevada; Eureka County, Nevada; Lincoln County, Nevada; Nye County, Nevada; and Saguache County, Colorado.

Locations: Arizona, California, Colorado, Nevada, New Mexico, and Utah.

Contacts: *For further information about this PEIS, contact:* Linda Resseguie, BLM Washington Office, e-mail: linda_resseguie@blm.gov, phone: (202) 912-7337; or Jane Summerson, DOE Solar PEIS Document Manager, e-mail: jane.summerson@ee.doe.gov, phone: (202) 287-6188; or visit the PEIS Web site at http://solareis.anl.gov.

Abstract: The BLM and DOE are considering taking actions to facilitate solar energy development in compliance with various orders, mandates, and agency policies. For the BLM, these actions include the evaluation of a new BLM Solar Energy Program applicable to all utility-scale solar energy development on BLM-administered lands in six southwestern states (Arizona, California, Colorado, Nevada, New Mexico, and Utah). For DOE, they include the evaluation of developing new program guidance relevant to DOE-supported solar projects. The Draft PEIS assesses the environmental, social, and economic effects of the agencies' proposed actions and alternatives.

For the BLM, the Draft PEIS analyzes a no action alternative, under which solar energy development would continue on BLM-administered lands in accordance with the terms and conditions of the BLM's existing solar energy policies, and two action alternatives for implementing a new BLM Solar Energy Program. Under the solar energy development program alternative (BLM's preferred alternative), the BLM would establish a new Solar Energy Program of administration and authorization policies and required design features and would exclude solar energy development from certain BLM-administered lands. Under this alternative, approximately 22 million acres of BLM-administered lands would be available for right-of-way (ROW) application. A subset of these lands, about 677,400 acres, would be identified as solar energy zones (SEZs), or areas where the BLM would prioritize solar energy and associated transmission infrastructure development. Under the SEZ program alternative, the same policies and design features would be adopted, but development would be excluded from all BLM-administered lands except those located within the SEZs.

For DOE, the Draft PEIS analyzes a no action alternative, under which DOE would continue to conduct environmental reviews of DOE-funded solar projects on a case-by-case basis, and one action alternative, under which DOE would develop programmatic guidance to further integrate environmental considerations into its analysis and selection of solar projects that it will support.

The EPA Notice of Availability (NOA) of the Draft PEIS was published in the *Federal Register* on December 17, 2010. Comments on the Draft PEIS are due by March 17, 2011.

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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

AADT	annual average daily traffic
AASHTO	American Association of State Highway and Transportation Officials
AC	alternating current
ACC	air-cooled condenser
ACEC	Area of Critical Environmental Concern
ADEQ	Arizona Department of Environmental Quality
ADOT	Arizona Department of Transportation
ADWR	Arizona Department of Water Resources
AERMOD	AMS/EPA Regulatory Model
AFC	Application for Certification
AGL	above ground level
AIRFA	American Indian Religious Freedom Act
AMA	active management area
AML	animal management level
ANHP	Arizona National Heritage Program
APE	area of potential effect
APLIC	Avian Power Line Interaction Committee
APP	Avian Protection Plan
AQCR	Air Quality Control Region
AQRV	air quality-related value
ARB	Air Resources Board
ARRA	American Recovery and Reinvestment Act of 2009
ARRTIS	Arizona Renewable Resource and Transmission Identification Subcommittee
ARS	Agricultural Research Service
ARZC	Arizona and California
ATSDR	Agency for Toxic Substances and Disease Registry
AUM	animal unit month
AVWS	Audio Visual Warning System
AWBA	Arizona Water Banking Authority
AWEA	American Wind Energy Association
AWRM	Active Water Resource Management
AZ DOT	Arizona Department of Transportation
AZDA	Arizona Department of Agriculture
AZGFD	Arizona Game and Fish Department
AZGS	Arizona Geological Survey

BA	biological assessment
BAP	base annual production
BEA	Bureau of Economic Analysis
BISON-M	Biota Information System of New Mexico
BLM	Bureau of Land Management
BMP	best management practice
BNSF	Burlington Northern Santa Fe
BO	biological opinion
BOR	U.S. Bureau of Reclamation
BPA	Bonneville Power Administration
BRAC	Blue Ribbon Advisory Council on Climate Change
BSE	Beacon Solar Energy
BSEP	Beacon Solar Energy Project
BTS	Bureau of Transportation Statistics
CAA	Clean Air Act
CAAQS	California Air Quality Standards
Caltrans	California Department of Transportation
C-AMA	California-Arizona Maneuver Area
CAP	Central Arizona Project
CARB	California Air Resources Board
CAReGAP	California Regional Gap Analysis Project
CASQA	California Stormwater Quality Association
CASTNET	Clean Air Status and Trends NETwork
CAWA	Colorado Agricultural Water Alliance
CCC	Civilian Conservation Corps
CDC	Centers for Disease Control and Prevention
CDCA	California Desert Conservation Area
CDFG	California Department of Fish and Game
CDOT	Colorado Department of Transportation
CDOW	Colorado Division of Wildlife
CDPHE	Colorado Department of Public Health and Environment
CDWR	California Department of Water Resources
CEC	California Energy Commission
CEQ	Council on Environmental Quality
CES	constant elasticity of substitution
CESA	California Endangered Species Act
CESF	Carrizo Energy Solar Farm
CFR	*Code of Federal Regulations*
CGE	computable general equilibrium
CIRA	Cooperative Institute for Research in the Atmosphere
CLFR	compact linear Fresnel collector
CPC	Center for Plant Conservation
CNDDB	California Natural Diversity Database
CNEL	community noise equivalent level
CNHP	Colorado National Heritage Program

Colorado DWR	Colorado Department of Water Resources
CPUC	California Public Utilities Commission
CPV	concentrating photovoltaic
CRBSCF	Colorado River Basin Salinity Control Forum
CREZ	competitive renewable energy zone
CRSCP	Colorado River Salinity Control Program
CSA	Candidate Study Area
CSC	Coastal Services Center
CSFG	carbon-sequestration fossil generation
CSP	concentrating solar power
CSQA	California Stormwater Quality Association
CSRI	Cultural Systems Research, Incorporated
CTG	combustion turbine generator
CTPG	California Transmission Planning Group
CTSR	Cumbres & Toltec Scenic Railroad
CUP	Conditional Use Permit
CVP	Central Valley Project
CWA	Clean Water Act
CWCB	Colorado Water Conservation Board
CWHRS	California Wildlife Habitat Relationship System
DC	direct current
DHS	U.S. Department of Homeland Security
DNA	Determination of NEPA Adequacy
DNI	direct normal insulation
DNL	day-night average sound level
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
DRECP	California Desert Renewable Energy Conservation Plan
DSM	demand side management
DTC/C-AMA	Desert Training Center/California–Arizona Maneuver Area
DWMA	Desert Wildlife Management Area
EA	environmental assessment
ECAR	East Central Area Reliability Coordination Agreement
ECOS	Environmental Conservation Online System (USFWS)
EERE	Energy Efficiency and Renewable Energy (DOE)
Eg	band gap energy
EIA	Energy Information Administration
EIS	environmental impact statement
EISA	Energy Independence and Security Act of 2007
EMF	electromagnetic field
E.O.	Executive Order

EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
EQIP	Environmental Quality Incentives Program
ERCOT	Electric Reliability Council of Texas
ERO	Electric Reliability Organization
ERS	Economic Research Service
ESA	Endangered Species Act of 1973
ESRI	Environmental Systems Research Institute
FAA	Federal Aviation Administration
FBI	Federal Bureau of Investigation
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Map
FLPMA	Federal Land Policy and Management Act of 1976
FONSI	Finding of No Significant Impact
FR	*Federal Register*
FRCC	Florida Reliability Coordinating Council
FSA	Final Staff Assessment
FTE	full-time equivalent
FY	fiscal year
G&TM	Generation and Transmission Modeling
GCRP	U.S. Global Climate Research Program
GDA	generation development area
GHG	greenhouse gas
GIS	geographic information system
GPS	global positioning system
GTM	Generation and Transmission Model
GUAC	Groundwater Users Advisory Council
GWP	global warming potential
HA	herd area
HAP	hazardous air pollutant
HAZCOM	hazard communication
HCE	heat collection element
HCP	Habitat Conservation Plan
HMA	Herd Management Area
HMMH	Harris Miller Miller & Hanson, Inc.
HRSG	heat recovery steam generator
HSPD	Homeland Security Presidential Directive
HTF	heat transfer fluid
HVAC	heating, ventilation, and air-conditioning

I	Interstate
IARC	International Agency for Research on Cancer
IBA	important bird area
ICE	internal combustion engine
ICWMA	Imperial County Weed Management Area
IEC	International Electrochemical Commission
IFR	instrument flight rule
IID	Imperial Irrigation District
IM	Instruction Memorandum
IMPS	Iron Mountain Pumping Station
IMS	interim mitigation strategy
INA	Irrigation Non-Expansion Area
IOP	Interagency Operating Procedure
IOU	investor-owned utility
IPPC	Intergovernmental Panel on Climate Change
ISA	Independent Science Advisor; Instant Study Area
ISB	Intermontane Seismic Belt
ISCC	integrated solar combined cycle
ISDRA	Imperial Sand Dunes Recreation Area
ISEGS	Ivanpah Solar Energy Generating System
ITP	incidental take permit
IUCNNR	International Union for Conservation of Nature and Natural Resources
IUCNP	International Union for Conservation of Nature Pakistan
KGA	known geothermal resources area
KML	keyhole markup language
KOP	key observation point
KSLA	known sodium leasing area
LCC	Landscape Conservation Cooperative
LCOE	levelized cost of energy
L_{dn}	day-night average sound level
LDWMA	Low Desert Weed Management Area
L_{eq}	equivalent sound pressure level
LLA	limited land available
LLRW	low-level radioactive waste (waste classification)
LRG	Lower Rio Grande
LSA	lake and streambed alteration
LSE	load-serving entity
LTVA	long-term visitor area
MAAC	Mid-Atlantic Area Council
MAIN	Mid-Atlantic Interconnected Network
MAPP	methyl acetylene propadiene stabilizer; Mid-Continent Area Power Pool
MCAS	Marine Corps Air Station
MCL	maximum contaminant level

MFP	Management Framework Plan
MIG	Minnesota IMPLAN Group
MLA	maximum land available
MOA	military operating area
MOU	Memorandum of Understanding
MPDS	maximum potential development scenario
MRA	Multiple Resource Area
MRI	Midwest Research Institute
MRO	Midwest Reliability Organization
MSDS	Material Safety Data Sheet
MSL	mean sea level
MTR	military training route
MWA	Mojave Water Agency
MWD	Metropolitan Water District
MWMA	Mojave Weed Management Area
NAAQS	National Ambient Air Quality Standards
NADP	National Atmospheric Deposition Program
NAGPRA	Native American Graves Protection and Repatriation Act
NAHC	Native American Heritage Commission (California)
NAIC	North American Industrial Classification System
NASA	National Aeronautics and Space Administration
NCA	National Conservation Area
NCCAC	Nevada Climate Change Advisory Committee
NCDC	National Climatic Data Center
NCES	National Center for Education Statistics
NDCNR	Nevada Department of Conservation and Natural Resources
NDEP	Nevada Division of Environmental Protection
NDOT	Nevada Department of Transportation
NDOW	Nevada Department of Wildlife
NDWP	Nevada Division of Water Planning
NDWR	Nevada Division of Water Resources
NEAP	Natural Events Action Plan
NEC	National Electric Code
NED	National Elevation Database
NEP	Natural Events Policy
NEPA	National Environmental Policy Act of 1969
NERC	North American Electricity Reliability Corporation
NHA	National Heritage Area
NHNM	National Heritage New Mexico
NHPA	National Historic Preservation Act of 1966
NID	National Inventory of Dams
NM DOT	New Mexico Department of Transportation
NLCS	National Landscape Conservation System
NMAC	*New Mexico Administrative Code*
NMBGMR	New Mexico Bureau of Geology and Mineral Resources

NMDGF	New Mexico Department of Game and Fish
NMED	New Mexico Environment Department
NMED-AQB	New Mexico Environment Department-Air Quality Board
NMFS	National Marine Fisheries Service
NMOSE	New Mexico Office of the State Engineer
NMSU	New Mexico State University
NNHP	Nevada Natural Heritage Program
NNL	National Natural Landmark
NNSA	National Nuclear Security Administration
NOA	Notice of Availability
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NP	National Park
NPL	National Priorities List
NPS	National Park Service
NRA	National Recreation Area
NRCS	Natural Resources Conservation Service
NREL	National Renewable Energy Laboratory
NRHP	*National Register of Historic Places*
NRS	*Nevada Revised Statutes*
NSC	National Safety Council
NSO	no surface occupancy
NSTC	National Science and Technology Council
NTS	Nevada Test Site
NTTR	Nevada Test and Training Range
NVCRS	Nevada Cultural Resources Inventory System
NV DOT	Nevada Department of Transportation
NWCC	National Wind Coordinating Committee
NWI	National Wetlands Inventory
NWPP	Northwest Power Pool
NWR	National Wildlife Refuge
NWSRS	National Scenic River System
O&M	operation and maintenance
ODFW	Oregon Department of Fish and Wildlife
OHV	off-highway vehicle
ONA	Outstanding Natural Area
ORC	organic Rankine cycle
OSE/ISC	Office of the State Engineer/Interstate Stream Commission
OSHA	Occupational Safety and Health Administration
OTA	Office of Technology Assessment
PA	Programmatic Agreement
PAD	Preliminary Application Document
PAH	polycyclic aromatic hydrocarbon

PAT	peer analysis tool
PCB	polychlorinated biphenyl
PCM	purchase change material
PCS	power conditioning system
PCU	power converting unit
PEIS	programmatic environmental impact statement
PFYC	potential fossil yield classification
PIER	Public Interest Energy Research
P.L.	Public Law
PLSS	Public Land Survey System
PM	particulate matter
$PM_{2.5}$	particulate matter with a mean aerodynamic diameter of 2.5 µm or less
PM_{10}	particulate matter with a mean aerodynamic diameter of 10 µm or less
POD	plan of development
POU	publicly owned utility
PPA	Power Purchase Agreement
PPE	personal protective equipment
PSD	Prevention of Significant Deterioration
PURPA	Public Utility Regulatory Policy Act
PV	photovoltaic
PVID	Palo Verde Irrigation District
PWR	public water reserve
QRA	qualified resource area
R&I	relevance and importance
RCI	residential, commercial, and industrial (sector)
RCRA	Resource Conservation and Recovery Act of 1976
RD&D	research, development, and demonstration; research, development, and deployment
RDBMS	Relational Database Management System
RDEP	Restoration Design Energy Project
REA	Rapid Ecoregional Assessment
REAT	Renewable Energy Action Team
REDI	Renewable Energy Development Infrastructure
ReEDS	Regional Energy Deployment System
REPG	Renewable Energy Policy Group
RETA	Renewable Energy Transmission Authority
RETAAC	Renewable Energy Transmission Access Advisory Committee
RETI	Renewable Energy Transmission Initiative
REZ	renewable energy zone
RF	radio frequency
RFC	Reliability First Corporation
RFDS	reasonably foreseeable development scenario
RGP	Rio Grande Project
RGWCD	Rio Grande Water Conservation District

RMP	Resource Management Plan
RMPA	Rocky Mountain Power Area
RMZ	Resource Management Zone
ROD	Record of Decision
ROI	region of influence
ROS	recreation opportunity spectrum
ROW	right-of-way
RPG	renewable portfolio goal
RPS	Renewable Portfolio Standard
RRC	Regional Reliability Council
RSEP	Rice Solar Energy Project
RSI	Renewable Systems Interconnection
RTTF	Renewable Transmission Task Force
RV	recreational vehicle
SAAQS	State Ambient Air Quality Standards
SAMHSA	Substance Abuse and Mental Health Services Administration
SCADA	supervisory control and data acquisition
SCE	Southern California Edison
SCRMA	Special Cultural Resource Management Area
SDRREG	San Diego Regional Renewable Energy Group
SDWA	Safe Drinking Water Act of 1974
SEGIS	Solar Energy Grid Integration System
SEGS	Solar Energy Generating System
SEI	Sustainable Energy Ireland
SEIA	Solar Energy Industrial Association
SES	Stirling Energy Systems
SETP	Solar Energy Technologies Program (DOE)
SEZ	solar energy zone
SHPO	State Historic Preservation Office(r)
SIP	State Implementation Plan
SLRG	San Luis & Rio Grande
SMA	Special Management Area
SMP	suggested management practice
SNWA	Southern Nevada Water Authority
SPP	Southwest Power Pool
SRMA	Special Recreation Management Area
SSA	Socorro Seismic Anomaly
SSI	self-supplied industry
ST	solar thermal
STG	steam turbine generator
SUA	special use airspace
SWAT	Southwest Area Transmission
SWIP	Southwest Intertie Project
SWPPP	Stormwater Pollution Prevention Plan
SWReGAP	Southwest Regional Gap Analysis Project

TAP	toxic air pollutant
TCC	Transmission Corridor Committee
TDS	total dissolved solids
TEPPC	Transmission Expansion Planning Policy Committee
TES	thermal energy storage
TSA	Transportation Security Administration
TSCA	Toxic Substances Control Act of 1976
TSDF	treatment, storage, and disposal facility
TSP	total suspended particulates
UACD	Utah Association of Conservation Districts
UBWR	Utah Board of Water Resources
UDA	Utah Department of Agriculture
UDEQ	Utah Department of Environmental Quality
UDNR	Utah Department of Natural Resources
UDOT	Utah Department of Transportation
UDWQ	Utah Division of Water Quality
UDWR	Utah Division of Wildlife Resources
UGS	Utah Geological Survey
UNEP	United Nations Environmental Programme
UNPS	Utah Native Plant Society
UP	Union Pacific
UREZ	Utah Renewable Energy Zone
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
USGS	U.S. Geological Survey
Utah DWR	Utah Division of Water Rights
UTTR	Utah Test and Training Range
UWS	Underground Water Storage, Savings and Replenishment Act
VACAR	Virginia-Carolinas Subregion
VCRS	Visual Contrast Rating System
VFR	visual flight rule
VOC	volatile organic compound
VRI	Visual Resource Inventory
VRM	Visual Resource Management
WA	Wilderness Area
WAPA	Western Area Power Administration
WECC	Western Electricity Coordinating Council
WECC CAN	Western Electricity Coordinating Council – Canada
WEG	wind erodibility group
WGA	Western Governors' Association

WGFD	Wyoming Game and Fish Department
WHA	wildlife habitat area
WHO	World Health Organization
WRAP	Water Resources Allocation Program; Western Regional Air Partnership
WRCC	Western Regional Climate Center
WREZ	Western Renewable Energy Zones
WRRI	Water Resources Research Institute
WSA	Wilderness Study Area
WSC	wildlife species of special concern
WSMR	White Sands Missile Range
WSR	Wild and Scenic River
WSRA	Wild and Scenic Rivers Act of 1968
WWII	World War II
YPG	Yuma Proving Ground
ZITA	zone identification and technical analysis
ZLD	zero liquid discharge

CHEMICALS

CH_4	methane	NO_2	nitrogen dioxide
CO	carbon monoxide	NO_x	nitrogen oxides
CO_2	carbon dioxide		
CO_2e	carbon dioxide equivalent	O_3	ozone
H_2S	hydrogen sulfide	Pb	lead
Hg	mercury		
		SF_6	sulfur hexafluoride
N_2O	nitrous oxide	SO_2	sulfur dioxide
NH_3	ammonia	SO_x	sulfur oxides

UNITS OF MEASURE

ac-ft	acre-foot (feet)	°F	degree(s) Fahrenheit
bhp	brake horsepower	ft	foot (feet)
		ft^2	square foot (feet)
°C	degree(s) Celsius	ft^3	cubic foot (feet)
cf	cubic foot (feet)		
cfs	cubic foot (feet) per second	g	gram(s)
cm	centimeter(s)	gal	gallon(s)
		GJ	gigajoule(s)
dB	decibel(s)	gpcd	gallon per capita per day
dBA	A-weighted decibel(s)	gpd	gallon(s) per day

gpm	gallon(s) per minute
GW	gigawatt(s)
GWh	gigawatt hour(s)
GWh/yr	gigawatt hour(s) per year
h	hour(s)
ha	hectare(s)
Hz	hertz
in.	inch(es)
J	joule(s)
K	degree(s) Kelvin
kcal	kilocalorie(s)
kg	kilogram(s)
kHz	kilohertz
km	kilometer(s)
km^2	square kilometer(s)
kPa	kilopascal(s)
kV	kilovolt(s)
kVA	kilovolt-ampere(s)
kW	kilowatt(s)
kWh	kilowatt-hour(s)
kWp	kilowatt peak
L	liter(s)
lb	pound(s)
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
mg	milligram(s)
Mgal	million gallons
mi	mile(s)
mi^2	square mile(s)
min	minute(s)
mm	millimeter(s)
MMt	million metric ton(s)
MPa	megapascal(s)
mph	mile(s) per hour
MW	megawatt(s)
MWe	megawatt(s) electric
MWh	megawatt-hour(s)
ppm	part(s) per million
psi	pound(s) per square inch
psia	pound(s) per square inch absolute
rpm	rotation(s) per minute
s	second(s)
scf	standard cubic foot (feet)
TWh	terawatt hours
VdB	vibration velocity decibel(s)
W	watt(s)
yd^2	square yard(s)
yd^3	cubic yard(s)
yr	year(s)
µg	microgram(s)
µm	micrometer(s)

ENGLISH/METRIC AND METRIC/ENGLISH EQUIVALENTS

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

Multiply	By	To Obtain
English/Metric Equivalents		
acres	0.004047	square kilometers (km^2)
acre-feet (ac-ft)	1,234	cubic meters (m^3)
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)	0.00081	acre-feet (ac-ft)
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)	247.1	acres
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)

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READER'S GUIDE

The U.S. Department of the Interior (DOI) Bureau of Land Management (BLM) and the U.S. Department of Energy (DOE) have jointly prepared the "Draft Programmatic Environmental Impact Statement for Solar Energy Development in Six Southwestern States" (Solar PEIS). For the BLM, the PEIS evaluates the agency's proposed actions to establish a new BLM Solar Energy Program applicable to utility-scale solar energy development on BLM-administered lands in six southwestern states (Arizona, California, Colorado, Nevada, New Mexico, and Utah). For DOE, the PEIS evaluates the agency's proposed action to develop new program guidance relevant to DOE-supported solar projects.

The PEIS contains two levels of analyses. First, it evaluates the environmental impacts of utility-scale solar energy technologies considered to be viable for deployment over the next 20 years, and the potential effects of the agencies establishing new solar energy development programs or guidance. Some chapters address this broad, programmatic scope. Second, it provides in-depth environmental analyses of the BLM's 24 proposed solar energy zones (SEZs) to inform decisions about whether to identify those locations as areas in which the BLM would prioritize utility-scale solar energy development. Some chapters pertain only to the SEZs. Both BLM action alternatives include a SEZ component.

The public will have 90 days to review this Draft PEIS. Given that the document consists of about 11,000 pages, 16 chapters and 14 appendices, a comprehensive review of the document will be aided by a clear understanding of how information presented in the Draft PEIS is organized and how that information supports the agencies' evaluation of alternatives. This Reader's Guide has been prepared to assist the public's review. It includes general guidance as well as a section-by-section summary and guide.

In addition, the agencies want to acknowledge that there are some inconsistencies and data gaps that were identified too late in the preparation of the Draft PEIS to be accommodated in the document. These inconsistencies and gaps are identified following the section-by-section summary and guide. It is anticipated that additional inconsistencies and data gaps will be identified during the public review period. These problems will be addressed in the Final PEIS. At this time, the agencies do not believe that these inconsistencies and gaps substantively affect the analyses in the Draft PEIS, nor do they anticipate that supplemental analyses will be required.

General Guidance

- Sections of the Draft PEIS have been divided into separate volumes. The volumes are identified in the section-by-section guide below, along with the approximate number of pages. The volume contents are also listed in the front of each volume.

- Given the length of the Draft PEIS, readers are encouraged to maximize their use of the electronic version of the document. All sections of the Draft PEIS can be downloaded from the project Web site (http://solareis.anl.gov).

- The electronic copies of all sections are provided in PDF format, with bookmarks included to assist in navigating through the text.

- Acronyms are defined upon their first use in each section. A master list of all acronyms used in the Draft PEIS is provided in the front of each volume.

- Separate reference lists have been compiled for each section of the Draft PEIS, as applicable.

- Page numbering starts over within each section of the Draft PEIS. Page numbers denote the section and the page (e.g., 1-10 is the tenth page in Chapter 1 and A-10 is the tenth page in Appendix A).

- Line numbers appear on each page to assist in submitting and responding to comments on the Draft PEIS.

- Reviewers are strongly encouraged to submit their comments on the Draft PEIS via the comment form provided on the project Web site (http://solareis.anl.gov).

Section-By-Section Summary and Guide

Executive Summary (Vol. 1, ~24 pages)	This stand-alone summary provides an understanding of why the agencies have prepared the Draft PEIS, summary-level descriptions of each agency's proposed actions and alternatives, and the potential impacts of these actions.
Chapters	
1: Introduction (Vol. 1, ~32 pages)	This chapter provides a description of applicable federal orders and mandates; the purpose and need for the agencies' actions; the scope of analysis; which agencies are cooperating in preparation of the PEIS; the relationship of the proposed actions to other programs, policies, and plans; and an overview of solar energy technologies and resources considered in the PEIS.

2: Description of Alternatives and Reasonably Foreseeable Development Scenario (Vol. 1, ~36 pages)	This chapter provides a complete description of the agencies' alternatives, the reasonably foreseeable development scenario, and alternatives considered but eliminated from detailed analysis. Evaluations of these alternatives are presented in Chapters 6 and 7 for BLM and DOE, respectively. The entire set of policies and design features proposed under BLM's action alternatives as the agency's Solar Energy Program is provided in Appendix A (Section A.2). The active solar right-of-way (ROW) applications that have been submitted to the BLM and some general information about each application are given in Appendix B. The land use plan amendments proposed to implement the program under both BLM action alternatives are described in Appendix C.
3: Overview of Solar Energy Power Production Technologies, Development, and Regulation (Vol. 1, ~60 pages)	This chapter provides general descriptions of the solar energy technologies evaluated in the Draft PEIS and overviews of the development process, existing regulatory requirements, relevant agency guidelines on impact mitigation, and other aspects of solar energy development. For a more detailed technical description of the solar technologies, read Appendix F. For a more detailed presentation on relevant federal, state, and county requirements pertaining to solar development, read Appendix H.
4: Affected Environment (Vol. 1, ~210 pages)	This chapter provides a general description of the affected environment in the six-state study area. This description provides the basis for identifying the potential impacts described in Chapter 5 and the supporting programmatic-level analyses. More detailed descriptions of the affected environments in each of the proposed SEZs are provided in Chapters 8 through 13.
5: Impacts of Solar Energy Development and Potential Mitigation Measures (Vol. 1, ~310 pages)	This chapter provides a general description of the potential impacts of utility-scale solar energy power production facilities, as well as required transmission interconnections, and a discussion of potentially applicable mitigation measures. The impact analyses presented in this chapter are described in the context of the affected environment presented in Chapter 4. Mitigation measures identified in this chapter were reviewed for incorporation as required programmatic design features that would be applicable to all utility-scale solar energy development on BLM-administered lands under the agency's proposed Solar Energy

	Program. These proposed design features are presented in Appendix A.
6: Analysis of BLM's Solar Energy Development Alternatives (Vol. 1, ~112 pages)	This chapter presents an analysis of the potential impacts of BLM's three alternatives for management of utility-scale solar energy development, including cumulative impacts of utility-scale solar energy development in the six-state area over the next 20 years, and other National Environmental Policy Act (NEPA) considerations.
7: Analysis of DOE's Alternatives (Vol. 1, ~10 pages)	This chapter presents an analysis of the potential impacts of DOE's alternatives, including cumulative impacts and other NEPA considerations.
8–13: Affected Environment and Impact Assessment for Proposed Solar Energy Zones in Each State 8. Arizona (Vol. 2, ~1,100 pages) 9. California (Vol. 3, Part 1 and Part 2, ~1,440 pages) 10. Colorado (Vol. 4, ~1,330 pages) 11. Nevada (Vol. 5, Part 1 and Part 2, ~2,390 pages) 12. New Mexico (Vol. 6, ~1,100 pages) 13. Utah (Vol. 7, ~920 pages)	Chapters 8 through 13 provide detailed descriptions of the affected environments in BLM's proposed SEZs and assessments of potential impacts, including cumulative impacts of development in each SEZ and the surrounding area. The SEZ analysis is organized by state in individual chapters. The impact analyses presented in the SEZ sections build upon the programmatic impact assessment presented in Chapter 5. These chapters also identify SEZ-specific design features that would be required under BLM's proposed Solar Energy Program for projects located within SEZs. These SEZ-specific design features are in addition to the programmatic design features. Information presented in these chapters will be useful in the review of future projects proposed in the SEZs.
14: Consultation and Coordination Undertaken To Support Preparation of the PEIS (Vol. 1, ~10 pages)	This chapter describes the actions the agencies have taken in terms of public scoping; government-to-government consultation; coordination with BLM state and field offices; and cooperation, consultation, and coordination with other agencies.

15: List of Preparers (Vol. 1, ~10 pages)	This chapter identifies the organizations and individuals who supported preparation of the Draft PEIS, including staff at the BLM, DOE, Argonne National Laboratory, and the National Renewable Energy Laboratory.
16: Glossary (Vol. 1, ~86 pages)	This chapter provides definitions of technical terms used in the Draft PEIS.
Appendices	
A: Current and Proposed BLM Solar Energy Polices and Design Features (Vol. 8, ~180 pages)	This appendix provides (1) copies of BLM's current Solar Energy Policies and (2) the programmatic administration and authorization polices and design features proposed for BLM's new Solar Energy Program.
B: Active Solar Applications (Vol. 8, ~10 pages)	This appendix provides detailed information about active ROW applications received by the BLM for utility-scale solar energy development on BLM-administered lands in the six-state study area as of February 2010. This set of applications was used to support analysis in the PEIS.
C: Proposed BLM Land Use Plan Amendments under the BLM Action Alternatives of the Solar Energy Development PEIS (Vol. 8, ~20 pages)	This appendix lists all of the land use plans in the six-state study area and identifies the amendments that would be made to implement BLM's proposed Solar Energy Program under both of BLM's action alternatives.
D: Summary of Regional Initiatives and State Plans for Solar Energy Development and Transmission Development to Support Renewable Energy Development (Vol. 8, ~40 pages)	This appendix provides a summary of regional and state-level initiatives related to renewable energy development, including state Renewable Portfolio Standards (RPSs), renewable energy zoning initiatives, and related transmission planning efforts. The appendix includes maps showing how designations from some of these initiatives relate to BLM's proposed designations for solar energy development.
E: Methods for Estimating Reasonably Foreseeable Development Scenarios for Solar Energy Development (Vol. 8, ~60 pages)	This appendix describes the methods used to project the levels of utility-scale solar energy development over the next 20 years within each of the six states. The calculations from one of the methods, based on state RPSs, were used to establish a reasonably foreseeable development scenario to support analyses in the PEIS.
F: Solar Energy Technology Overview (Vol. 8, ~100 pages)	This appendix provides a detailed discussion of the solar energy technologies evaluated in the Draft PEIS. This information supports the general descriptions provided in Chapter 3.

G: Transmission Constraint Analysis (Vol. 8, ~20 pages)	This appendix provides information about the existing electricity transmission grid in the six-state study area, designated transmission corridors, and planned or proposed new transmission projects. It also presents the results of analyses of the extent to which lands proposed to be made available for ROW application under the BLM action alternatives are constrained by lack of transmission access.
H: Federal, State, and County Requirements Potentially Applicable to Solar Energy Projects (Vol. 8, ~40 pages)	This appendix lists the major federal and state laws, county ordinances, and Executive Orders that establish permit, approval, or consultation requirements that may apply to the siting, construction, operation, and decommissioning of utility-scale solar projects and transmission projects.
I: Ecoregions of the Six-State Study Area and Land Cover Types of the Proposed Solar Energy Zones (Vol. 8, ~50 pages)	This appendix provides detailed descriptions of ecoregions within the six-state study area, as defined by the U.S. Environmental Protection Agency, including state maps showing where the lands proposed to be made available for ROW application under the BLM action alternatives occur within the ecoregions, and the land cover types and descriptions for the proposed solar energy zones. This information supports the ecological analyses of general impacts (Chapter 5), the comparison of alternatives (Chapter 6), and the analyses for the SEZs (Chapters 8–13).
J: Special Status Species Associated with BLM's Alternatives in the Six-State Study Area (Vol. 8, ~270 pages)	This appendix provides information on federally listed species (i.e., species listed under the Endangered Species Act), BLM-designated sensitive species, state-listed species, and rare species that occur on BLM-administered lands that are included under the three alternatives considered in the PEIS. Information in the appendix includes listing status, suitable habitat types, and occurrence of these species on available lands under the three BLM alternatives.
K: Government-to-Government and Cultural Resource Consultations (Vol. 8, ~390 pages)	This appendix documents the consultation correspondence for the PEIS, including government-to-government consultations among the DOE, BLM, and Native American Tribes, and cultural resource consultations.
L: GIS Data Sources and Methodology (Vol. 8, ~20 pages)	This appendix describes the data and methodology used for geographic information system (GIS) mapping and analysis in the PEIS.

M: Methodologies and Data Sources for the Analysis of Impacts of Solar Energy Development on Resources (Vol. 8, ~74 pages)	This appendix describes the methodologies used in the PEIS for analysis of impacts on resources.
N: Viewshed Maps for Proposed Solar Energy Zones (Vol. 8, ~150 pages)	This appendix presents viewshed maps for four solar technology heights for each of the proposed SEZs.

Recognized Data Inconsistencies and Gaps

- Because utility-scale solar development requires substantial amounts of land, the BLM originally planned to exclude contiguous areas of less than 247 acres (1 km^2) from lands available for development, and such lands are not currently shown in the maps or included in the acreages presented under the program alternatives. However, comments received through ongoing, internal scoping indicate that such parcels could be used to support community-scale solar energy development or projects on adjacent private or Tribal lands. For these reasons, small parcels that otherwise meet the criteria of the program alternatives are included in the program alternatives. Maps and acreages will be updated in the Final PEIS.

- The BLM proposes to exclude many categories of lands from utility-scale solar energy development. These categories, listed in Chapter 2, Table 2.2-2, include a number of resources and resource uses for which GIS data are not consistently available across the six-state study area. Examples include areas designated in land use plans for seasonal restrictions, Visual Resource Management Classes I and II, and areas with important cultural or archaeological resources. As a result, the maps and acreage estimates showing lands that would be available for ROW application include some areas that would be excluded from development. The BLM intends that all categories of lands listed in Table 2.2-2 would be excluded, and exclusions that could not be mapped in the Draft PEIS would be identified during the ROW application process.

- The BLM is currently compiling new visual resource inventory (VRI) data for each of the BLM field offices in the six-state study area in which SEZs have been proposed. Some of these inventories were not completed in time for the new data to be included in the Draft PEIS analyses of visual resource impacts. Specifically, VRI data were not available for the proposed Brenda and Bullard Wash SEZs in Arizona, nor for any of the SEZs proposed in Nevada. The new VRI data will be incorporated into the analyses presented in the Final PEIS.

- The BLM currently is processing a number of solar energy project ROW applications as “fast-track” projects. Environmental impact statements (EISs)

are being prepared or have been completed for each of these projects. Information collected in preparation of these EISs was incorporated into the Draft PEIS as available; however, the BLM acknowledges it was unable to achieve this comprehensively. This information will be integrated into the Final PEIS, as appropriate.

- A number of the land use plans in the six-state study area are undergoing revision. The Draft PEIS integrated the decisions of the land use plans of record (i.e., those plans for which Records of Decision have been issued). The BLM recognizes that some of the land use plan revisions will be completed prior to issuance of the Final PEIS. Land use plans that are undergoing revision or amendment concurrent with the development of the PEIS (e.g., land use plan amendments for fast-track projects) will be reviewed to identify and resolve inconsistencies between the PEIS and individual planning efforts, and appropriate changes will be made in the Final PEIS.

- GIS data were assembled from multiple sources to support analyses in the PEIS. In all cases, the agencies consider the data used to be the best available data. However, data gaps and inconsistencies have been identified during late stage internal reviews and reviews by the cooperating agencies. Some of these issues are a result of the way in which the GIS data have been generated (e.g., data generated by digitizing paper maps). Others are a result of discrepancies between data sets managed by different federal agencies, or offices within an agency. For example, the boundaries of lands administered by various federal agencies are constantly being updated by the administering agency at the local level, but there is no mandate to communicate these updates to the BLM, which maintains the boundaries at the national level. Efforts will be made to reconcile these issues for the Final PEIS.

- Only those species that are known to occur in the SEZ regions are discussed in Appendix J because the need for an expanded species analysis by alternative was identified too late in preparation of the Draft PEIS to be accommodated in this version of the document. It is anticipated that a discussion of all species with potential for impacts under each alternative will be developed between the Draft and Final PEIS.

1 INTRODUCTION

A number of Executive Orders (E.O.s), Congressional mandates, and federal agency orders and policies promote expedited and concentrated federal action supporting the development of domestic renewable energy resources. The U.S. Department of the Interior (DOI) Bureau of Land Management (BLM) is considering taking further actions to facilitate solar energy development in compliance with these orders and mandates. The U.S. Department of Energy (DOE) is considering actions to do the same. Among these actions, both agencies are evaluating the implementation of new programs or whether to develop new guidance that will further facilitate utility-scale solar energy development and maximize the mitigation of associated environmental impacts.[1]

These agencies are working jointly as lead agencies to prepare this programmatic environmental impact statement (PEIS), "Programmatic Environmental Impact Statement for Solar Energy Development in Six Southwestern States," to evaluate the new proposed BLM program and whether to develop DOE guidance. The "Notice of Intent to Prepare a Programmatic Environmental Impact Statement (EIS) to Evaluate Solar Energy Development, Develop and Implement Agency-Specific Programs, Conduct Public Scoping Meetings, Amend Relevant Agency Land Use Plans, and Provide Notice of Proposed Planning Criteria" (the NOI) was published in Volume 73, page 30908 of the *Federal Register* (73 FR 30908) on May 29, 2008.

This PEIS evaluates the potential environmental, social, and economic effects of the agencies' proposed actions and alternatives in accordance with the National Environmental Policy Act (NEPA), the Council on Environmental Quality's regulations for implementing NEPA (Title 40, Parts 1500–1508 of the *Code of Federal Regulations* [40 CFR Parts 1500–1508]), and applicable BLM and DOE authorities.[2] Programmatic NEPA analyses are broadly scoped analyses that assess the environmental impacts of federal actions across a span of conditions, such as facility types, geographic regions, or multiproject programs.

The following sections provide information about applicable federal orders and mandates; solar energy technologies and resources evaluated in the scope of this PEIS; the objectives, requirements, and scope of analyses for the BLM and DOE; the participation of cooperating agencies; the relationship of the proposed programs and strategies evaluated by this PEIS to other programs, policies, and plans; and the organization of the PEIS chapters and appendices.

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[1] Utility-scale facilities are defined as projects that generate electricity that is delivered into the electricity transmission grid, generally with capacities greater than 20 megawatts (MW).

[2] For the BLM, these authorities include the BLM's NEPA Handbook (BLM 2008); DOI's NEPA Implementing Procedures, 43 CFR Part 46; and Chapter 11 of the DOI's Departmental Manual (DM) 516 (DOI 2008). For DOE, these authorities include DOE's NEPA Implementing Procedures, 10 CFR Part 1021, and the Floodplain and Wetland Environmental Review Requirements, 10 CFR Part 1022.

1.1 APPLICABLE FEDERAL ORDERS AND MANDATES

The following orders and mandates, presented in chronological order, establish requirements for the DOI and/or DOE related to renewable energy development. They provide the drivers for specific actions being taken or being proposed by these agencies to facilitate solar energy development.

1.1.1 Executive Order 13212

On May 18, 2001, the President signed E.O. 13212, "Actions to Expedite Energy-Related Projects," which states that "the increased production and transmission of energy in a safe and environmentally sound manner is essential" (*Federal Register*, Volume 66, page 28357, May 22, 2001). Executive departments and agencies are directed to "take appropriate actions, to the extent consistent with applicable law, to expedite projects that will increase the production, transmission, or conservation of energy." Executive Order 13212 further states that "For energy-related projects, agencies shall expedite their review of permits or take other actions as necessary to accelerate the completion of such projects, while maintaining safety, public health, and environmental protections. The agencies shall take such actions to the extent permitted by law and regulation and where appropriate."

1.1.2 Energy Policy Act of 2005

On August 8, 2005, the Energy Policy Act of 2005 (Public Law [P.L.] 109-58) was signed into law. Section 211 of the Act states, "It is the sense of the Congress that the Secretary of the Interior should, before the end of the 10-year period beginning on the date of enactment of this Act, seek to have approved non-hydropower renewable energy projects located on the public lands with a generation capacity of at least 10,000 megawatts of electricity." To date, the BLM has approved geothermal projects with a total generation capacity of 1,350 megawatts (MW), wind projects with a total capacity of 587 MW, and solar projects with a total capacity of 3,572 MW. Other applications that are being processed could contribute to this goal.

1.1.3 Energy Independence and Security Act of 2007

On December 19, 2007, the Energy Independence and Security Act of 2007 (EISA) (P.L. 110-140) was signed into law. Section 603 of the EISA requires DOE to assess methods to integrate electric power generated at utility-scale solar facilities into regional electricity transmission systems and to identify transmission system expansions and upgrades needed to move solar-generated electricity to growing electricity demand centers throughout the United States. In addition, this section requires DOE to consider methods to reduce the amount of water consumed by concentrating solar power (CSP) systems.

1.1.4 DOI Secretarial Order 3285A1

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 production of solar energy on public lands (Secretary of the Interior 2009) The Secretarial Order requires DOI agencies and bureaus to work collaboratively with each other and with other federal agencies, individual states, Tribes, local governments, and other interested stakeholders, including renewable energy generators and transmission and distribution utilities, to encourage the timely and responsible development of renewable energy and associated transmission, while protecting and enhancing the nation's water, wildlife, and other natural resources; to identify appropriate areas for generation and necessary transmission; to develop best management practices for renewable energy and transmission projects on public lands to ensure the most environmentally responsible development and delivery of renewable energy; and to establish clear policy direction for authorizing the development of solar energy on public lands. On February 22, 2010, Secretarial Order 3285 was amended to clarify Departmental roles and responsibilities in prioritizing development of renewable energy (Secretary of the Interior 2010). The amended order is referred to as Secretarial Order 3285A1.

As a land management agency with a multiple-use mission, the BLM, consistent with Secretarial Order 3285A1, must make land use decisions that are environmentally responsible and sustain the health and productivity of the public lands for the use and enjoyment of present and future generations. The BLM recognizes that for solar energy development to be successful, it must be consistent with protection of other important resources and values, including units of the National Park System; national wildlife refuges; other specially designated areas; wildlife; and cultural, historic, and paleontological values.

1.1.5 Executive Order 13514

On October 5, 2009, the President signed E.O. 13514, "Federal Leadership in Environmental, Energy, and Economic Performance," which requires that federal agencies take efforts to align their policies to advance local planning efforts for energy development, including renewable energy (*Federal Register,* Volume 74, page 52117, Oct. 5, 2009). Specifically, the order states that agencies shall "…advance regional and local integrated planning by…aligning Federal policies to increase the effectiveness of local planning for energy choices such as locally generated renewable energy."

1.2 OVERVIEW OF SOLAR ENERGY TECHNOLOGIES AND RESOURCES CONSIDERED IN THE PEIS

The scope of the PEIS includes analyses of the use of multiple solar energy technologies at utility-scale over the next 20 years on lands within six southwestern states—Arizona, California, Colorado, Nevada, New Mexico, and Utah—where the solar energy resources are among the best in the United States.

Several technologies are currently in use and are being refined for the utility-scale capture of solar energy (i.e., ≥20 MW). The technologies evaluated in this PEIS are CSP, which includes parabolic trough, power tower, and dish engine systems, and photovoltaic (PV) (see Section 3.1 for details on these technologies). The main component that all the technologies have in common is a large solar field where solar collectors capture the sun's energy. In the parabolic trough and power tower systems, the energy is concentrated in a heat transfer fluid (HTF) and transferred to a power block, where steam-powered turbine systems generate electricity using similar technology to that used in fossil fuel–fired power plants. In contrast, the dish engine and PV systems are composed of many individual units or modules that generate electricity directly and whose output is combined; these systems do not use a central power block. Figure 1.2-1 shows a typical solar field for each of these technology types.

Commercially feasible utility-scale solar energy development requires adequate direct normal insolation (DNI) and large areas of land. Under clear sky conditions, about 85% of the sunlight is DNI, and 15% is scattered light that comes in at many different angles. DNI can be used by all solar energy systems, whereas the scattered light can only be used by PV systems. Because the solar resources in the six-state study area have high solar insolation levels, they are highly suitable for utility-scale solar power plants. Direct normal insolation levels in the six-state study area are depicted in Figure 1.2-2; in this PEIS, DNI levels greater than or equal to 6.5 $kWh/m^2/day$ are generally considered to be optimal for solar development. The BLM's analysis in this PEIS is limited to utility-scale solar development on lands administered by the BLM within the six-state study area. DOE's analysis considers all lands within the six-state study area because its support to projects is not restricted to projects located on BLM-administered lands.

The scope of this PEIS is limited to utility-scale solar development, in part, because the Energy Policy Act of 2005 and DOI Secretarial Order 3285A1 require that the BLM take steps to facilitate development at that scale (see Section 1.1). The development of distributed generation, small-scale solar energy facilities, such as roof-top mounted PV systems, is not included in the scope of this PEIS. While such solar energy development will be an important component of future electricity supplies (and is the focus of separate DOE initiatives; see Section 2.5.1), current research indicates that development of both distributed generation and utility-scale solar power will be needed, along with other energy resources and energy efficiency technologies (NREL 2010c). One analysis of available roof space concluded that up to 23% of required electricity supplies could be met with roof-top PV systems, although integrating PV into the electric grid at levels that high could be challenging (Denholm and Margolis 2008). On a per-watt basis, small-scale PV systems are more expensive than utility-scale systems (NREL 2010c). Because these systems typically do not include electricity storage, they cannot provide power during the evenings or at night, and the power output can fluctuate significantly during cloudy weather. As a result, buildings equipped with roof-top PV systems remain dependent on the grid, and electric utilities must maintain adequate generating capacity to provide electricity to these customers when needed. Ultimately, both utility-scale and distributed-generation solar power will need to be deployed at increased levels, and the highest penetration of solar power overall will require a combination of both types (NREL 2010c).

FIGURE 1.2-1 Typical Solar Fields for Various Technology Types: (a) Solar Parabolic Trough (Source: Hosoya et al. 2008), (b) Solar Power Tower (Credit: Sandia National Laboratories. Source: NREL 2010a), (c) Dish Engine (Credit: R. Montoya. Source: Sandia National Laboratories 2008), and (d) PV (Credit: Arizona Public Service. Source: NREL 2010b)

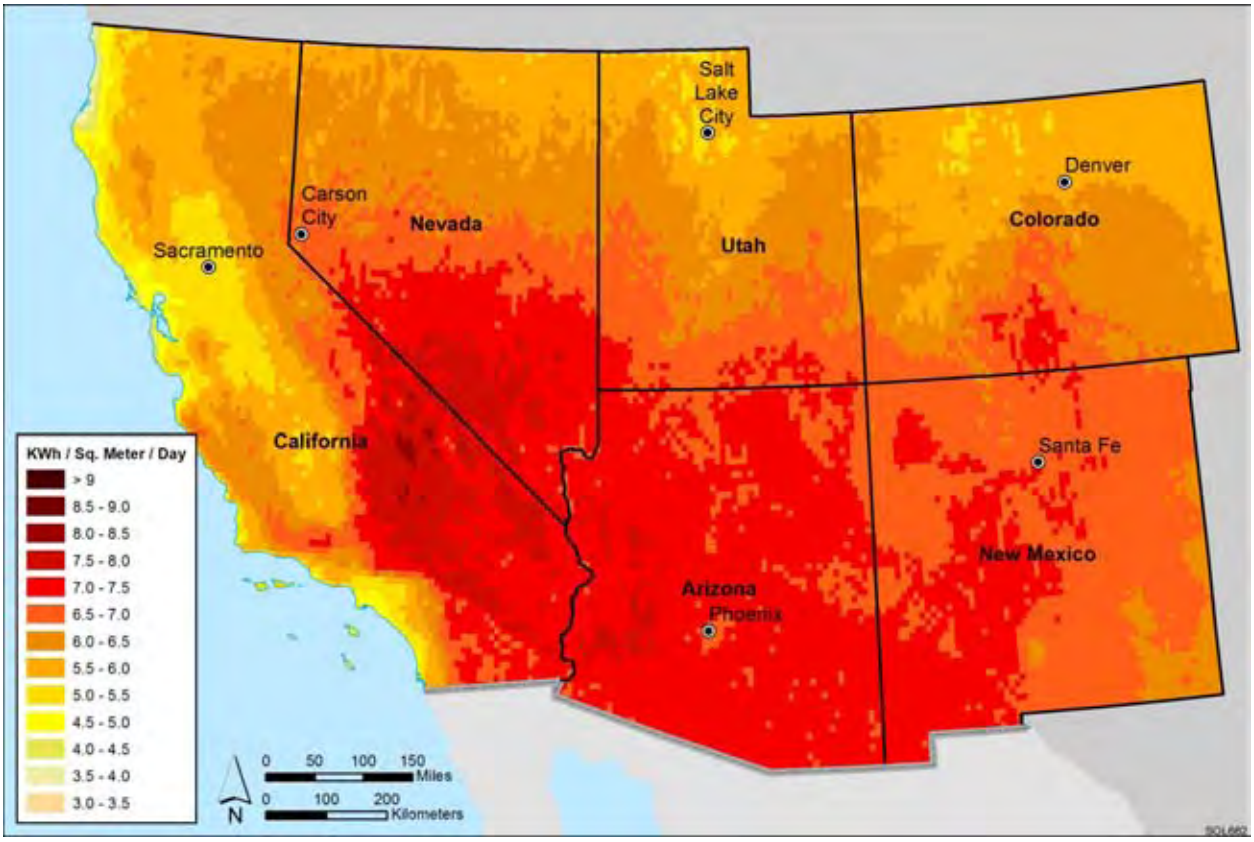

FIGURE 1.2-2 Solar Direct Normal Insolation Levels in the Southwestern United States

1.3 BLM REQUIREMENTS AND OBJECTIVES FOR THE PEIS

The BLM has identified utility-scale solar energy development as a potentially critical component in meeting the applicable orders and mandates discussed in Section 1.1. The BLM administers approximately 245 million acres (>1 million km^2) of public lands in 11 western states and Alaska. This administrative responsibility encompasses stewardship, conservation, and resource use, including the development of energy resources in an environmentally sound manner. Utility-scale solar energy facilities have not yet been constructed on BLM-administered public lands, but there is great interest in such development (see Section 1.3.3 for information on active solar applications on BLM-administered lands).

The BLM developed and issued a Solar Energy Development Policy in 2007 (BLM 2007) to address increased interest in solar energy development on BLM-administered lands and to implement goals to construct renewable energy facilities on public lands. This 2007 policy established procedures for processing right-of-way (ROW) applications for solar energy development projects on public lands administered by the BLM in accordance with the requirements of the Federal Land Policy and Management Act of 1976 (FLPMA) (*United States Code*, Title 43, Section 1701 et seq. [43 USC 1701 et seq.]) and the BLM's implementing regulations (43 CFR Part 2800), and for evaluating the feasibility of installing solar energy systems on BLM administrative facilities. This policy was updated in 2010 by two more detailed

policies that establish a maximum term for authorizations, diligent development requirements, bond coverage, potential best management practices for solar energy development projects, and interim guidance on how to calculate rent for utility-scale solar energy facilities (BLM 2010a,b). These three BLM policies are shown in their entirety in Appendix A, Section A.1.

The BLM's current practice is to evaluate solar energy ROW applications on a project-specific basis. In addition, many of the BLM's land use plans do not specifically address solar energy development; therefore, projects that are not in conformance with the existing land use plan require individual land use plan amendments. Moreover, the BLM does not have a standard set of mitigation measures that would be applied consistently to all solar energy development projects.

The BLM is developing this PEIS to evaluate a proposed program to further support utility-scale solar energy development on BLM-administered lands, as detailed below.

1.3.1 BLM's Purpose and Need

The BLM has identified a need to respond in a more efficient and effective manner to the high interest in siting utility-scale solar energy development on public lands and to ensure consistent application of measures to mitigate the adverse impacts of such development. The BLM is therefore considering replacing certain elements of its existing solar energy policies (described above) with a comprehensive Solar Energy Program that would allow the permitting of future solar energy development projects to proceed in a more efficient and standardized manner. While the proposed Solar Energy Program will further the BLM's ability to meet the mandates of E.O. 13212 and the Energy Policy Act of 2005, it also has been designed to meet the requirements of Secretarial Order 3285A1 (Secretary of the Interior 2010) related to identifying and prioritizing specific locations best-suited for utility-scale solar energy development on public lands.

In order to identify areas best suited for utility-scale solar energy development, the BLM preliminarily identified 24 Solar Energy Study Areas that would be evaluated in the PEIS as part of the proposed program to determine suitability for solar energy development. The BLM applied preliminary suitability criteria to nominate proposed Solar Energy Study Areas in each of the six states for evaluation in the Solar PEIS; these criteria included high solar resource availability, suitable slope, proximity to roads and transmission lines or designated corridors, and size consisting of at least 2,500 acres (8.1 km^2) of BLM-administered public lands. In addition, sensitive lands, wilderness, and other high-conservation-value lands as well as lands with conflicting uses were excluded. These Solar Energy Study Areas were announced on June 30, 2009, in the *Federal Register* (74 FR 31307), and the public and other agencies were provided the opportunity to comment on them. On the basis of the comments received and the resource conflicts identified, Solar Energy Study Area locations and boundaries were refined to create the proposed solar energy zones (SEZs) that would be fully analyzed in the Solar PEIS. A full description of this process is included in Section 2.2.2.2.

Considering the above, the objectives of BLM's proposed Solar Energy Program include:

- Facilitating near-term utility-scale solar energy development on public lands;
- Minimizing potential negative environmental, social, and economic impacts;
- Providing flexibility to consider a variety of solar energy projects (location, facility size, technology, and so forth);
- Optimizing existing transmission infrastructure and corridors; and
- Standardizing and streamlining the authorization process for utility-scale solar energy development on BLM-administered lands.

The anticipated elements of the BLM's proposed Solar Energy Program include:

1. Identification of lands excluded from utility-scale solar energy development in the six-state study area;
2. Identification of priority areas within the lands open to solar energy development that are best suited for utility-scale production of solar energy in accordance with the requirements of Secretarial Order 3285A1 (i.e., proposed SEZs);
3. Establishment of mitigation requirements for solar energy development on public lands to ensure the most environmentally responsible development and delivery of solar energy; and
4. Amendment of BLM land use plans in the six-state study area to adopt those elements of the new Solar Energy Program that pertain to planning.

Chapter 2 provides a detailed discussion of the BLM's proposed action and alternatives.

1.3.2 BLM's Decisions To Be Made

On the basis of the analyses presented in this PEIS, the BLM anticipates making the following land use planning decisions that will establish the foundation for a comprehensive Solar Energy Program:

1. Land use plan amendments to identify exclusion areas for utility-scale solar energy development in the six-state study area;
2. Land use plan amendments to identify priority areas within the lands open to solar energy development that are best suited for utility-scale production of solar energy (i.e., proposed SEZs); and

3. Land use plan amendments to establish design features (i.e., mitigation requirements) for solar energy development on public lands to ensure the most environmentally responsible development and delivery of solar energy (some may be SEZ-specific, as necessary).

In addition to the planning decisions described above, the Secretary of the Interior may decide to withdraw the public lands encompassed by SEZs from potentially conflicting uses through the issuance of a Public Land Order (see Section 1.3.5, BLM Land Withdrawals). Other policy and guidance as described in Section 1.3.3 may also be issued by the BLM regarding procedural elements of the Solar Energy Program on the basis of existing statutes and regulations.

1.3.3 Authorization Process for Solar Energy Development on BLM Lands

Currently, applications for utility-scale solar energy facilities on BLM-administered lands are processed on a project-specific basis as ROW authorizations issued in accordance with Title V of FLPMA and the BLM's ROW regulations (43 CFR Part 2800). When the BLM authorizes the construction of utility-scale solar energy generation facilities on BLM-administered lands, it must comply with NEPA, the Endangered Species Act (ESA), the National Historic Preservation Act, and other applicable statutes and regulations. The BLM's project-specific environmental analysis must address all applicable components of the solar energy generation facility, including, as appropriate, the installation and maintenance of solar collectors, the availability and consumption of water for steam generation and cooling, oil or gas backup generators, the creation and use of thermal or electrical storage, turbines or engines, access roads, electrical inverters and transmission facilities, and water or natural gas pipelines. In addition, solar energy development must be in conformance with the existing, approved land use plan (see Section 1.3.4, BLM Land Use Planning Process). To help meet the requirements of Section 504 of FLPMA to limit unnecessary damage to the environment and the objectives of the implementing regulations (43 CFR 2801.2(a) and (b)) to protect natural resources on the public lands and adjacent lands and to prevent unnecessary or undue degradation to the public lands, the BLM has established sound environmental policies, procedures, and siting and mitigation strategies for solar energy development on the public lands (see Appendix A).

As of February 2010, the BLM had 127 active applications for ROW authorizations for solar facilities to be located on BLM-administered lands (see Appendix B for a complete list of these applications).[3] These include approximately 55 applications for lands in California,

[3] The BLM has received more than 300 such applications to date; some, however, have been terminated because the developer withdrew the application or because due diligence requirements were not met. Some applications cannot currently be processed because they describe lands already applied for by another company. While many of the active applications ultimately may not be issued for a variety of reasons (e.g., withdrawal by applicant, failure of applicant to provide sufficient analysis of impacts and/or agree to meet mitigation requirements), many applicants are providing sufficiently detailed plans and analyses that are likely to result in ROW authorizations. The BLM is proceeding with the processing of these applications during the preparation of this PEIS, but it is planning to incorporate the program established through this PEIS into the processing of applications that occurs subsequent to the release of the Record of Decision. The applications as of February 2010 were used to support analyses in the PEIS; however, as of December 1, 2010, the BLM had 104 active applications, including 30 in California, 35 in Nevada, 36 in Arizona, and 3 in New Mexico.

34 applications for Nevada lands, 34 applications for Arizona lands, and 4 applications for New Mexico lands; there were no applications for lands in Colorado or Utah (see Figure 1.3-1). The applications encompass all of the solar technologies reviewed in this PEIS. They range in power-producing capacity from 4 to 4,100 MW (with an average of about 650 MW), and the amount of land applied for ranges from 40 to 36,000 acres (0.16 to 145.7 km^2) (with an average of about 10,000 acres [45.5 km^2]). The BLM is in the process of reviewing and processing these applications in accordance with BLM's existing Solar Energy Policies (BLM 2007; 2010a,b).

Fourteen of the active applications are being processed as "fast-track" projects (BLM 2010c). These projects, shown in Figure 1.3-1, include applications for which the companies involved have demonstrated to the BLM that they have made sufficient progress to formally start the environmental review and public participation process. They are advanced enough in the permitting process that they could potentially be cleared for approval by December 2010. The proposed fast-track projects total approximately 6,022 MW of generating capacity; one is located in Arizona, four are in Nevada, and the rest are in California.[4]

A number of legislative and departmental initiatives are underway that, if enacted, could provide specific guidance to the BLM on its Solar Energy Program. For example, the BLM may employ alternative procedures for authorizing solar energy development, such as issuing ROWs on a competitive basis in some priority solar development areas. The BLM may also decide to dispose of some parcels of land through land sales or exchanges to support the development of solar energy on a case-by-case basis. The BLM's existing ROW regulations, contained in 43 CFR Part 2800, existing land sale regulations, contained in 43 CFR Parts 2710 and 2711, and existing exchange regulations, contained in 43 CFR Part 2200, provide for these possible procedural approaches. The NEPA analysis contained in the Solar PEIS will be used to the extent practicable to support future decisions; however, in some cases additional NEPA analysis may be necessary. Depending on the timing of such decisions, these program elements may be included in the Record of Decision (ROD) for the Solar PEIS or may be issued in separate decision documents.

1.3.4 BLM Land Use Planning Process

The 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. An RMP typically covers public lands within a particular BLM field office. The BLM's Land Use Planning Handbook (H-1601-1; BLM 2005a) provides specific guidance for preparing, amending, and revising land use plans.

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4 Six fast-track projects have been approved in California and two have been approved in Nevada: BrightSource Energy's Ivanpah Solar Electric Generating System, Tessera Solar's Imperial Valley and Calico Solar Projects, Chevron Energy Solution's Lucerne Valley Solar Project, NextEra's Genesis Ford Dry Lake Solar Project, Solar Millennium's Blythe and Amargosa Farm Road Solar Projects, and First Solar's Silver State North Solar Project.

FIGURE 1.3-1 BLM-Administered Lands and Active Solar Facility ROW Applications in the Six-State Study Area

As part of the land use planning process, the BLM identifies existing and potential development areas for renewable energy projects (e.g., wind and solar), communication sites, and other uses. The BLM also identifies ROW avoidance or exclusion areas (areas to be avoided but that may be available for location of ROWs with special stipulations, and areas that are not available for location of ROWs). In addition, the BLM identifies terms and conditions that may apply to ROW corridors or development areas, including best management practices to minimize environmental impacts and limitations on other uses that would be necessary to maintain the corridor and ROW values (H-1601-1, Appendix C(E); BLM 2005a). Many of the existing land use plans in the six-state study area do not specifically address ROWs for solar energy development, although they contain many provisions, stipulations, and guidelines that are relevant to such development activities.

Solar energy development projects, as with other implementation actions, must be in conformance with the applicable land use plan. In cases where a proposed solar energy facility is not in conformance with the applicable land use plan, the BLM can reject the application for a ROW or amend the land use plan to allow for the ROW. The BLM must determine whether to initiate a plan amendment process when a proposal changes the scope of resource uses or the terms, conditions, and/or decisions of an approved plan (43 CFR 1610.5-5). Land use plan amendments are subject to environmental review under NEPA and must be completed in accordance with BLM planning regulations (43 CFR 1610 et seq.).

As part of the BLM proposed program, land use plans in the six-state study area would be amended to address solar energy development (see Appendix C for a list of the proposed plan amendments associated with this PEIS). The amendments would become part of the land use plans and would include the exclusion areas, priority solar energy development areas, and required mitigation measures identified in this PEIS. Only approved land use plans can be amended. Land use plans that are undergoing revision or amendment concurrent with the development of the Solar PEIS (e.g., land use plan amendments for fast-track projects) will be reviewed to identify and resolve inconsistencies between the PEIS and individual planning efforts. In the event that the BLM determines that it is appropriate to amend additional land use plans outside the six-state study area, in order to adopt elements of the program, the BLM would initiate the planning process and conduct NEPA analysis incorporating by reference the analysis in the Solar PEIS, as appropriate.

1.3.5 BLM Land Withdrawals

A withdrawal of federal land withholds the land from settlement, sale, location, or entry under some or all public land laws. Withdrawals are accomplished through Public Land Orders for the purpose of:

- Limiting activities to maintain other public values;
- Reserving an area for a particular public purpose or program; or

- Transferring administrative jurisdiction/responsibility for an area from one department, bureau, or agency to another.

The Secretary of the Interior has withdrawal authority, which he can delegate to agency officials in the Office of the Secretary who are appointed by the President and confirmed by the Senate. As a possible mechanism to support the establishment of priority areas that are best suited for utility-scale production of solar energy, the BLM sought and received permission from the Secretary of the Interior to issue a notice of proposed withdrawal for the 24 identified Solar Energy Study Areas. This notice, published in the *Federal Register* (74 FR 31308) on June 30, 2009, segregates the public lands encompassed in the 24 Solar Energy Study Areas (approximately 676,000 acres [2,735.7 km^2]) for up to 2 years from surface entry and mining, while various studies and analyses are conducted to support a final decision on withdrawing the land from conflicting uses. The required withdrawal studies and analyses will be completed as part of the Solar PEIS (see Section 1.3.6.2). The Secretary of the Interior's final decision regarding the withdrawal of these lands will be made based on the Solar PEIS; however, the Secretary's ROD will be made separate from the BLM's ROD for the Solar PEIS.

1.3.6 BLM Scope of the Analysis

The geographic scope of the PEIS for the BLM includes all BLM-administered lands in the six-state study area (i.e., in Arizona, California, Colorado, Nevada, New Mexico, and Utah) (see Figure 1.3-1). This scope was determined based on an internal initial resource assessment showing that these states include the majority of BLM-administered lands with the most prospective solar energy resources suitable for utility-scale development over the next 20 years.

The scope of the impact analysis includes an assessment of the environmental, social, and economic impacts of utility-scale solar facilities and required transmission connections from these facilities to the existing electricity transmission grid. As discussed in Section 1.2, viable utility-scale solar technologies to be deployed over the next 20 years include parabolic trough, power tower, dish engine systems, and PV. These technologies are discussed in greater detail in Section 3.1. For the purposes of the Solar PEIS, "utility-scale" solar energy development is defined as projects capable of generating 20 MW or greater. As a result, the new Solar Energy Program would apply only to projects of this scale; decisions regarding projects that are less than 20 MW would continue to be made in accordance with existing land use plan requirements.[5]

As part of the PEIS process, the BLM considered designating additional electricity transmission corridors on BLM-administered lands to facilitate utility-scale solar energy development. An analysis of this issue conducted during preparation of the Draft PEIS indicated that the majority of BLM-administered lands with developable solar resources are

[5] Co-generation projects involving a mix of solar energy technologies and other energy technologies (e.g., natural gas, wind, hydropower) would be subject to the requirements of the new Solar Energy Program if the solar energy component is 20 MW or greater.

not constrained from development[6] on the basis of the location of existing transmission lines or designated transmission corridors (see Appendix G). This transmission analysis only considered the locations of existing transmission lines and designated corridors and did not look at the available capacity on existing lines (i.e., the analysis assumed lines could be upgraded if needed). On the basis of the results of this analysis, the designation of additional electricity transmission corridors on BLM-administered lands has not been included in the scope of this PEIS. Although the BLM has deemed the designation of new corridors unnecessary, the PEIS does evaluate the potential impacts associated with constructing and operating interconnections from solar energy facilities to the transmission grid.

1.3.6.1 Programmatic Scope

The PEIS evaluates the potential environmental, social, and economic effects of establishing broad solar energy program elements and strategies across the six-state study area. The programmatic analysis will provide the basis for future utility-scale solar energy development decisions. Because the proposed program involves environmental effects over a broad geographic and time horizon, the depth and detail of the impact analysis is fairly general, focusing on major impacts in a qualitative manner.

The PEIS does not assess site-specific issues associated with any future individual solar energy development projects. A variety of location-specific factors (e.g., soil type, watershed, groundwater availability and presence of jurisdictional waters, habitat, vegetation, viewshed, public sentiment, the presence of threatened and endangered species, and the presence of cultural resources) would vary considerably from site to site, especially over a six-state region. In addition, the variations in technology and project size and design would greatly determine the magnitude of the impacts from given projects. The effects of these location-specific and project-specific factors typically cannot be fully anticipated or addressed in a programmatic analysis; such effects must be evaluated at the project level. This PEIS identifies the range of potential impacts and identifies relevant mitigation requirements applicable to utility-scale solar energy development in general. Site-specific and species-specific issues would be addressed during individual project reviews, where resolution of these issues is more readily achievable. NEPA analyses for site-specific solar energy proposals would tier to the Solar PEIS (see Section 1.3.8, BLM Requirements for Further Environmental Analysis).

1.3.6.2 Proposed Solar Energy Zone Scope

In addition to the programmatic analysis described above, the Solar PEIS also provides in-depth environmental analysis to inform the identification of the BLM's proposed SEZs within the six-state study area as those locations that are best suited for utility-scale solar energy development (i.e., high resource value and low [or limited] resource and/or environmental conflicts).

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6 "Constrained from development" was defined as being located more than 25 mi (40 km) from an existing transmission line or designated corridor (see details in Section 3.2.5).

Through the ROD for the PEIS, the BLM may decide to carry forward some or all of the proposed SEZs as part of the agency's Solar Energy Program. Land use plans would be amended to identify the SEZs and adopt all applicable management requirements. Further, the Secretary of the Interior may decide to withdraw the public lands encompassed in the SEZs from potentially conflicting uses through the issuance of a Public Land Order (see Section 1.3.5, BLM Land Withdrawals).

1.3.7 BLM Planning Criteria

Planning criteria are the constraints, standards, and guidelines that determine what the BLM will or will not consider during its planning process. As such, they establish parameters and help focus the structure and preparation of the PEIS. The following are the planning criteria that were considered during preparation of the PEIS:

- The BLM will prepare RMP amendments in compliance with FLPMA, the ESA, the Clean Water Act (CWA), the Clean Air Act (CAA), NEPA, and all other applicable laws, E.O.s, and BLM management policies.

- The BLM will use the PEIS as the analytical basis for any decision it makes to amend these RMPs.

- The BLM will develop a reasonably foreseeable development scenario (RFDS) to predict future levels of development. It will identify lands available for utility-scale solar energy development, lands available for utility-scale solar energy development that have restrictive stipulations, and lands not available for utility-scale solar energy development in affected plans.

- The BLM will limit its amendment of these plans to utility-scale solar energy development and associated transmission issues and will not address the management of other resources, although the BLM will consider and analyze the impacts from increased use on other managed resource values.

- The BLM will continue to manage other resources in the affected planning areas under the pre-existing terms, conditions, and decisions in the applicable RMPs for those other resources.

- The BLM will recognize valid existing rights under the RMPs, as amended.

- The BLM will coordinate with federal, state, and local agencies, and Tribal governments in the PEIS and plan amendment process to strive for consistency with existing plans and policies, to the extent practicable.

- The BLM will coordinate with Tribal governments and provide strategies for the protection of recognized traditional uses in the PEIS and plan amendment process.

- The BLM will take into account appropriate protection and management of cultural and historic resources in the PEIS and plan amendment process and will engage in all required consultation.

- The BLM will recognize in the PEIS and plan amendments the special importance of public lands to people who live in communities surrounded by public lands and the importance of public lands to the nation as a whole.

- The BLM will make every effort to encourage public participation throughout the PEIS process.

- The BLM has the authority to develop protective management prescriptions for lands with wilderness characteristics within RMPs. As part of the public involvement process for land use planning, the BLM will consider public input regarding lands to be managed to maintain wilderness characteristics.

- Environmental protection and energy production are both desirable and necessary objectives of sound land management practices and are not to be considered mutually exclusive priorities.

- The BLM will consider and analyze relevant climate change impacts as part of the PEIS process, including the anticipated climate change benefits of solar energy.

1.3.8 BLM Requirements for Further Environmental Analysis

As discussed previously, the Solar PEIS will not eliminate the need for site-specific environmental review for future individual utility-scale solar energy development proposals (see Section 1.3.6.1, Programmatic Scope). The BLM will make separate decisions whether or not to authorize individual solar energy projects in conformance with the existing land use plan(s) as amended by the Solar PEIS. Site-specific environmental reviews for utility-scale solar energy projects commenced after the ROD for the Solar PEIS is signed will be tiered to the Solar PEIS. All site-specific environmental reviews will include a requirement for additional project-specific public involvement. The BLM retains the discretion to reject solar ROW applications based on site-specific issues and concerns, even in those areas available or open for application in the existing land use plan.

In cases where a broad policy, plan, program, or project will later be translated into site-specific projects, subsequent analyses are referred to as “tiered” analyses. Tiering refers to the coverage of general matters in a broader EIS (such as national program or policy statements) with subsequent narrower EISs or environmental assessments (EAs) (such as regional program statements or ultimately site-specific statements) incorporating by reference the general discussions and concentrating solely on the issues specific to the EIS or EA subsequently prepared (40 CFR 1508.28).

Tiering will typically result in a more efficient environmental analysis process for future solar energy development proposals. Since the BLM has completed in-depth environmental analyses for the proposed SEZs as part of the PEIS (see Section 1.3.6.2, Proposed Solar Energy Zone Scope), it is expected that projects proposed in SEZs would require limited additional environmental review. The determination of the necessary level of additional NEPA analysis, however, would be made on a case-by-case basis at the time a solar energy project application was received.

The proposed Solar Energy Program will establish specific policies and requirements regarding the approval of future utility-scale solar energy projects on BLM-administered lands. These policies and requirements are itemized in Appendix A.

1.4 DOE REQUIREMENTS AND OBJECTIVES FOR THE PEIS

Different offices within DOE address different aspects and/or approaches to the mission of solar power development. For example, one aspect of DOE's Office of Energy Efficiency and Renewable Energy (EERE) mission is to develop cost-competitive solar energy systems for the United States by providing technical assistance and funding for research. EERE's Solar Energy Technologies Program (Solar Program) is working to improve the efficiency and reduce the cost of solar technology through research, development, and demonstration in partnership with industry, universities, and national laboratories. The Solar Program also facilitates the deployment of solar technology through resource assessment; development of codes and standards; market and policy analysis; and by providing technical information to national, state, and local entities. DOE is also evaluating its sites around the country for suitability for various renewable energy technologies, including solar. As another example, the Solar Program and DOE's National Nuclear Security Administration (NNSA) have proposed a solar demonstration project at the Nevada National Security Site (previously named the Nevada Test Site), to demonstrate the technical and commercial potential of advanced concentrating solar power and concentrating photovoltaic technologies and systems. In addition, NNSA is evaluating a generic commercial solar power installation in the draft Nevada National Security Site Site-Wide Environmental Impact Statement (NNSS SWEIS; DOE/EIS-0426), which is scheduled for completion in 2012. In addition, DOE's Loan Guarantee Program provides financial support for the development of renewable energy projects, including solar energy projects, implemented at utility scales.

DOE's Western Area Power Administration (Western) markets and transmits wholesale electrical power through an integrated 17,000-circuit mile, high-voltage transmission system across 15 western states, including parts of the six-state study area for this PEIS. Western's Open Access Transmission Service Tariff provides open access to its transmission system. Western provides these services through an interconnection if there is available capacity on the transmission system, while protecting power deliveries to existing customers and transmission system reliability, and considering the applicant's objectives. With respect to new utility-scale solar energy facilities, any interconnection between such a facility and the Western transmission system would need to comply with Western's interconnection policies and environmental requirements and would require NEPA review in accordance with DOE's NEPA regulations.

While solar technologies generally are considered to be clean and sustainable, they can result in adverse direct and indirect impacts on the environment, especially utility-scale facilities. DOE is interested in exploring new ways to generate and store energy captured from the sun while minimizing the impacts of solar development on the environment and reducing the cost of solar energy development. DOE is committed to supporting the development of these and other solar and renewable energy projects in an environmentally responsible manner.

1.4.1 DOE's Purpose and Need

As discussed in Section 1.2, DOE is required to take actions to meet mandates under E.O.s 13212 and 13514, as well as Section 603 of the EISA. DOE's purpose and need is to satisfy both E.O.s and comply with congressional mandates to promote, expedite, and advance the production and transmission of environmentally sound energy resources, including renewable energy resources and, in particular, cost-competitive solar energy systems at the utility scale.

Specifically, DOE proposes to further integrate environmental considerations into its analysis and selection of solar projects that it will support. DOE will build on the BLM's analysis of potential impacts of utility-scale solar development on the environment for all phases of development (i.e. during site characterization, construction, operation, and decommissioning), and on the identified potential mitigation measures, to provide a technical basis for development of guidance. DOE would consider, as appropriate, the relevance of the analytical results for all lands, not just BLM-administered lands.

DOE would use this information to develop guidance for the development of solar energy projects. DOE's investment and deployment strategy would incorporate a decision-making framework of guidance for early consideration of sound environmental practices and potential mitigation measures for solar energy development. Development of a framework of guidance, based on the analyses of the PEIS, would give DOE the tools with which to make more informed, environmentally sound decisions at the outset, would help to streamline future environmental analysis and documentation for DOE-supported solar projects, and would support DOE's efforts to comprehensively (1) determine where to make technology and resource investments to minimize the environmental impacts of solar technologies, and (2) establish environmental mitigation recommendations for financial assistance recipients to consider in project plans when applying for DOE funding.

Western's purpose and need for participating in this PEIS is to identify potential transmission impacts and recommend mitigation measures for transmission lines associated with solar energy projects. Western anticipates using the transmission environmental impact and mitigation measures analysis in this PEIS to streamline its own NEPA documents once specific projects are identified and interconnection requests are filed with Western. With the PEIS providing the basis for this analysis, project-specific NEPA documentation for interconnections should be more concise and take less time to prepare, resulting in efficiencies for both Western and the project proponent.

Chapter 2 provides a more detailed discussion of DOE's proposed action and descriptions of alternatives.

1.4.2 DOE's Decisions To Be Made

On the basis of the analysis of this PEIS, DOE could implement new strategies for funding solar projects that would emphasize the development of solar energy technologies that minimize environmental impacts, such as impacts on water use and land use. In addition, DOE would develop guidance that all projects receiving support from DOE would use, as appropriate, a consistent set of mitigation measures as developed and identified on the basis of the impact analyses in this PEIS.

At this time, Western does not anticipate making any specific decisions at the programmatic level on the basis of the analysis in this PEIS. It anticipates using the analyses of transmission development to more expeditiously prepare project-specific NEPA documents and expedite decisions regarding future interconnection requests related to solar energy development and other energy development in the six-state study area.

1.4.3 DOE's Scope of the Analysis

The geographic scope of applicability for DOE's proposed guidance that would be developed on the basis of analyses in this PEIS, includes both BLM-administered lands and other lands. DOE may support solar projects within SEZs identified by the BLM; on other BLM-administered lands; or on other federal, state, Tribal, or private lands. Similarly, Western may be involved in associated transmission development on lands administered by any of these entities.

The scope of the impact analysis includes an assessment of the environmental, social, and economic impacts of utility-scale solar facilities and required transmission connections from these facilities to the existing electricity transmission grid. As discussed in Section 1.2, viable solar technologies to be deployed over the next 20 years include parabolic trough, power tower, dish engine systems, and PV. These technologies are discussed in greater detail in Section 3.1.

1.5 COOPERATING AGENCIES

The BLM and DOE are lead agencies jointly preparing this PEIS. Because the scope of the PEIS is of interest to numerous federal, state, Tribal, and local agencies, several agencies expressed an interest in participating as cooperating agencies. The entities listed below are cooperating in the preparation of this PEIS, and Memoranda of Understanding (MOUs) between these agencies and the DOE and/or the BLM have been established, as appropriate. The cooperating agencies were given the opportunity to review the PEIS prior to release of the public draft.

The following agencies are participating as cooperating agencies in the preparation of this PEIS:

- U.S. Department of Defense (DoD);
- U.S. Bureau of Reclamation (BOR);
- U.S. Fish and Wildlife Service (USFWS);
- U.S. National Park Service (NPS);
- U.S. Environmental Protection Agency (EPA), Region 9;
- U.S. Army Corps of Engineers (USACE), South Pacific Division;
- State of Arizona Game and Fish Department (AZGFD);
- State of California, California Energy Commission (CEC);
- State of California Public Utilities Commission (CPUC);
- State of Nevada Department of Wildlife (NDOW);
- N-4 Grazing Board, Nevada;
- State of Utah Public Lands Policy Coordination Office;
- Clark County (Nevada), including Clark County Department of Aviation;
- Dona Ana County (New Mexico);
- Esmeralda County (Nevada);
- Eureka County (Nevada);
- Lincoln County (Nevada);
- Nye County (Nevada); and
- Saguache County (Colorado).

In addition, the State of California has established an Interagency Working Group on the Solar Energy Development PEIS as a means of facilitating and coordinating federal, state, and county agency participation in the PEIS process for the state. The CEC is coordinating this working group. Members of the California Interagency Working Group include all of the federal agencies that are participating as cooperators as well as several State of California agencies

(including the Native American Heritage Commission, Office of Planning and Research, Department of Parks and Recreation, State Lands Commission, and Department of Fish and Game), and Inyo and San Bernardino Counties.

1.6 RELATIONSHIP OF THE BLM'S PROPOSED PROGRAM AND DOE'S PROPOSED STRATEGY TO OTHER PROGRAMS, POLICIES, AND PLANS

1.6.1 Renewable Portfolio Standards and Other Regional and State Initiatives

Some interstate and state initiatives have been created whose mission is to facilitate renewable energy development. This is partially in response to the passage of Renewable Portfolio Standards (RPSs) requiring that a certain percentage of a state's electricity capacity requirements be supplied from renewable sources (e.g., solar, wind, geothermal, or biomass) by a given year. The six states in the PEIS study area all have RPSs; Table 1.6-1 gives the specific requirements for each state along with information about other state initiatives.

The Western Governors' Association and DOE launched the Western Renewable Energy Zones (WREZ) initiative in May 2008, with DOE providing substantial funding. The WREZ initiative, which encompasses the Western Interconnection region, seeks to identify those areas in the West with vast renewable resources to expedite the development and delivery of renewable energy to where it is needed.[7] The scope of the WREZ initiative includes solar, wind, biomass, geothermal, and hydropower resources. The initiative is intended to facilitate the construction of renewable energy facilities and expansion of the electricity transmission system needed to deliver the energy to load centers across the Western Interconnection (WGA and DOE 2009).

The state-level and WGA initiatives are discussed in more detail in Appendix D. The appendix includes maps showing how designations from these initiatives relate to the BLM's proposed designations for solar energy development.

1.6.2 Related Initiatives

There are many ongoing and recently completed efforts addressing how best to enable environmentally responsible renewable energy development and its associated transmission needs in the Western United States. Examples of those initiatives are identified below; others are presented in Appendix D of this document. All demonstrate, to some degree, the challenges in identifying appropriate areas for renewable energy and transmission and underscore the importance of collaboration among agencies and stakeholders.

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[7] The Western Interconnection is the name of the electricity grid, overseen by the Western Electricity Coordinating Council, that serves the states of Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming; part of west Texas; the Canadian provinces of Alberta and British Columbia; and a small portion of northern Mexico in Baja California.

TABLE 1.6-1 RPS Requirements and Other State Initiatives in the Six-State Study Area[a]

State	RPS Requirements	Other State Renewable Energy Initiatives
Arizona	15% by 2025	Arizona Renewable Resource and Transmission Identification Subcommittee (ARRTIS 2009).
California	20% by 2010 and 33% by 2020[b]	Renewable Energy Transmission Initiative (RETI) (CEC 2010).
		Desert Renewable Energy Conservation Plan (DRECP)—to prioritize and streamline renewable energy projects in the Mojave and Colorado Desert Regions on the basis of renewable energy potential and plant and animal habitat protection.
Colorado	30% by 2020	Colorado's Renewable Energy Development Infrastructure (Colorado Governor's Energy Office 2007, 2009).
Nevada	25% by 2025[c]	Renewable Energy Transmission Access Advisory Committee (RETAAC) (State of Nevada 2007 and 2009).
New Mexico	20% by 2020[d]	New Mexico's Renewable Energy Transmission Authority (RETA; 2010).
Utah	20% by 2025[e]	Utah Renewable Energy Zone Task Force (Berry et al. 2009; State of Utah 2010).

[a] The RPS requirements are current as of July 2010 and were obtained from the Database of State Incentives for Renewables & Efficiency (North Carolina Solar Center and Interstate Renewable Energy Council [2010]).

[b] The 33% standard is a goal established in 2009 by Governor Schwarzenegger in E.O. S-21-09 and has not been adopted by law or regulation as a requirement.

[c] Includes a solar set-aside requiring 5% of the utilities' portfolios be from solar energy through 2015, and 6% per year beginning in 2016.

[d] Includes a solar set-aside requiring 20% of the utilities' portfolios be from solar energy by 2020.

[e] Utah's RPS is a voluntary standard.

1.6.2.1 Energy Corridor Designation

In accordance with Section 368 of the Energy Policy Act of 2005, DOE and the BLM worked with the U.S. Forest Service (USFS) and DoD to prepare the *Programmatic Environmental Impact Statement, Designation of Energy Corridors on Federal Land in the 11 Western States*, which evaluates issues associated with the designation of energy corridors on federal lands in 11 western states, including the 6 states included in this PEIS plus Idaho, Montana, Oregon, Washington, and Wyoming (DOE and DOI 2008). Energy corridors are land corridors in which energy transport facilities (e.g., electric transmission lines, natural gas pipelines) could be sited. On the basis of the West-wide Energy Corridor PEIS, the BLM and USFS have amended their respective land use plans to designate a series of energy corridors

across the western states. The lands identified in these amendments are within the planning areas that are included within the scope of this Solar PEIS.

The designation of energy corridors is likely to affect energy development throughout the western United States, including utility-scale solar energy development, because the siting of energy corridors will facilitate development by removing key restraints on development and construction of new electric transmission lines on federally managed lands. Information regarding the West-wide Energy Corridor PEIS (Corridor PEIS) is available at http://corridoreis.anl.gov. The development of transmission infrastructure will be a component of all solar energy projects. The Corridor PEIS provides standards and guidelines for transmission development that should make reviews and approvals of transmission projects located in established corridors more efficient.

1.6.2.2 Landscape Conservation Cooperatives and BLM's Proposed Landscape Approach

The DOI is establishing a national network of Landscape Conservation Cooperatives (LCCs). LCCs are management–science partnerships composed of private, state, and federal representatives who agree to establish a shared vision of landscape health and sustainability. The LCCs will facilitate collaboration, provide science-based information and tools needed for developing resource management strategies, and promote coordinated partnership actions at the landscape and local levels. The LCCs and the BLM's proposed landscape approach (discussed below) are complementary efforts that are anticipated to become more fully integrated as they progress.

The BLM's proposed landscape approach consists of five interconnected components that provide a framework for integrating science and management:

- Rapid Ecoregional Assessments (REAs);
- Ecoregional Direction;
- Field Implementation;
- Monitoring for Adaptive Management; and
- Science Integration.

REAs are currently underway for eight ecoregions. (For an explanation and maps of the ecoregions in the six-state study area, see Appendix I.) The REAs will synthesize existing information about resource conditions and trends within an ecoregion, highlight and map areas of high ecological value, and gauge their potential risk from climate change, wildfires, invasive species, energy development (including renewable energy), and urban growth. Ecoregional Direction will use the results of the REAs, with input from BLM staff, partner agencies, stakeholders, and tribes, to identify key management priorities for the public lands within an

ecoregion. Field Implementation will include the establishment of mitigation measures for authorized land uses, amending land use plans (where necessary), and monitoring.

Management priorities established through Ecoregional Direction, Field Implementation, and Adaptive Management components of the landscape approach may influence where and how solar energy is sited in the future, by identifying additional areas of low resource conflict where solar energy should be prioritized or areas from which solar energy development should be excluded. The Solar Energy Program is designed to adapt and conform to new management direction and land use plan amendments that result from REAs.

1.6.2.3 California Desert Renewable Energy Conservation Plan

In California, federal and state agencies (including the BLM) are cooperating on renewable energy development and have formed the Renewable Energy Action Team (REAT). In October 2009, a MOU between California Governor Schwarzenegger and Department of the Interior Secretary Salazar launched the Desert Renewable Energy Conservation Plan (DRECP) initiative. More information about the REAT is available on the CEC Web site (http://www.energy.ca.gov/33by2020/index.html); more information about the DRECP is available at http://www.drecp.org.

The DRECP is intended to advance state and federal natural resource conservation goals in the Mojave and Colorado desert regions of southern California, while also facilitating the timely and streamlined permitting of renewable energy projects. The DRECP will include a strategy that identifies and maps areas for renewable energy development and areas for long-term natural resource conservation. This initiative could result in amendments to BLM land use plans related to solar and other renewable energy development.

1.6.2.4 Arizona Restoration Design Energy Project

The BLM Arizona State Office is preparing an EIS to identify lands across the state of Arizona that may be suitable for the development of renewable energy. This initiative, called the Restoration Design Energy Project (RDEP), will focus on the reuse of previously developed or disturbed lands for renewable energy generation and other alternative land uses. The RDEP will build on the analyses in the Solar PEIS and could, through the land use plan amendment process, refine or prioritize additional areas in Arizona where solar energy development may occur. More information about the RDEP is available at http://www.blm.gov/az/st/en/prog/energy/arra_solar.html.

1.6.2.5 Wind Energy Development PEIS

On June 24, 2005, the BLM issued a Notice of Availability for its *Final Programmatic Environmental Impact Statement on Wind Energy Development on BLM-Administered Lands in the Western United States, Including Proposed Amendments to Selected Land Use Plans*

(Wind PEIS) (BLM 2005b). This PEIS evaluated a program of policies and mitigation measures applicable to wind energy development on BLM-administered lands and included amendments for appropriate BLM land use plans. The wind energy development program implemented by the ROD for the Wind PEIS is similar to BLM's proposed program for solar energy development being developed under this PEIS. The Notice of Availability for the Wind PEIS ROD was published in Volume 71, page 1768 of the *Federal Register* (71 FR 1768) on January 11, 2006; information regarding the Wind Energy Programmatic EIS is available at http://windeis.anl.gov.

1.6.2.6 Geothermal PEIS

In October 2008, the BLM and USFS jointly issued the *Final Programmatic Environmental Impact Statement for Geothermal Leasing in the Western United States*, evaluating geothermal energy development in 12 western states, including Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming (BLM and USFS 2008). On December 17, 2008, the BLM signed a ROD to facilitate geothermal leasing of the federal mineral estate in these states. The decision (1) allocates BLM lands as open to be considered for geothermal leasing or closed for geothermal leasing and identifies those National Forest System lands that are legally open or closed to leasing; (2) develops a RFDS that indicates a potential for 12,210 MW of electrical generating capacity from 244 power plants by 2025, plus additional direct uses of geothermal resources; and (3) adopts stipulations, best management practices, and procedures for geothermal leasing and development. The BLM's ROD implemented these actions through amendments to 114 BLM land use plans. Information regarding the Geothermal Energy Programmatic EIS is available at http://www.blm.gov/wo/st/en/prog/energy/geothermal/geothermal_nationwide.html.

1.7 ORGANIZATION OF THE PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

This Draft PEIS consists of Chapters 1 through 16 and 14 appendices, listed below. To assist in navigating the document, a Reader's Guide has also been developed.

- Chapter 1 discusses the purpose and need for the agencies' actions; the scope of analysis; cooperating agencies, and the relationship of the proposed actions to other programs, policies, and plans.

- Chapter 2 describes the alternatives assessed in this PEIS. These alternatives present different options for the BLM's management of solar energy development on BLM-administered lands and for DOE's strategy for support of solar energy projects. The chapter includes discussions of the RFDS and describes alternatives considered but eliminated from further analysis in the PEIS.

- Chapter 3 presents information describing solar energy technologies and projects, including descriptions of typical activities conducted during each phase of development, regulatory requirements, health and safety aspects,

hazardous materials and waste management, transportation considerations, and relevant existing agency guidelines on impact mitigation. Information presented in this chapter is applicable to BLM's proposed Solar Energy Program, DOE's proposed strategy, and Western's future project-specific analyses.

- Chapter 4 provides a general description of the existing conditions and trends of resources and resource uses in the six-state study area that may be affected by implementing the BLM's and DOE's proposed alternatives. The description of the affected environment provides the basis for identifying potential impacts in sufficient detail to support the programmatic nature of the Solar PEIS. Information presented in this chapter also is applicable to Western's future project-specific analyses.

- Chapter 5 describes both potential impacts common to all types of utility-scale solar energy power production facilities as well as technology-specific impacts. Impacts from required transmission interconnections are also described. The chapter identifies programmatic level impact mitigation measures that the BLM evaluated in order to determine appropriate mitigation requirements for its proposed Solar Energy Program. Information presented in this chapter is applicable to Western's future project-specific analyses.

- Chapter 6 analyzes the potential impacts of BLM's alternatives described in Chapter 2. These analyses evaluate the effectiveness of the alternatives at meeting BLM's established program objectives and summarize the potential environmental consequences of the alternatives, including the expected cumulative impacts of solar energy development on BLM-administered lands and other NEPA considerations.

- Chapter 7 describes the potential impacts of DOE's alternatives described in Chapter 2, including cumulative impacts and other NEPA considerations. These analyses evaluate the effectiveness of the alternatives at facilitating and mitigating potential impacts from solar energy development supported by the DOE on BLM-administered lands and other federal, state, private, and Tribal lands.

- Chapters 8 through 13 present the affected environment and impact assessment (including cumulative impacts) for solar energy development in SEZs proposed in Arizona, California, Colorado, Nevada, New Mexico, and Utah, respectively. These chapters also identify SEZ-specific mitigation measures, where appropriate, that would be implemented in addition to the programmatic level mitigation measures identified in Chapter 5.

- Chapter 14 describes the consultation and coordination activities conducted in the course of this PEIS, including public scoping, government-to-government consultation, coordination with BLM state and field offices, and interagency

consultation and coordination. It also discusses the potential adoption of the program and strategy for solar energy development analyzed in the PEIS by other organizations, such as other federal agencies, Tribes, or other entities responsible for the approval of utility-scale solar energy projects.

- Chapters 15 and 16 provide the list of preparers and a glossary, respectively.

- Appendix A provides current and proposed program administration and authorization policies and required design features for BLM's Solar Energy Program. Section A.1 shows the current BLM Solar Energy Policies (BLM 2007; 2010a,b) in their entirety. Section A.2 outlines the BLM's proposed new solar program under both of its action alternatives, including policies and required design features.

- Appendix B provides a list of applications for ROWs for solar energy development received by the BLM through February 2010.

- Appendix C contains a list of each of the BLM land use plans that are proposed for amendment through this PEIS, the proposed changes, and the amount of land that would be available for ROW application.

- Appendix D gives a summary of the activities of other regional and state plans and programs related to solar energy development and/or transmission planning, including maps showing how designations from some of these initiatives relate to BLM's proposed designations for solar energy development.

- Appendix E describes the methodologies that were used to construct the RFDS and to project the amount of solar power generation over the next 20 years.

- Appendix F provides an overview of solar energy technologies.

- Appendix G provides an analysis showing locations in the study area that have location-constrained transmission (i.e., locations that are greater than 25 mi [40 km] from existing transmission lines and/or designated energy transmission corridors).

- Appendix H contains information about federal and state regulations and statutes that may be applicable to solar energy development.

- Appendix I contains detailed descriptions of ecoregions in the six-state study area, state maps showing where the potentially developable solar resources occur within the ecoregions, and the land cover types and descriptions for the proposed SEZs.

- Appendix J provides information on federally listed species (i.e., species listed under the Endangered Species Act) and BLM-designated sensitive species that occur on BLM-administered lands that are included under the three alternatives considered in the PEIS. Information in the appendix includes listing status, suitable habitat types, and occurrence of these species in alternative areas.

- Appendix K documents consultation correspondence for the PEIS, including government-to-government consultation among the DOE, BLM, and Native American Tribes, and cultural resource consultations.

- Appendix L documents the data and methodology used for geographic information system (GIS) mapping in this PEIS.

- Appendix M presents the methodologies used in the PEIS for analysis of impacts on resources.

- Appendix N presents viewshed maps for four solar technology heights for each of the proposed SEZs.

1.8 REFERENCES

Note to Reader: This list of references identifies Web pages and associated URLs where reference data were obtained for the analyses presented in this PEIS. 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. The original information has been retained and is available through the Public Information Docket for this PEIS.

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2 DESCRIPTION OF ALTERNATIVES AND REASONABLY FORESEEABLE DEVELOPMENT SCENARIO

2.1 INTRODUCTION

This programmatic environmental impact statement (PEIS) examines alternative management approaches for utility-scale solar energy development that could be implemented by the U.S. Department of the Interior (DOI) Bureau of Land Management (BLM) and the U.S. Department of Energy (DOE).

For the BLM, the PEIS examines the no action alternative, which would continue the BLM's existing policies, and two action alternatives, each of which would have the BLM establish a comprehensive program to facilitate utility-scale solar energy development on BLM lands.[1] The BLM may choose to adopt one of the alternatives or a combination of alternatives; selected alternatives may also vary by geographic region. The BLM's final decisions regarding its Solar Energy Program will be informed by public comment and ongoing consultations. The three BLM alternatives that are examined include:

- A no action alternative that continues the issuance of right-of-way (ROW) authorizations for utility-scale solar energy development on BLM-administered lands by implementing the requirements of the BLM's existing solar energy policies on a project-by-project basis. Lands available for solar energy development would include those areas currently allowable under existing applicable laws and statutes (approximately 99 million acres [400,000 km^2] in the six-state study area) and in conformance with the approved land use plan(s).

- A solar energy development program alternative that applies new program administration and authorization policies and design features[2] for utility-scale solar energy development on BLM-administered lands to a subset of BLM-administered lands that would be available for solar energy ROW applications (approximately 22 million acres [87,336 km^2] in the six-state study area). Within the available lands, the BLM would identify approximately 677,400 acres (2,741 km^2) in solar energy zones, which are lands identified by the BLM as best-suited for utility-scale production of solar energy and where the BLM would prioritize development (as well as development of associated transmission infrastructure).

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[1] Utility-scale facilities are defined as projects that generate electricity that is delivered into the electricity transmission grid, generally with capacities greater than 20 megawatts (MW). As a result, the BLM's new Solar Energy Program would apply only to projects of this scale; decisions regarding projects that are less than 20 MW would continue to be made in accordance with existing land use plan requirements.

[2] See text box on page 2-4 for more information about design features versus mitigation measures.

- A solar energy zone (SEZ) program alternative that applies the same new program administration and authorization policies and design features to utility-scale solar energy development but restricts applications to SEZs only (up to approximately 677,400 acres [2,741 km^2] in the six-state study area).

DOE examines two alternatives in this PEIS:

- A no action alternative under which DOE continues its existing case-by-case process for addressing environmental concerns for solar projects supported by the agency on any lands (i.e., not restricted to BLM-administered lands); and

- A programmatic environmental guidance alternative that develops guidance with recommended environmental best management practices and mitigation measures that could be applied to all DOE solar energy projects.

This chapter describes each of the agencies' alternatives in detail, including the specific policies, guidelines, and mitigation measures that would be implemented under the various alternatives. The BLM program would be applicable to all utility-scale solar energy technologies implemented under BLM jurisdiction in the six-state study area (i.e., projects implemented under a BLM-issued ROW authorization). The DOE guidance would be applicable to all utility-scale solar energy technologies implemented under DOE's jurisdiction (i.e., DOE-funded solar projects), as appropriate. Technologies described in Chapter 3 are representative of technologies most likely to be deployed over the next 20 years; however, the agencies' programs could apply to other technologies, with additional mitigation requirements developed on a project-by-project basis, as applicable.

This chapter also presents the results of a reasonably foreseeable development scenario (RFDS) analysis for solar energy over the next 20 years (Section 2.4) and discusses other alternatives and issues considered but eliminated from detailed analysis in this PEIS (Section 2.5).

2.2 BLM'S ALTERNATIVES

The three BLM alternatives introduced above are described in the following subsections. The total estimated acreages of BLM-administered lands potentially available for utility-scale solar energy ROW applications under each of the three alternatives are summarized by state in Table 2.2-1. Maps showing the approximate locations of these lands (and of specifically excluded BLM-administered lands) are provided in Figures 2.2-1 through 2.2-6 at the end of this chapter.

2.2.1 No Action Alternative

Under the no action alternative, solar energy projects would be developed through ROW authorizations in accordance with the BLM's existing Solar Energy Policies (BLM 2007,

TABLE 2.2-1 Summary of Potentially Developable BLM-Administered Land under the No Action Alternative, the Solar Energy Development Program Alternative, and the SEZ Program Alternative[a]

State	Total State Acreage[b]	BLM-Administered Lands Constituting No Action Alternative (acres)	BLM-Administered Lands Constituting Solar Energy Development Program Alternative (acres)[c]	BLM-Administered Lands Constituting SEZ Program Alternative (acres)
Arizona	72,700,000	9,218,009	4,485,944	13,735
California	100,200,000	11,067,366	1,766,543	339,090
Colorado	66,500,000	7,282,061	148,072	21,050
Nevada	70,300,000	40,794,055	9,084,050	171,265
New Mexico	77,800,000	12,188,361	4,068,324	113,052
Utah	52,700,000	18,182,368	2,028,222	19,192
Total	440,200,000	98,732,220	21,581,154	677,384

[a] To convert acres to km^2, multiply by 0.004047.

[b] From Table 4.2-1.

[c] The acreage estimates were calculated on the basis of the best available geographic information system (GIS) data. GIS data were not available for the entire set of exclusions listed in Table 2.2-2; thus the exact acreage could not be calculated. Exclusions that could not be mapped would be identified during the ROW application process.

2010a,b) (see Appendix A, Section A.1). These policies establish general guidelines for processing solar energy development applications, a maximum term for authorizations, and requirements for diligent development and bond coverage; they also provide interim guidance to BLM field offices on how to calculate rent for utility-scale solar energy facilities. National Environmental Policy Act (NEPA) analyses for solar energy development on BLM-administered lands would be prepared on a project-by-project basis. ROW exclusion areas and mitigation measures for solar energy development would be implemented in accordance with approved land use plans. In addition, projects that require land use plan amendments would be dealt with on an individual basis as needed. BLM-administered lands currently off-limits to solar energy development include lands prohibited by law, regulation, Presidential proclamation or Executive Order (e.g., lands in the National Landscape Conservation System[3,4]).

[3] The boundaries of National Landscape Conservation System (NLCS) units may be expanded by legislation, or Congress may establish entirely new NLCS units. See, for example, Public Law (P.L.) 111-11. Such lands would be removed automatically from the area of BLM-administered public lands available for solar energy development.

[4] Wilderness areas within the NLCS do not include the Tabeguache Area in Colorado because it is not officially designated as wilderness; however, by act of Congress, this area is to be managed as wilderness and, as a result, solar energy development is prohibited in the Tabeguache Area.

2.2.2 BLM Action Alternatives

2.2.2.1 Program Components Common to Both BLM Action Alternatives

The BLM proposes to establish a common set of program administration and authorization policies and required design features applicable to all future utility-scale solar energy development on BLM-administered lands. These program components would be common to both of the action alternatives. The policies and design features would bring consistency and efficiency to the BLM's solar energy development authorization process and as part of project formulation would help to avoid and/or minimize many of the potential resource impacts associated with solar energy development.

Solar Energy Program Administration and Authorization Policies

As part of its action alternatives, the BLM proposes to adopt a set of standard program administration and authorization policies for utility-scale solar energy development on BLM-administered lands, replacing certain elements of its current Solar Energy Policies (BLM 2007, 2010a,b; see Appendix A, Section A.1).[5] The proposed policies establish requirements for coordination and/or consultation with other federal and state agencies and for government-to-government consultation, and establish requirements for public involvement. Collectively, these

Design Features and Mitigation Requirements

Design features are mitigation measures that have been incorporated into the proposed action or alternatives to avoid or reduce adverse impacts. The proposed programmatic design features of the Solar Energy Program would apply to all utility-scale solar energy ROWs on BLM-administered lands under both action alternatives. Additional design features have been proposed for individual SEZs.

Mitigation measures are measures that could reduce or avoid adverse impacts. Mitigation measures can include (40 CFR 1508.20):

- Avoiding the impact altogether by not taking a certain action or parts of an action;
- Minimizing the impact by limiting the degree of magnitude of the action and its implementation;
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment;
- Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and
- Compensating for the impact by replacing or providing substitute resources or environments.

[5] It is anticipated that elements of the existing policies addressing rental fees, term of authorizations, due diligence, bonding requirements, and BLM access to records would remain in effect.

policies ensure that all projects are thoroughly reviewed, input is collected from all interested stakeholders, and projects that could result in significant adverse impacts are eliminated early in the planning process. The proposed policies are presented in Appendix A, Section A.2.1. These policies would apply to all future and existing ROW applications.

Applications for solar energy ROWs are continuing to be received during the development of the PEIS for all lands not currently excluded as described in Section 2.2.1 or not currently excluded in approved land use plans. These applications are being processed in accordance with the BLM's current Solar Energy Policies (BLM 2007, 2010a,b) (see Appendix A, Section A.1, of this PEIS). The BLM has notified applicants previously through the *Federal Register* Notice (June 30, 2009) that any ROW authorization for a solar energy application filed before issuance of the BLM's Record of Decision (ROD) for the Solar PEIS could be subject to the requirements adopted in the ROD, including any alternative procedures developed by the BLM for noncompetitive and competitive processes. Applications for solar energy ROWs received after June 30, 2009, for lands inside the Solar Energy Study Areas (to be termed solar energy zones at issuance of the ROD) would be subject to the ROD for the Solar PEIS and any alternative procedures developed by the BLM for non-competitive and competitive processes. Any applications for solar energy ROWs received after issuance of the ROD would be subject to the conditions contained in the ROD.

The BLM's proposed action alternatives identified in this PEIS would not eliminate the need for site-specific environmental review for individual utility-scale solar energy development applications. Site-specific environmental reviews would be tiered to the PEIS. Tiering would involve incorporating relevant data and analyses from the PEIS and narrowing detailed analyses to site-specific and project-specific considerations. Additional mitigation measures could be applied to individual projects as part of future site-specific environmental reviews in the form of stipulations in the ROW authorization, as appropriate, to address site-specific issues such as specific species and/or habitat concerns. The BLM retains the authority to deny applications for solar ROWs based on site-specific issues or concerns, even in areas available or open to application.

As a key element of the proposed Solar Energy Program, the BLM would establish a new policy requiring the implementation of an adaptive management plan for solar energy development (see Appendix A, Section A.2.1). Although this document identifies the affected environment and anticipated impacts from solar energy development, the BLM recognizes that data regarding actual impacts of solar energy development on various resources are still limited. The proposed policy would require adaptive management to ensure that new data and lessons learned about the impacts of solar energy projects would be reviewed and, as appropriate, incorporated into the Solar Energy Program. The proposed adaptive management plan, to be coordinated with potentially affected natural resource management agencies, would identify how the impacts of the Solar Energy Program will be evaluated; types of monitoring that would be responsive to the data needs for program evaluation; science-based thresholds for modification of policy or individual project management based upon monitoring results; and a description of the process by which changes will be incorporated into the Solar Energy Program, including revisions to policies and design features. Sources of information to be considered in the context

of adaptive management include data from specific project evaluations (for which monitoring will be required) as well as from project-specific and regional long-term monitoring programs.

Required Solar Energy Design Features

As part of its action alternatives, the BLM proposes to adopt a set of required design features to ensure the most environmentally responsible development and delivery of utility-scale solar energy on BLM-administered lands. The proposed design features are presented in Appendix A, Section A.2.2, by resource area and also by project phase (e.g., siting and design, site characterization, construction, operations, and decommissioning) where appropriate.

Design features are means, measures, or practices intended to reduce or avoid adverse environmental impacts. The design features have been formulated on the basis of a comprehensive analysis of the potential impacts of utility-scale solar energy development and potentially applicable mitigation measures (Chapter 5). Existing, relevant mitigation guidance (Section 3.7.3) and comments received during scoping for the Draft PEIS (summarized in Section 14.1) also were reviewed. On the basis of those reviews, the BLM identified required programmatic design features that would be applicable to all utility-scale solar energy projects on BLM-administered lands.

The required design features would establish the minimum specifications for management of individual solar energy projects and mitigation of adverse impacts. These design features are items that would need to be incorporated into project-specific Plans of Development (PODs) and ROW authorization stipulations. Since these features represent the most widely accepted methods to avoid and/or minimize impacts, they do not lend themselves to alternatives analysis. In general, the design features are accepted practices that are known to be effective when implemented properly at the project level. However, their applicability and overall effectiveness cannot be fully assessed except at the project-specific level when the project location and design are known.

Many of the potential design features indicate the need for project-specific plans. The content and applicability of these plans will depend on specific project requirements and locations. These plans, which are listed in Table 5.1-1, are identified in the design features presented in Appendix A. The authorizing officer would need to determine the adequacy of such plans before approving a specific project.

2.2.2.2 Solar Energy Development Program Alternative

Lands Available

As discussed throughout the PEIS, all BLM-administered lands are not appropriate for solar energy development. Environmental and technical screening tools can be used to guide solar energy developers to areas where there are fewer resource conflicts and potential

controversy. This process has been described as "screening for success." Under the solar energy development program alternative, the BLM would make a more limited amount of BLM-administered lands available for utility-scale solar energy ROW applications than under the no action alternative by excluding or "screening out" categories of land that are known or believed to be unsuitable for utility-scale solar development. This would allow time and effort to be directed to those projects which have a greater chance of success. The exclusions would apply only to the siting of utility-scale solar energy generation facilities and not to any required supporting linear infrastructure, such as roads, transmission lines, and natural gas or water pipelines. Management decisions for supporting linear infrastructure, including available lands, are defined in existing applicable land use plans. Siting of supporting infrastructure would be analyzed in project-specific environmental reviews.

Because of the characteristics of the solar energy technologies evaluated in this PEIS, there are limitations with respect to the slope of the land upon which they can be constructed. These limitations are discussed in detail in Section 3.1. On the basis of these limitations, the BLM would limit the lands available for utility-scale solar development to those with slopes of less than 5%. Additionally, the BLM chose a minimum solar insolation level threshold of 6.5 kWh/m^2/day to identify lands that would potentially be available for solar energy development. That criterion was established on the basis of the assumption that at insolation levels below 6.5 kWh/m^2/day, utility-scale development would be less economically viable given current technologies. These proposed restrictions will help maximize the efficient use of BLM-administered lands and meet the multiple use intent of the Federal Land Policy and Management Act of 1976 (FLPMA) by reserving for other uses lands that are not well-suited for solar energy development.[6]

Utility-scale solar energy development involves large parcels of land (e.g., a range of facility sizes from 90 to 6,750 acres [0.4 to 27 km^2] is assumed in this PEIS; see Section 3.1.5) that are converted to single-use (year-round, permanent development). The BLM has determined that because of the nature of these activities, utility-scale solar energy development is not compatible with many of the resources, resource uses, and special designations that exist on BLM-administered lands. The proposed exclusions under the solar energy development program alternative are listed in Table 2.2-2. Note that many of these exclusions refer back to decisions made in the approved land use plans (e.g., ROW avoidance areas). It is anticipated that the BLM will continue to amend or revise land use plans over time to adapt to changing circumstances or new information, and that the shape, size, and/or location of exclusions or priority development areas may change accordingly. The Solar Energy Program is intended to adapt and conform to future land use plan decisions. As an example, the Restoration and Energy Design Project currently underway in Arizona (see Section 1.6.2.4), could result in the refinement of the

[6] Because utility-scale solar development requires substantial amounts of land, the BLM originally planned to exclude contiguous areas of less than 247 acres (1 km^2) from lands available for development, and such lands are not currently shown in the maps or included in the acreages presented under the program alternatives. However, comments received through ongoing, internal scoping indicate that such parcels could be used to support community-scale solar energy development or support projects on adjacent private or Tribal lands. For these reasons, small parcels that otherwise meet the criteria of the program alternatives are included in the program alternatives. Maps and acreages will be updated in the Final PEIS.

TABLE 2.2-2 Areas for Exclusion under the BLM Solar Energy Development Program Alternative[a]

1. Lands with slopes greater than or equal to 5%.
2. Lands with solar insolation levels less than 6.5 kWh/m^2/day.
3. All Areas of Critical Environmental Concern (ACECs), including Desert Wildlife Management Areas (DWMAs) in the California Desert District.
4. All critical habitat areas (designated and proposed) for listed species under the Endangered Species Act of 1973 (as amended).
5. All areas where the applicable land use plan designates no surface occupancy (NSO).
6. All areas where there is an applicable land use plan decision to protect lands with wilderness characteristics.
7. All Special Recreation Management Areas (SRMAs), developed recreational facilities, and special-use permit recreation sites (e.g., ski resorts and camps).
8. All areas where solar energy development proposals are not demonstrated to be consistent with the land use management prescriptions for or where the BLM has made a commitment to take certain actions with respect to sensitive species habitat, including but not limited to sage-grouse core areas, nesting habitat, and winter habitat; Mohave ground squirrel habitat; and flat-tailed horned lizard habitat.
9. All ROW exclusion areas designated in applicable plans.
10. All ROW avoidance areas designated in applicable plans.
11. All areas where the land use plan designates seasonal restrictions.
12. All Desert Tortoise translocation sites identified in applicable land use plans.
13. Big Game Migratory Corridors identified in applicable land use plans.
14. Big Game Winter Ranges identified in applicable land use plans.
15. Research Natural Areas.
16. Lands categorized as Visual Resource Management Class I or II (and, in Utah, Class III[b]).
17. National Recreation Trails and National Back Country Byways.
18. National Historic and Scenic Trails, including a corridor of 0.25 mi (0.4 km) from the centerline of the trail, except where a corridor of a different width has been established.
19. National Historic and Natural Landmarks.

TABLE 2.2-2 (Cont.)

20.	Within the boundary of properties listed in the *National Register of Historic Places* and additional lands outside the designated boundaries to the extent necessary to protect values where the setting and integrity is critical to their designation or eligibility.
21.	Areas with important cultural and archaeological resources, such as traditional cultural properties and Native American sacred sites, as identified through consultation.
22.	Wild, Scenic, and Recreational Rivers, including a corridor of 0.25 mi (0.4 km) from the ordinary high-water mark on both sides of the river, except where a corridor of a different width has been established.
23.	Segments of rivers determined to be eligible or suitable for Wild or Scenic River status, including a corridor of 0.25 mi (0.4 km) from the ordinary high-water mark on either side of the river.
24.	Old Growth Forest.
25.	Lands within a solar energy development application found to be inappropriate for solar energy development through an environmental review process that occurred prior to finalization of this PEIS.[c]

[a] Consultation with the U.S. Fish and Wildlife Service is ongoing and could result in the modification, refinement, or addition of exclusion areas.

[b] In Utah, Visual Resource Management (VRM) Class III lands have also been removed due to the high sensitivity and location proximity to Zion, Bryce, Capital Reef, Arches, and Canyonlands National Parks and to significant cultural resource special management areas (in southeast Utah).

[c] For example, lands considered but not included in the approved applications for BrightSource Energy's Ivanpah Solar Electric Generating System, Tessera Solar's Imperial Valley and Calico Solar Projects, NextEra's Genesis Ford Dry Lake Solar Project, and Solar Millennium's Blythe Solar Project.

exclusion areas in Arizona under the Solar Energy Program, in the identification of additional areas where solar energy development will be a priority, or both.

It was not possible to obtain complete geographic information system (GIS) data across the six-state study area for the entire set of exclusions listed in Table 2.2-2; thus the exact footprint of the alternative could not be mapped (and the exact total acreage could not be calculated).[7] However, data for several key exclusion area categories were obtained and are used in this PEIS as an interim estimate of the Solar Energy Program footprint. Exclusion areas that were mapped for the solar energy development program alternative (in addition to those excluded under the no action alternative) include lands with slope greater than or equal to 5%; lands with average solar insolation of less than 6.5 kWh/m^2/day; critical habitat for threatened or endangered species as designated by the U.S. Fish and Wildlife Service; and the following areas designated under various BLM programs: Areas of Critical Environmental Concern (ACECs); Desert Wildlife Management Areas (DWMAs); flat-tailed horned lizard habitat, Mohave ground

[7] As a result of ongoing fast-track project evaluations, some additional BLM-administered lands will be found to be inappropriate for solar development. After identification, such areas will be excluded from lands open for solar ROW application.

squirrel habitat; ROW exclusion and avoidance areas, No Surface Occupancy (NSO) areas, and Special Recreation Management Areas (SRMAs).[8] Exclusion areas that could not be mapped due to lack of data would be identified during pre-application consultations with local BLM staff or site-specific evaluation of individual ROW applications.

Priority Areas in Lands Available (SEZs)

Under the solar energy development program alternative, the BLM would identify a number of SEZs within the lands available for solar energy development ROWs. An SEZ is defined by the BLM as an area with few impediments to utility-scale production of solar energy where BLM would prioritize solar energy and associated transmission infrastructure development. The BLM worked closely with BLM state and field office staff to identify potential SEZs for further analysis and provided initial criteria to guide the effort. Staff was asked to identify areas that were near existing transmission or designated corridors, near existing roads, generally had a slope of 1 to 2% or less, and were a minimum of 2,500 acres (10.1 km^2). Staff was also requested to screen out National Landscape Conservation System (NLCS) lands and the classes of lands listed in Table 2.2-2. Preliminary results of the Western Governors' Association Western Renewable Energy Zone initiative (see Appendix D.1) were used to focus proposed SEZs in Colorado, New Mexico, and Utah to particular BLM administrative units.

BLM state and field office staff then applied additional filters based on local conditions, institutional knowledge, and coordination efforts. For example, in Arizona, BLM staff used information developed in conjunction with the Arizona Renewable Resource and Transmission Identification Subcommittee (ARRTIS) initiative (see Appendix D.2.2) as the foundation for additional analysis and then selected potential SEZs from areas depicted as having "low sensitivity" based on data provided by the Arizona Department of Game and Fish. In California, proposed SEZs were identified in part based on preliminary outcomes of the Renewable Energy Transmission Initiative (RETI) (see Appendix D.2.3), a collaborative stakeholder process. In Utah, BLM staff used GIS data maintained by the Division of Wildlife Services to screen out sensitive habitat, considered information from Class I cultural surveys, and considered rangeland values in order to identify areas with low potential for resource conflicts. In New Mexico, BLM staff considered U.S. Department of Agriculture (USDA) Agricultural Research Service ecological site descriptions to identify proposed SEZs where loss of topsoil and lack of seed source would make habitat restoration efforts difficult and cost-prohibitive.

The identification of areas of Tribal concern is underway as part of the ongoing Tribal consultation process. Any changes to the proposed SEZs that are agreed upon during these consultations will be incorporated into the Final PEIS.

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[8] Information on ACEC and critical habitat exclusion areas were available for all six states in the study area. Other exclusion areas were not mapped for each state, but only where applicable and if GIS data were available. DWMAs, lizard, and ground squirrel habitat were mapped only in the California Desert District; ROW-exclusion and avoidance areas were mapped only in Arizona, New Mexico, and Utah; NSO areas were mapped only in California, Colorado, Nevada and Utah.

A public scoping period to receive comments on the proposed SEZs was conducted from June 30 to September 14, 2009 (see Section 14.1). Comments from scoping, as well as additional input from BLM state and field office staff, were used to make some modifications to the proposed SEZs. For example, the proposed Dry Lake Valley North, Afton, and Wah Wah Valley SEZs were expanded based on field office identification of favorable adjacent areas. Two of the New Mexico SEZs were altered to exclude Aplomado falcon habitat and one was altered to exclude additional sensitive resources, including playas of importance to migratory shorebirds. The revised total land area of the proposed SEZs is approximately 677,400 acres (2,741 km^2), which is an increase of about 2,300 acres (9.4 km^2) over the total acreage as published on June 30, 2009 (which was approximately 675,100 acres [2,732 km^2]).

The proposed SEZs evaluated in the PEIS are listed in Table 2.2-3. As part of the PEIS, the BLM conducted an in-depth analysis for each of the SEZs. The analyses included a site visit to each SEZ, and an extensive effort to collect and evaluate existing data on important resources (e.g., soils, hydrology, land cover, species distribution, air quality, existing ROWs, mining claims, and demographics). Modeling of air quality impacts during construction was conducted, and GIS-based analyses of ecological impacts were included. Local BLM, county, and state offices were contacted, as needed. The SEZ analyses are presented in Chapters 8 through 13.

Through the SEZ analyses, the BLM discovered potentially significant adverse impacts on various resources and resource uses in some of the SEZs. Where adverse impacts have been identified, additional SEZ-specific design features have been developed, including identification of lands or land types within SEZs where solar development must be avoided (Table 6.1-2). The complete list of SEZ-specific design features is provided in Appendix A, Section A.2.3. Based on the potential conflicts identified, some of the proposed SEZ areas may be reduced in size or eliminated entirely when the final SEZs are identified in the ROD for this PEIS. In the future, based on lessons learned from individual projects and/or new information (e.g., ecoregional assessments), the BLM could decide to expand SEZs, add SEZs, or remove or reduce SEZs. Changes to SEZs would have to go through a land use planning process, which would be subject to the appropriate environmental analysis.

Management of SEZs

The BLM would take the following management actions in areas selected as SEZs:

- Place a priority on utility-scale solar energy development over other land uses;
- Consider offering lands for solar energy development through competitive processes or other means;
- Focus BLM resources to process solar ROW applications;
- Provide in-depth environmental analyses to support a streamlined environmental process for future solar development activities, with an

TABLE 2.2-3 Proposed SEZs and Approximate Acreage by State[a]

Proposed SEZ (BLM Office/County)	Approximate Acreage
Arizona	
Brenda (Lake Havasu/La Paz)	3,878
Bullard Wash (Hassayampa/Yavapai)	7,239
Gillespie (Lower Sonoran/Maricopa)	2,618
Total	13,735
California	
Imperial East (El Centro/Imperial)	5,722
Iron Mountain (Needles/San Bernadino)	106,522
Pisgah (Barstow/San Bernadino)	23,950
Riverside East (Palm Springs–South Coast/Riverside)	202,896
Total	339,090
Colorado	
Antonito Southeast (La Jara/Conejos)	9,729
De Tilla Gulch (Saguache/Saguache)	1,522
Fourmile East (La Jara/Alamosa)	3,882
Los Mogotes East (La Jara/Conejos)	5,918
Total	21,050
Nevada	
Amargosa Valley (Southern Nevada/Nye)	31,625
Delamar Valley (Ely/Lincoln)	16,552
Dry Lake (Southern Nevada/Clark)	15,649
Dry Lake Valley North (Ely/Lincoln)	76,874
East Mormon Mountain (Ely/Lincoln)	8,968
Gold Point (Battle Mountain/Esmeralda)	4,810
Millers (Battle Mountain/Esmeralda)	16,787
Total	171,265
New Mexico	
Afton (Las Cruces/Dona Ana)	77,623
Mason Draw (Las Cruces/Dona Ana)	12,909
Red Sands (Las Cruces/Otero)	22,520
Total	113,052
Utah	
Escalante Valley (Cedar City/Iron)	6,614
Milford Flats South (Cedar City/Beaver)	6,480
Wah Wah Valley (Cedar City/Beaver)	6,097
Total	19,192
Total	677,384

[a] To convert acres to km^2, multiply by 0.004047.

anticipated lower-level effort at the specific site if there are no new circumstances or information relevant to environmental concerns at that site;

- Apply specific mitigation requirements as necessary;

- Investigate and promote opportunities to consolidate facilities within SEZs in order to reduce development costs and minimize environmental impacts; and

- Prioritize associated electricity transmission projects and needs.

The Secretary of the Interior may decide to withdraw the public lands included in the SEZs from potentially conflicting uses through the issuance of a Public Land Order. As a possible mechanism to support the establishment of priority areas that are best suited for utility-scale production of solar energy, the Secretary of the Interior issued a notice of proposed withdrawal for the preliminary SEZ areas (June 30, 2009). This notice segregates the public lands encompassed in the SEZ areas for up to 2 years from surface entry and mining while various studies and analyses are made to support a final decision on the withdrawal application (see Section 1.3.5, BLM Land Withdrawals). A Secretarial decision regarding withdrawal is a separate action from the land use plan amendments that would be addressed in the ROD for this PEIS. The decision to withdraw lands would rely on the analysis in this PEIS but would be the subject of a separate decision document.

The acreage totals of BLM-administered lands available for utility-scale solar energy ROW applications under the solar energy development program alternative are summarized by state in Table 2.2-1. The areas of the subset of those lands that are within the proposed SEZs are also summarized in Table 2.2-1. Maps showing the approximate locations of the lands available, including the SEZs, are provided in Figures 2.2-1 through 2.2-6 at the end of this chapter. Exclusion areas that could not be mapped due to lack of data would be identified during pre-application consultations with local BLM staff or site-specific evaluation of individual ROW applications.

BLM Land Use Plans To Be Amended

Under the solar energy development program alternative, most of the land use plans in the six-state study area would be amended to address utility-scale solar energy development.[9]

[9] Under this alternative, most of the land use plans in the six-state study area would be amended. Section 2815(d) of the National Defense Authorization Act (NDAA) for Fiscal Year 2000 (P.L. 106-65) placed a moratorium on planning efforts on BLM-administered lands "adjacent to, or near the Utah Test and Training Range (UTTR) and Dugway Proving Grounds or beneath Military Operating Areas, Restricted Areas, and airspace that make up the UTTR" NDAA § 2815(a), 113 Stat. 512, 852 (1999). This area encompasses a portion of the lands within the boundaries of the Box Elder, Pony Express, House Range, Warm Springs, and Pinyon land use plans. Within these areas, decisions related to whether lands would be available for ROW application, and adoption of the policies and design features of the PEIS, cannot be implemented via land use plan amendments at this time. Solar energy development ROW applications would be deferred until such time plan amendments or new land use plan(s) address solar energy development. No SEZs are located within the UTTR affected areas.

The amendments would identify lands that would be excluded from utility-scale solar energy development, lands that would be available for ROW application, and lands that would be included in SEZs. For those areas that would be available for application, the plans would be amended to adopt the proposed program administration and authorization policies and programmatic and SEZ-specific design features. Land use plans that are undergoing revision or amendment concurrent with the Solar PEIS will be reviewed to identify and resolve inconsistencies between the PEIS and individual planning efforts. The BLM field offices that administer lands to be made available for solar ROW applications under the solar energy development program alternative are listed in Table 2.2-4, along with the approximate amount of land that would be made available. The specific amendments for this alternative are presented in Appendix C.

2.2.2.3 SEZ Program Alternative

In response to comments received during the scoping process and concerns expressed regarding resource impacts, the BLM has elected to consider an alternative that limits utility-scale solar energy development to priority areas (i.e., to SEZs). Under the SEZ program alternative, the BLM would adopt the same set of standard program administration and authorization policies for utility-scale solar energy development as proposed under the solar energy development program alternative, but it would authorize such solar energy development only in SEZs. Unlike the solar energy development program alternative, lands outside of SEZs would be excluded from utility-scale solar energy ROWs. Under the SEZ program alternative, the management of SEZs would be the same as described for the solar energy development program alternative, including the potential for the BLM to expand, add, remove, or reduce SEZs in the future on the basis of new information and lessons learned (see Section 2.2.2.2). In addition to the proposed program administration and authorization policies and programmatic design features (i.e., those that would apply to all solar projects on BLM-administered lands), SEZ-specific design features have been identified in the PEIS and may be adopted as part of the ROD. Detailed analyses of impacts of solar energy development within the proposed SEZs are provided in Chapters 8 through 13; these assessments are incorporated into the assessment of BLM alternatives provided in Chapter 6.

Lands Available

Under the SEZ program alternative, the BLM would accept utility-scale solar ROW applications only for lands within identified SEZs. The proposed SEZs are the same as those proposed under the solar energy development program alternative (areas given in Table 2.2-1; locations shown in Figures 2.2-1 through 2.2-6 at the end of this chapter). As stated in Section 2.2.2.2, the locations of the proposed SEZs were preliminarily identified by BLM state and field office staff as locations thought to have few impediments to solar energy development.

TABLE 2.2-4 BLM Field Offices with Lands Available for Solar Facility ROW Application under the Solar Energy Development Program and SEZ Program Alternatives[a]

Field/District Office	Approximate Acres Available: Solar Energy Development Program Alternative[b]	Approximate Acres Available: SEZ Program Alternative
Arizona		
Arizona Strip	906,507	0
Hassayampa	338,445 (7,239 in SEZs)	7,239
Kingman	625,777	0
Lake Havasu	536,993 (3,878 in SEZs)	3,878
Lower Sonoran	555,328 (2,618 in SEZs)	2,618
Safford	709,824	0
Tucson	136,024	0
Yuma	677,046	0
Total	4,485,944	13,735
California		
Bakersfield	337	0
Barstow	359,871 (23,950 in SEZs)	23,950
Bishop	95,509	0
El Centro	221,533 (5,722 in SEZs)	5,722
Needles	667,447 (106,522 in SEZs)	106,522
Palm Springs-South Coast	408,077 (202,896 in SEZs)	202,896
Ridgecrest	13,769	0
Total	1,766,543	339,090
Colorado		
Columbine	363	0
Del Norte	9,869	0
Dolores	9,042	0
Gunnison	3,124	0
La Jara	76,831 (19,529 in SEZs)	19,529
Royal Gorge	10,755	0
Saguache	38,088 (1,522 in SEZs)	1,522
Total	148,072	21,050

TABLE 2.2-4 (Cont.)

Field/District Office	Approximate Acres Available: Solar Energy Development Program Alternative[b]	Approximate Acres Available: SEZ Program Alternative
Nevada		
Battle Mountain	4,028,449 (21,597 in SEZs)	21,597
Carson City	863,456	0
Ely	3,327,761 (102,394 in SEZs)	102,394
Southern Nevada	789,823 (47,273 in SEZs)	47,273
Winnemucca	74,561	0
Total	9,084,050	171,265
New Mexico		
Carlsbad	257,828	0
Farmington	364,575	0
Las Cruces (District)	1,792,899 (113,052 in SEZs)	113,052
Rio Puerco	287,054	0
Roswell	722,150	0
Soccoro	633,472	0
Taos	10,346	0
Total	4,068,324	113,052
Utah		
Cedar City	804,181 (19,192 in SEZs)	19,192
Fillmore	982,283	0
Kanab	23,572	0
Moab	1,210	0
Monticello	85,722	0
Richfield	122,646	0
St. George	8,608	0
Total	2,028,222	19,192
Total by Alternative	21,581,154	677,384

Footnotes on next page.

TABLE 2.2-4 (Cont.)

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[a] Proposed land use plan amendments for the plans in these field and district offices are presented in Appendix C. To convert acres to km^2, multiply by 0.00405. Totals may be off due to rounding.

[b] The acreage estimates were calculated on the basis of the best available GIS data. GIS data were not available for the entire set of exclusions listed in Table 2.2-2, so the exact acreage could not be calculated. Exclusions that could not be mapped would be identified during the ROW application process.

BLM Land Use Plans To Be Amended

Under the SEZ program alternative, most of the land use plans in the six-state study area would be amended to address solar energy development.[10] The amendments would identify lands that would be excluded from utility-scale solar energy development and lands that would be included in SEZs. For those SEZs where lands would be available for application, the plans would be amended to adopt the proposed program administration and authorization policies and programmatic and SEZ-specific design features. Land use plans that are undergoing revision or amendment concurrent with the Solar PEIS would need to carry forward the Solar PEIS amendments into future decisions. The proposed SEZs and the BLM field offices and counties in which they are located are listed in Table 2.2-3. The BLM field offices that administer lands to be identified as SEZs under the SEZ program alternative are listed in Table 2.2-4. The specific amendments for this alternative are presented in Appendix C.

2.3 DOE'S ALTERNATIVES

2.3.1 No Action Alternative

Under the no action alternative, DOE would continue its existing case-by-case process for addressing environmental concerns for solar projects supported by DOE on any lands (i.e., not restricted to BLM-administered lands). It would not develop programmatic environmental guidance with recommended environmental best management practices and mitigation measures that could be applied to all DOE-funded solar projects.

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[10] See footnote 9.

2.3.2 DOE's Proposed Action: Programmatic Environmental Guidance Alternative

2.3.2.1 Scope of DOE's Proposed Action

Under the proposed action (action alternative), DOE would develop programmatic environmental guidance to further integrate environmental considerations into its analysis and selection of solar projects that it would support. This PEIS assesses the potential impacts of utility-scale solar development on the environment in order to support the development of DOE's programmatic guidance.

Under DOE's programmatic environmental guidance alternative, DOE would use the information about environmental impacts provided in this PEIS to appropriately amend its programmatic approaches to facilitate the advancement of solar energy development. Investment and deployment strategies would incorporate guidance on environmental practices and mitigation recommendations for solar energy development in the decision-making process. Having guidance based on the analyses of this PEIS would give DOE the tools with which to make more informed, environmentally sound decisions regarding projects, and specifically would enable DOE to comprehensively (1) determine where to make technology and resource investments to minimize the environmental impacts of solar technologies; and (2) establish environmental mitigation recommendations for financial assistance recipients to consider in project plans when applying for DOE funding. The environmental practices and mitigation recommendations identified in the PEIS and adopted by DOE would help to streamline future environmental analysis and documentation for DOE-supported solar projects.

Specifically, the proposed action that DOE is considering under this PEIS is to develop guidance to address environmental impacts to be applied to DOE-funded solar projects, as applicable, in order to support research, development, and deployment of utility-scale solar projects, with DOE's mitigation recommendations to address programmatic technology performance goals (to be established at the time of future site-specific project NEPA reviews). These technology performance goals will be determined on the basis of the potential impacts of different solar technologies. The performance goals will also consider the results of the cumulative impacts of solar energy market penetration projected assuming a reasonably foreseeable development scenario (see Section 2.4).

2.3.2.2 DOE's Proposed Mitigation Recommendations under the Programmatic Environmental Guidance Alternative

DOE's proposed mitigation recommendations would be formulated on the basis of a comprehensive analysis of the potential impacts of utility-scale solar energy development and potentially applicable mitigation measures, as presented in Chapter 5. Existing, relevant mitigation guidance (Section 3.7.3) was reviewed, and comments received during scoping for the Draft PEIS (summarized in Section 14.1) were also considered. On the basis of these assessments and the input from this NEPA process, DOE would identify programmatic guidance

with recommended environmental practices and mitigation measures for all solar energy projects supported by the DOE. These mitigation recommendations would be used, as appropriate, for decision making and management of individual solar energy projects.

2.4 DESCRIPTION OF REASONABLY FORESEEABLE DEVELOPMENT SCENARIO

A full assessment of the potential impact of solar energy development on the quality of the human and ecological environment over the next 20 years requires that an estimate be made of the amount of development that might occur in the six-state study area over that time frame. The amount of power projected to be generated through solar energy development in the six-state study area through the year 2030 is referred to as the "Reasonably Foreseeable Development Scenario" (RFDS) in this PEIS. Two methods were used to estimate an RFDS for this assessment. One method used the Regional Energy Deployment System (ReEDS) model, developed by the National Renewable Energy Laboratory (NREL). The second method used each state's Renewable Portfolio Standards (RPSs; see Table 1.6.1) to estimate corresponding renewable energy and solar development required to meet those standards. Results obtained by both methods are presented in Table 2.4-1. Both methods require many assumptions (e.g., assumptions regarding future energy demand, energy costs, and possible future federal and state legislative requirements). Detailed discussions of the two methods, including assumptions used, are provided in Appendix E.

To establish an upper bound on potential environmental impacts under the various alternatives assessed in this PEIS, the maximum estimated development as projected by the RPS-based method is used as the RFDS for the cumulative impact assessments presented in Chapters 6 and 7.

2.4.1 Capacity Estimates Based on ReEDS Model

The ReEDS model, described in detail in Appendix E, Section E.1, estimates the degree to which solar energy technology will contribute to electricity generation over time, considering such issues as access to and cost of transmission capacity, solar technology developments, cost of other fuels, tax credits, and potential barriers to solar resource development. The model estimates both utility-scale concentrating solar power (CSP) and photovoltaic (PV) development levels. Factors like solar insolation levels and access to transmission facilities are used to estimate the probability of development in a specific geographic area. A summary of solar power development on BLM-administered lands and other lands in the six-state area over the next 20 years that is based on the ReEDS model is included in Table 2.4-1. The ReEDS estimates that consider the costs of solar in relation to other available energy sources resulted in lower estimated solar energy development through 2030 (i.e., about 22,000 MW) than the RPS-based estimates (i.e., about 32,000 MW).

TABLE 2.4-1 Projected Megawatts of Solar Power Development by 2030 (by State and Landholding) and Corresponding Developed Acreage Estimates

State	Landholding	Estimated Solar Energy Capacity from ReEDS Model[a] (MW)	Estimated Solar Energy Capacity Range from RPS-Based Method[b] (MW)	Estimated Solar Energy Development Assumed for PEIS (RFDS) (MW)[c]	Estimated Acres Developed under RFDS[d]
Arizona	BLM	1,768	485–2,424	2,424	21,816
	Non-BLM	1,724	162–808	808	7,272
California	BLM	2,207	3,084–15,421	15,421	138,789
	Non-BLM	8,487	1,028–5,140	5,140	46,260
Colorado	BLM	98	439–2,194	2,194	19,746
	Non-BLM	2,197	146–731	731	6,579
Nevada	BLM	1,153	348–1,701	1,701	15,309
	Non-BLM	548	116–567	567	5,103
New Mexico	BLM	353	167–833	833	7,497
	Non-BLM	3,204	56–278	278	2,502
Utah	BLM	0	244–1,219	1,219	10,971
	Non-BLM	0	81–406	406	3,654
	Total for BLM-administered lands	5,479	4,734–23,791	23,791	214,119
	Total for non-BLM lands	16,160	1,592–7,930	7,930	71,370

[a] See Appendix E, Section E.1, for details on the ReEDS model methods and assumptions. The estimates given include both utility-scale CPS and PV development; these two technologies are assumed to approximate all utility-scale solar development.

[b] See Appendix E, Section E.2, for details on the RPS-based methods and assumptions For the RPS-based method, it is assumed that 75% of development will occur on BLM-administered lands and that a range of 10 to 50% of the RPS-based requirement for renewable energy production would be provided from solar energy.

[c] RFDS = reasonably foreseeable development scenario; see text for description. The RPS-based method values were assumed in order to provide an upper-end estimate of solar development.

[d] Acreage calculated assuming land use of 9 acres/MW. To convert acres to km^2, multiply by 0.004047.

2.4.2 Capacity Estimates Based on RPS Values

On the basis of state-specific RPS requirements given in Table 1.6.1, future levels of solar energy generation in each of the six states were estimated. The methodology used, described in detail in Appendix E, Section E.2, relied on a number of assumptions and approximations about factors not well-defined at this time. For example, because most of the RPSs do not specify the amount of renewable energy to be generated by solar energy versus other qualifying renewable resources (e.g., wind, geothermal), the analysis calculated lower and upper ends of the range assuming 10% and 50% of the RPS requirements would be provided by solar facilities. Other factors, such as the potential for utilities to import renewable energy in order to meet RPS requirements, or to develop renewable energy specifically for export to other states, were not considered in the RPS-based calculations because such developments are difficult to predict with accuracy.

The RPS-based estimates of future solar energy generation at the state level were distributed between development that would occur on BLM-administered lands versus non-BLM-administered lands. An assumption was made that because of agency prioritization of development on BLM-administered lands, 75% of the predicted development would occur on BLM-administered lands. The solar energy development on BLM-administered lands and other lands estimated by use of this RPS-based method is presented in Table 2.4-1.

There is some uncertainty in the final results of the RPS-based method given the number of assumptions and approximations used; however, many of the assumptions were chosen specifically to result in higher projected levels of solar generation on BLM-administered lands. Consequently, the projections are likely to be high enough to accommodate increases in RPS standards, development of solar energy for markets outside of a given state, or other similar changes.

2.4.3 RFDS for This PEIS

Because the capacity estimates based on RPS values were considerably higher than those based on the ReEDS model (about 32,000 MW vs. 22,000 MW), the RPS-based estimates were assumed as the RFDS for programmatic impact analyses for the PEIS (to ensure an upper bound analysis of the impacts of the alternatives and of cumulative impacts). Unless market conditions change or advances in solar technology occur, the results of the ReEDS modeling suggest that the RPS-based RFDS levels used in the PEIS analyses are likely over-estimates of solar development through 2030.

The state-specific RFDS levels are presented in Table 2.4-2. The RFDS levels were also used to estimate the number of acres of BLM-administered lands and other lands that might be economically developable. Table 2.4-1 presents the state-specific assumed total number of BLM- and non-BLM-administered acres likely to be developed over the next 20 years, based on the assumed RFDS and on a high-end estimated land requirement of 9 acres/MW for development.

TABLE 2.4-2 Percentage of Available Lands Developed by the BLM Action Alternative Based on Estimated Acres Developed under the RFDS

State	Estimated Acres[a] Developed under the RFDS[b]	Solar Development Program Alternative: Total Proposed Acres[a] Available[c]	Solar Development Program Alternative: Percentage Developed under the RFDS	SEZ Program Alternative: Total Proposed Acres[a] Available[d]	SEZ Program Alternative: Percentage Developed under the RFDS
Arizona	21,816	4,485,944	0.5	13,735	100[e]
California	138,789	1,766,543	7.9	339,090	40.9
Colorado	19,746	148,072	13.3	21,050	93.8
Nevada	15,309	9,084,050	0.2	171,265	8.9
New Mexico	7,497	4,068,324	0.2	113,052	6.6
Utah	10,971	2,028,222	0.6	19,192	57.2
Total	214,119	21,581,154	1.0	677,384	31.6

[a] To convert acres to km^2, multiply by 0.004047.

[b] See Table 2.4-1 for basis for these estimates.

[c] See Section 2.2.2.2 for basis for these estimates.

[d] See Section 2.2.2.3 for basis for these estimates. For the purpose of the RFDS estimates of development, the entire acreage is used in the calculation of percentage developed; however, some portion will not be developable due to various restrictions.

[e] The estimated number of acres developed based on the RFDS projection exceeds the acreage proposed to be available in Arizona under the SEZ program alternative; thus it is assumed that 100% of the SEZs would be developed over the 20-year time frame assessed in this PEIS.

For the evaluation of BLM alternatives, the estimated percentage of BLM-administered lands available for development under the solar energy development program alternative (i.e., about 22 million acres [87,336 km^2]) or under the SEZ program alternative (i.e., about 677,400 acres [2,741 km^2]) that would be developed based on the RFDS projections varies by state. Under the solar energy development program alternative, the overall percentage of lands that would be developed based on the RFDS projections is about 1%, although in Colorado about 13% of the available lands potentially would be developed and in California almost 8% of the lands would be developed. Under the SEZ program alternative, the overall percentage of lands that would be developed is approximately 32%; however, it would be significantly higher in Colorado (94%), Utah (57%), and California (41%). In Arizona, the estimated number of acres developed based on the RFDS projection would exceed the acreage proposed to be available in the identified SEZs; therefore, the PEIS analyses assume all of the SEZ acreage would be developed under this alternative over the 20-year time frame assessed.

The RFDS estimate of development on BLM-administered lands in the six-state study area (23,791 MW) is only about 30% of the development that would occur if all currently active applications for ROW authorizations were approved (active applications total 74,219 MW).

However, it is not expected that all active applications will result in ROW authorizations; applications are often terminated either because the developer decides to drop the project or because the BLM determines that the application is not in conformance with land use plan decisions or there is a resource conflict.

In summary, the RFDS would be applicable to both BLM action alternatives. Note that not all of the lands considered available under either of the BLM action alternatives are likely to be developable, because of various constraints that could be identified during project-specific analyses. This factor is taken into account in the SEZ-specific analyses presented in Chapters 8 through 13, which assume that only 80% of the SEZ areas would be developable.[11] If the predicted development levels under the RFDS are accurate, development could be constrained in Arizona and Colorado by the amount of land available under the SEZ program alternative. However, as stated in Section 2.2.2.2, new SEZs may be identified in the future to provide additional developable lands.

Solar development on both BLM- and non-BLM-administered lands (estimated as 32,000 MW) is relevant for the evaluation of DOE's alternatives, because DOE may support solar projects on any lands. A small portion of the solar development in the six-state study area would be supported by DOE. However, through emphasizing support of projects researching ways to decrease environmental impacts (e.g., to decrease water consumption or land use), the DOE could influence the course of future solar development such that lower impact technologies would be employed.

2.5 ALTERNATIVES AND ISSUES CONSIDERED BUT ELIMINATED FROM DETAILED ANALYSIS

The BLM and DOE considered a number of additional alternatives and issues beyond those described in Sections 2.2 and 2.3 and being fully analyzed in this PEIS. This process included a review of the public comments received during both the initial scoping period held in 2008 (which are summarized in the scoping summary report [DOE and BLM 2008) and the second scoping period held in 2009. (See Chapter 14 for a discussion of the public scoping activities.)

Many of the suggestions provided through external scoping were incorporated into the Solar PEIS, including, but not limited to, the analysis of mitigation requirements (e.g., allowing only low-water-use technologies; using a specific species, such as jojoba, for revegetation); the exclusion of sensitive areas and, conversely, the development of some sensitive areas with appropriate mitigation; the analysis of a "zone-only" alternative; and focusing development in areas with existing transmission lines and roads to minimize the need for new infrastructure. Recommendations that the agencies analyze various development levels and scenarios were considered in constructing the RFDS analyzed in this PEIS. As discussed in Section 2.4, the

[11] SEZ-specific analyses presented in Chapters 8 through 13 have identified a number of potential conflicts that could restrict the amount of land available for development within the SEZs to 80% or less. These findings support the assumption that only 80% of a given SEZ would be developable.

agencies elected to evaluate a high development scenario in order to establish an upper bound on potential environmental impacts. Similarly, recommendations that the PEIS evaluate new and evolving solar energy technologies were considered in defining the scope of the PEIS analyses; however, the agencies determined it was appropriate to evaluate only those technologies considered to be technically and economically viable within the 20-year time frame being assessed.

The following sections discuss other suggestions that were not incorporated into the analyses in the PEIS and the basis for not including them.

2.5.1 Distributed Generation

A number of comments were received during the public scoping period suggesting that the agencies evaluate distributed generation of solar energy resources as opposed to, or in addition to, the development of centralized, utility-scale solar energy facilities. Distributed generation refers to the installation of small-scale solar energy facilities at individual locations at or near the point of consumption (e.g., use of solar PV panels on a business or home to generate electricity for on-site consumption). Distributed generation systems typically generate less than 10,000 kW. Other terms for distributed generation include on-site generation, dispersed generation, distributed energy, and others.

As discussed in Section 1.2, current research indicates that development of both distributed generation and utility-scale solar power will be needed to meet future energy needs in the United States, along with other energy resources and energy efficiency technologies (NREL 2010). For a variety of reasons (e.g., upper limits on integrating distributed generation into the electric grid, cost, lack of electricity storage in most systems, and continued dependency of buildings on grid-supplied power), distributed solar energy generation alone cannot meet the goals for renewable energy development. Ultimately, both utility-scale and distributed generation solar power will need to be deployed at increased levels, and the highest penetration of solar power overall will require a combination of both types (NREL 2010).

Alternatives incorporating distributed generation with utility-scale generation, or looking exclusively at distributed generation, do not respond to the BLM's purpose and need for agency action in this PEIS. The applicable federal orders and mandates providing the drivers for specific actions being evaluated in this PEIS compel the BLM to evaluate utility-scale solar energy development. As discussed in Section 1.1, the Energy Policy Act of 2005 (Public Law [P.L.] 109-58) requires the Secretary of the Interior to seek to approve non-hydropower renewable energy projects on public lands with a generation capacity of at least 10,000 MW of electricity by 2015; this level of renewable energy generation cannot be achieved through distributed generation systems. In addition, Order 3285A1 issued by the Secretary of the Interior requires the BLM and other Interior agencies to undertake multiple actions to facilitate large-scale solar energy production (Secretary of the Interior 2010). Accordingly, the BLM's purpose and need for agency action in this PEIS is focused on the siting and management of utility-scale solar energy development on public lands (see Section 1.3). Furthermore, the agency has no authority

or influence over the installation of distributed generation systems, other than on its own facilities, which the agency is evaluating at individual sites through other initiatives.

The evaluation of distributed generation systems does fall within the scope of DOE's mission; however, it is being handled in other initiatives separate from this PEIS. DOE recognizes that the present electric grid, built decades ago, was based on a centralized generation approach and was not designed to handle high levels of distributed renewable energy systems. In 2007, DOE launched the Renewable Systems Interconnection (RSI) study to identify the technical and analytical challenges that must be addressed to enable high penetration levels for distributed energy systems, with a particular emphasis on solar PV systems (see http://www1.eere.energy.gov/solar/rsi.html). As a result of the RSI study, in 2008, DOE initiated the Solar Energy Grid Integration Systems (SEGIS) program to further enhance distributed PV systems. Through these efforts, DOE is actively pursuing the expansion of distributed generation systems and their contribution to the country's electricity supply. While distributed generation of solar energy clearly is an important component of DOE's Solar Energy Technologies Program, inclusion in this analysis of an alternative incorporating distributed generation does not address the DOE's purpose and need to satisfy both Executive Orders (E.O.s) and respond to this congressional mandate and promote, expedite, and advance the production and transmission of environmentally sound energy resources, including renewable energy resources and, in particular, cost-competitive solar energy systems at the utility scale (see Section 1.4.1).

2.5.2 Conservation and Demand-Side Management

Like the requests for distributed generation alternatives, recommendations that the BLM and DOE evaluate alternatives incorporating conservation of energy and demand-side management do not respond to the purpose and need for agency action in this PEIS. In general, conservation initiatives would be designed to reduce energy consumption levels in order to reduce the need for increased electricity generation capacity. Demand-side management would involve specific actions taken by utilities, their regulators, and other entities to induce, influence, or compel consumers to reduce their energy consumption, particularly during periods of peak demand.

While these types of initiatives are important components of the country's efforts to address future energy needs, they do not respond to the purpose and need for agency action in this PEIS as defined by the agencies (see Sections 1.3 and 1.4). These efforts are beyond the scope of the BLM's land management responsibilities. Other programs within the DOE Office of Energy Efficiency and Renewable Energy focus on both conservation and demand-side management.

2.5.3 Analysis of Life-Cycle Impacts of Solar Energy Development

Several comments were submitted suggesting that this PEIS should address impacts associated with the life cycle of solar energy development, including the manufacturing of solar

facility components. The action agencies recognize that consideration of life-cycle impacts will provide valuable information supporting energy policy development in this country. However, the impacts associated with other solar energy life-cycle activities were not determined to be connected actions for the purposes of this PEIS (Title 40, Part 1808.25(a)(1) of the *Code of Federal Regulations* [40 CFR 1508.25(a)(1)]). As appropriate, these types of activities would be addressed as part of the cumulative effects analysis in project-specific environmental reviews.

For DOE, life-cycle analysis of energy development is an important research topic. Such analyses are being conducted by DOE across its programs, including life-cycle analyses for solar energy technologies.

2.5.4 Analysis of Development on Other Federal, State, or Private Lands

Comments were received suggesting that the scope of the PEIS include evaluation of development on other federal lands (e.g., lands managed by the U.S. Department of Defense), state lands, and private lands. A related suggestion was to sell BLM-administered public land to the private sector and limit all utility-scale solar power facilities to only private land. Alternatives based on these suggestions do not respond to the purpose and need for agency action in this PEIS and would not meet the objectives established for the BLM by the Energy Policy Act of 2005 and Secretarial Order 3285A1, both of which require the BLM to facilitate renewable energy development on public lands. As discussed in Section 1.3.5, the BLM has indicated that the agency may decide to dispose of some parcels of land to support the development of solar energy development. These decisions would be made on a case-by-case basis, however.

It is also important to point out that the analysis of solar energy development on other federal or private lands is encompassed in the scope of the PEIS analysis. The geographic scope of DOE's analysis includes all lands in the six-state study area. As discussed in Section 1.4.1, DOE may support solar projects on all types of lands, including BLM-administered lands and other federal, state, Tribal, and private lands. The description of the affected environment in Chapter 4 and the results of the analysis of potential impacts and mitigation measures in Chapter 5 may be applicable, as appropriate, across all lands within the study area. Because the scope of Chapters 4 and 5 encompasses all lands within the six-state study area, parties other than the BLM and DOE may be able to use the information in this PEIS to support their own analyses of utility-scale solar energy development in this area.

2.5.5 Restricting Development to Previously Disturbed Lands

A number of comments suggested that the agencies limit utility-scale solar energy development to lands that have been "previously disturbed." This issue has not been incorporated into the PEIS as an independent alternative; however, consideration was given to previously disturbed lands in identifying areas best suited to solar energy development. While there is no clear and well-established definition of what constitutes "previously disturbed public lands," nor are there any clearly defined thresholds for determining when lands cannot be restored to their

former, undeveloped state, the BLM identified some lands within SEZs as particularly well suited for solar development because previous human or natural disturbance had occurred on those lands. In addition, a proposed design feature requires projects to be sited on previously disturbed lands, to the extent practicable.

As discussed in Section 1.6.2.4, separate from the Solar PEIS, the BLM Arizona State Office, through its Restoration Design Energy Project (launched in April 2010), is taking steps to identify disturbed or previously disturbed sites in Arizona that can be made available for renewable energy projects (http://www.blm.gov/az/st/en/prog/energy/arra_solar.html). That initiative is not limited to public lands, but also includes private lands. Identified sites will be evaluated in terms of their restoration potential, potential for other land use, and technical suitability for renewable energy development. In the future, the BLM may implement similar programs in other states. In addition, the U.S. Environmental Protection Agency has launched the RE-Powering America's Land initiative to promote the siting of renewable energy production facilities on contaminated land (see http://www.epa.gov/renewableenergyland/index.htm); however, the types of contaminated properties it has identified are not likely to coincide substantially with BLM-administered public lands.

From DOE's perspective, it may elect to establish programmatic guidance that promotes utility-scale solar development on previously disturbed lands.

2.5.6 Restricting Development to Populated Areas

Suggestions also were made to restrict solar energy development to areas near population centers. While this issue has not been incorporated into the PEIS as an independent alternative, consideration was given to proximity of available lands to existing infrastructure such as transmission lines. Some of the proposed SEZs are located close to population centers. The Solar PEIS also analyzes the social, economic, and environmental impacts of constructing and operating solar energy facilities that may be located away from population centers.

From DOE's perspective, it may elect to establish programmatic guidance that promotes utility-scale solar development near populated areas.

2.5.7 Restricting Development to the Fast-Track Project Applications

Comments were received requesting that the BLM evaluate an alternative under which development on BLM-administered lands would be limited to the 14 proposed fast-track solar projects. These projects would be located in three states and would have a total electricity generating capacity of about 6,022 MW (see Section 1.3.3).[12] This alternative was not

[12] Six fast-track projects have been approved in California and two have been approved in Nevada: BrightSource Energy's Ivanpah Solar Electric Generating System, Tessera Solar's Imperial Valley and Calico Solar Projects, Chevron Energy Solution's Lucerne Valley Solar Project, NextEra's Genesis Ford Dry Lake Solar Project, Solar Millennium's Blythe and Amargosa Farm Road Solar Projects, and First Solar's Silver State North Solar Project.

considered for several reasons. While the fast-track projects would contribute to the goal of 10,000 MW of electricity generated from renewable energy projects located on public lands as set forth in the Energy Policy Act of 2005, an alternative limiting solar development to these projects would not meet the requirements of Secretarial Order 3285A1 to identify and prioritize locations best suited for large-scale production of solar energy on public lands. Limiting development to BLM-administered lands included in fast-track applications would completely exclude development on BLM-administered lands in three of the states included in this assessment (Colorado, New Mexico, and Utah). This restriction would arbitrarily limit solar development on BLM-administered lands over the next 20 years. Finally, since the fast-track projects are still in the environmental review phase, it is possible that some may not be approved or may be approved at a reduced capacity.

2.5.8 Analysis of Development on the Maximum Amount of Public Lands Allowable

Under both of the action alternatives being evaluated by the BLM in this PEIS, the BLM is considering restricting utility-scale solar energy development from lands where it has determined such development is incompatible with existing resources, resource uses, and special designations. These discretionary exclusions are listed in Section 2.2.2.2. The BLM has decided not to evaluate a maximum lands alternative that would make some or all of these potentially sensitive lands available for application for solar energy development, because it believes that ROW authorizations for solar energy development would not be approvable in these areas given existing resource protections. Utility-scale solar energy development requires that large parcels of land be converted to a single-use, with a year-round dominance over other potential uses of the land and long-term commitment of resources. These conditions are inherently in conflict with the important resources, resource uses, and special designations on some BLM-administered lands.

In determining which lands should be excluded from solar energy development, the BLM also has decided to not make lands available for application for solar energy development where the slope is equal to or greater than 5% or where the solar insolation level is less than 6.5 $kWh/m^2/day$. As discussed in Section 2.2.2.2, the solar technologies evaluated in the PEIS are limited in terms of the slope of the land on which they can be constructed, with 5% slope being a reasonable upper limit. The rationale for restricting the available lands based on the solar insolation level is to maximize the efficient use of BLM-administered lands and meet the multiple use intent of FLPMA by reserving for other uses lands that are not ideal for solar energy development.

On a related note, one commenter suggested that the PEIS should evaluate solar energy development in Wilderness Areas. This suggestion was not incorporated into any of the BLM's alternatives because such development is prohibited by law and, therefore, is not appropriate to analyze.

2.5.9 Changes to BLM's Proposed Solar Energy Zones

Several commenters requested evaluation of different and/or additional locations to the BLM's proposed SEZs. As discussed in Section 2.2.2.2, suggestions to modify the boundaries of the proposed SEZs were considered, along with input from BLM state and field office staff, in defining the areas proposed and evaluated in the PEIS. Modifications were made to SEZs in each of the six states; a detailed description of these modifications is included in the SEZ-specific sections in Chapters 8 through 13.

Suggestions to include additional SEZs were considered. However, because the site-specific evaluation of SEZs requires a large amount of data and lengthy evaluation time, the BLM decided to not include additional proposed SEZs in order to reduce impacts on the PEIS schedule. As discussed in Section 2.2.2.2, the BLM may evaluate additional SEZs in the future, using a process similar to that employed in this PEIS.

2.5.10 Other Suggested Alternatives

A few suggestions regarding alternatives to be analyzed in the Solar PEIS were determined to be beyond the scope of the DOE's and the BLM's purpose and need for agency action in this PEIS, as defined by the agencies. While certainly worthy of analysis, suggestions to also evaluate other electricity generation technologies (e.g., coal, nuclear, natural gas, geothermal, and wind) and compare the relative impacts and benefits of these alternatives were determined to be beyond the scope of this PEIS. In addition, suggestions to evaluate hauling ice from outside the study area to supply water for solar power facilities and to site solar power facilities in space were considered to be out of scope.

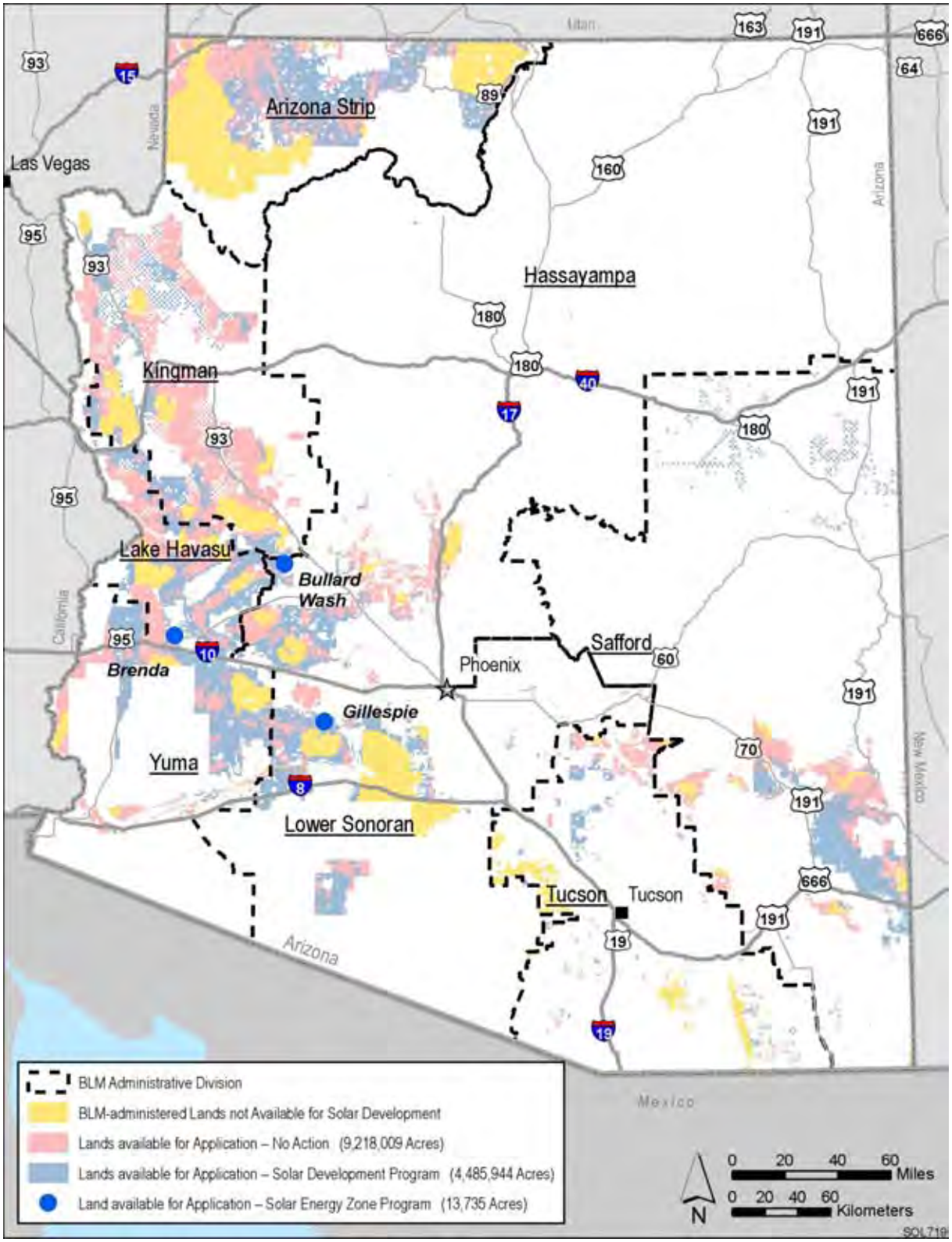

FIGURE 2.2-1 BLM-Administered Lands in Arizona Available for Application for Solar Energy ROW Authorizations under the BLM Alternatives Considered in This PEIS (Note: The lands available under the no action alternative include both the pink and blue shaded areas.)

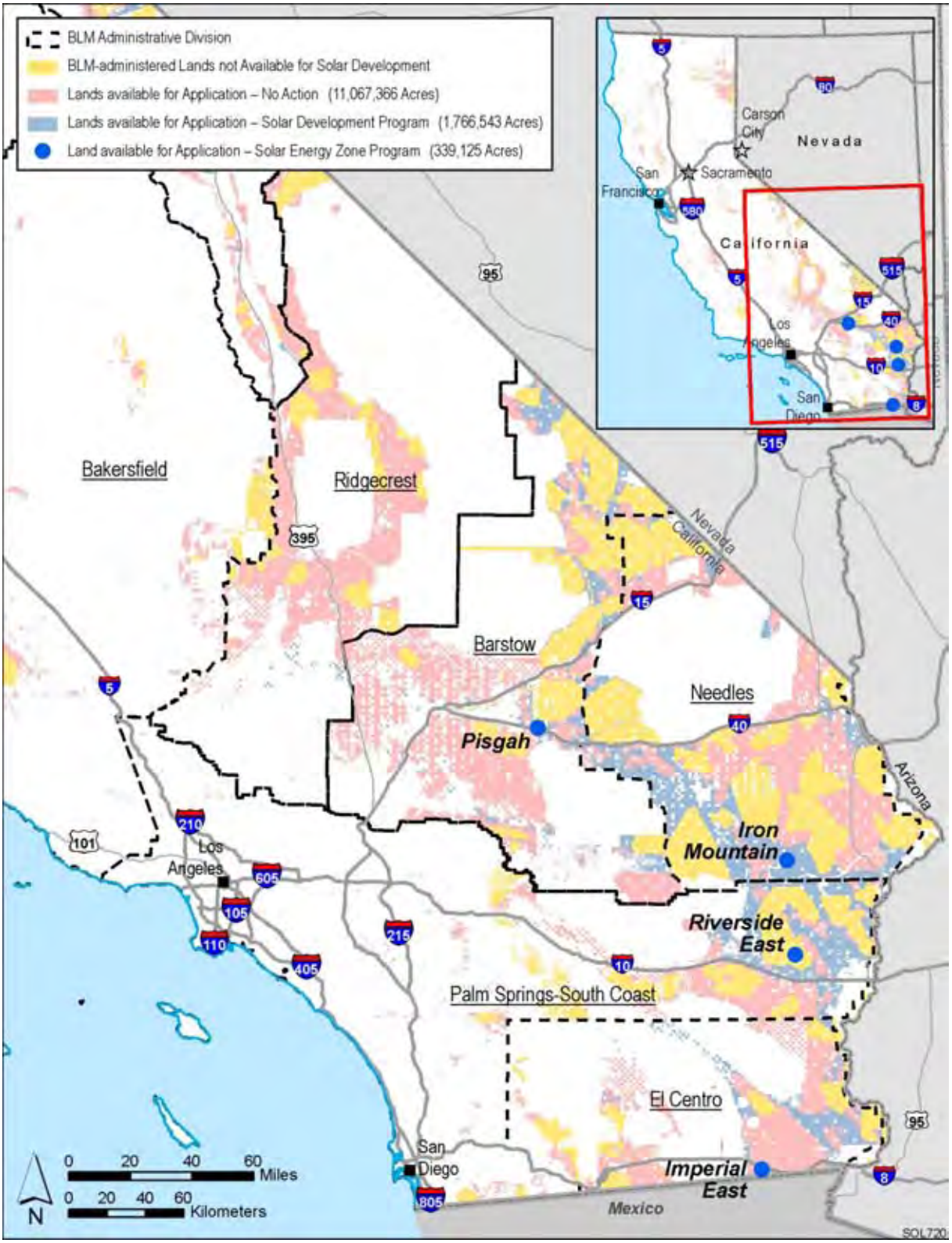

FIGURE 2.2-2 BLM-Administered Lands in California Available for Application for Solar Energy ROW Authorizations under the BLM Alternatives Considered in This PEIS (Note: The lands available under the no action alternative include both the pink and blue shaded areas.)

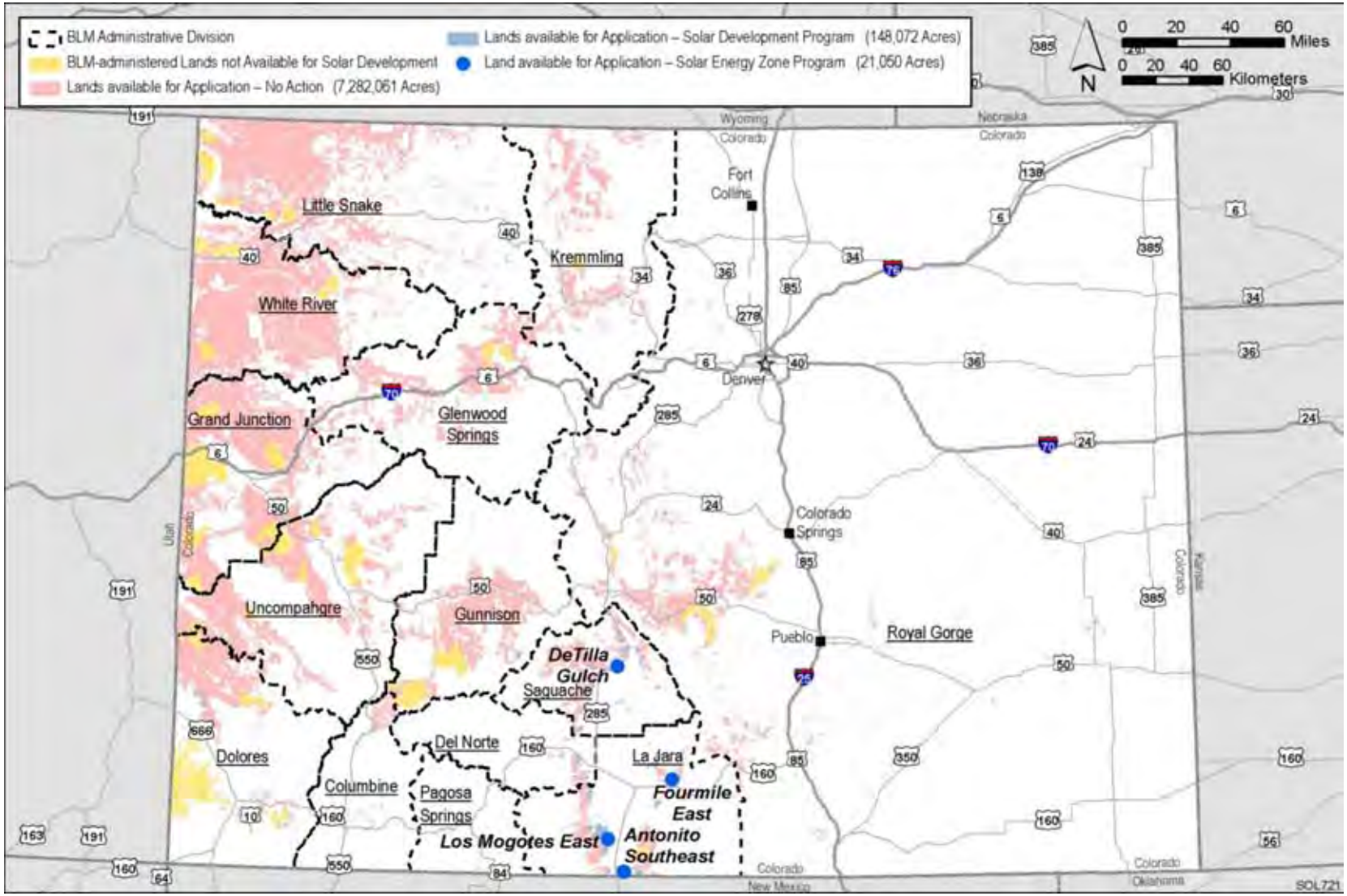

FIGURE 2.2-3 BLM-Administered Lands in Colorado Available for Application for Solar Energy ROW Authorizations under the BLM Alternatives Considered in This PEIS (Note: The lands available under the no action alternative include both the pink and blue shaded areas.)

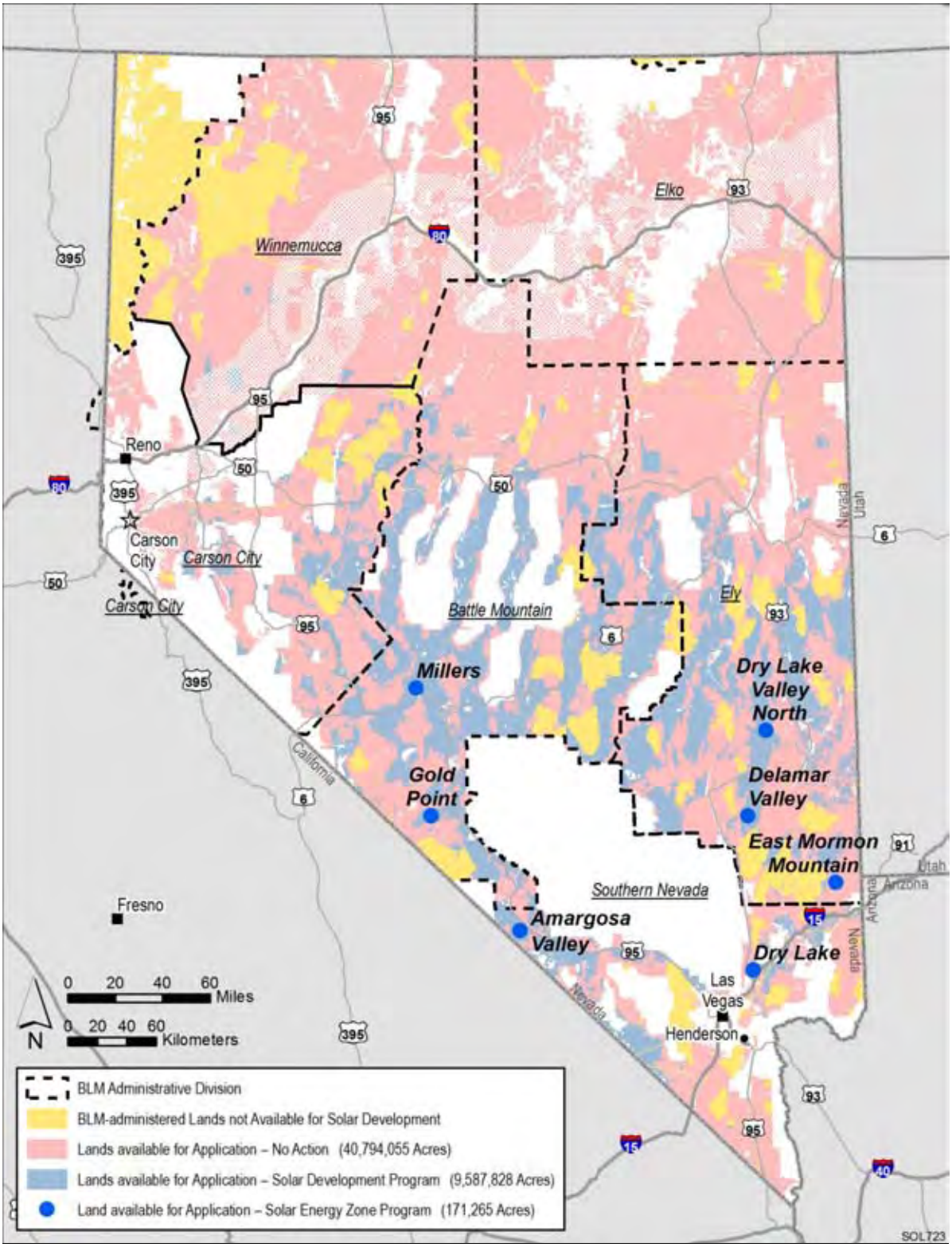

FIGURE 2.2-4 BLM-Administered Lands in Nevada Available for Application for Solar Energy ROW Authorizations under the BLM Alternatives Considered in This PEIS (Note: The lands available under the no action alternative include both the pink and blue shaded areas.)

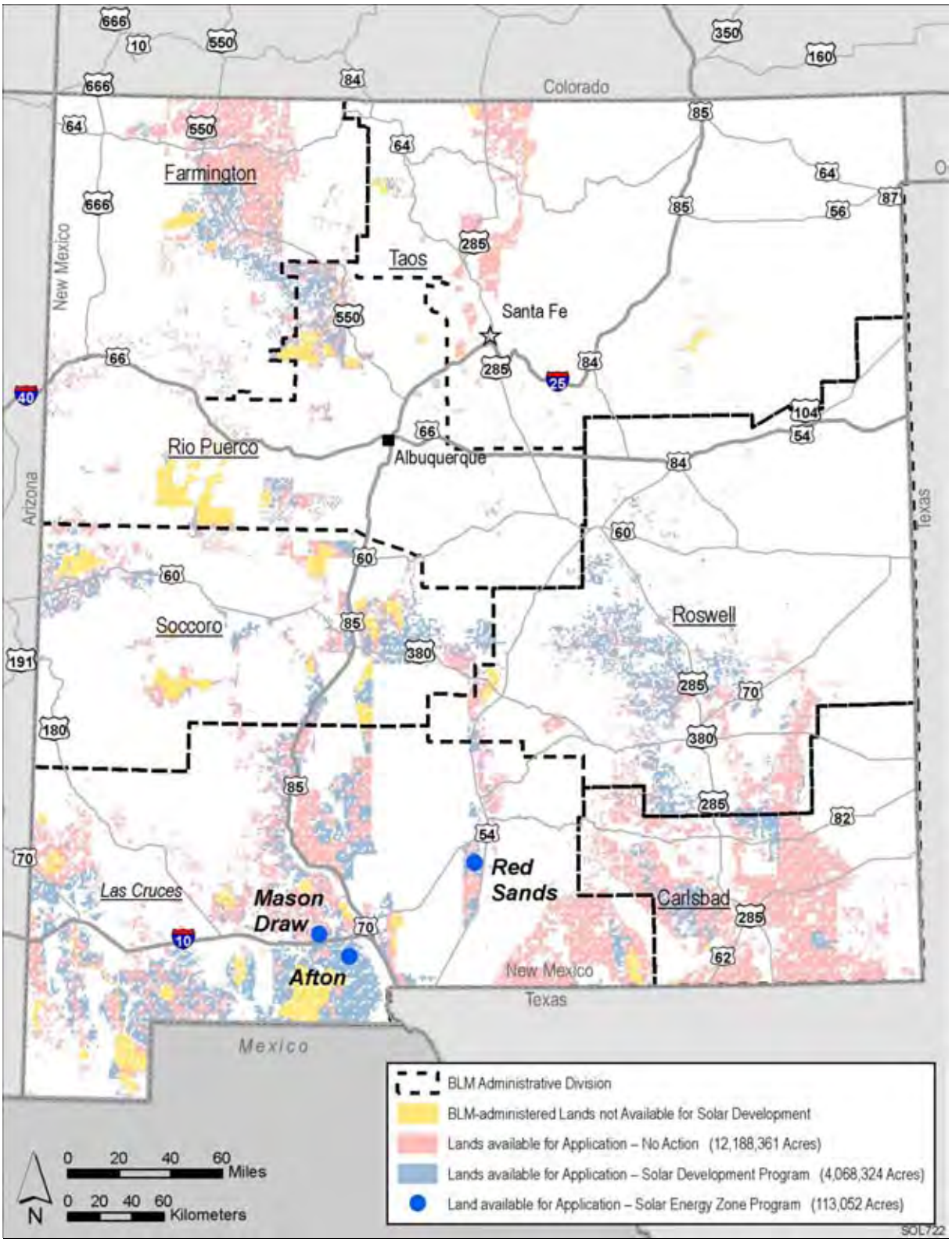

FIGURE 2.2-5 BLM-Administered Lands in New Mexico Available for Application for Solar Energy ROW Authorizations under the BLM Alternatives Considered in This PEIS (Note: The lands available under the no action alternative include both the pink and blue shaded areas.)

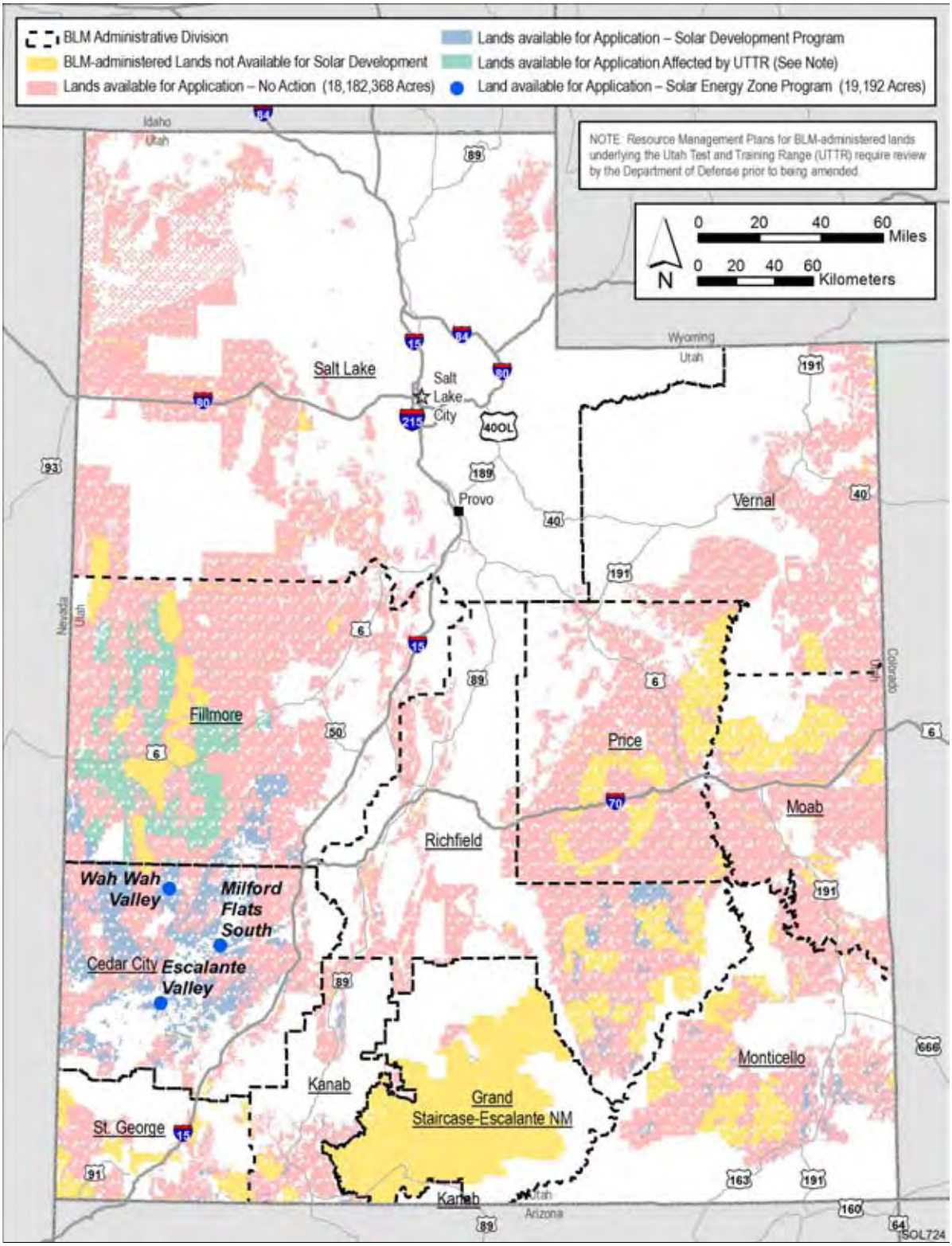

FIGURE 2.2-6 BLM-Administered Lands in Utah Available for Application for Solar Energy ROW Authorizations under the BLM Alternatives Considered in This PEIS (Note: The lands available under the no action alternative include both the pink and blue shaded areas.)

2.6 REFERENCES

Note to Reader: This list of references identifies Web pages and associated URLs where reference data were obtained for the analyses presented in this PEIS. 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. The original information has been retained and is available through the Public Information Docket for this PEIS.

BLM (Bureau of Land Management), 2007, *Instruction Memorandum 2007-097, Solar Energy Development Policy*, U.S. Department of the Interior, Washington, D.C., April 4.

BLM, 2010a, *Instruction Memorandum 2010-141, Solar Energy Interim Rental Policy*, U.S. Department of the Interior, Washington, D.C., June 10.

BLM, 2010b, *Instruction Memorandum 2011-003, Solar Energy Development Policy*, U.S. Department of the Interior, Washington, D.C., Oct. 7.

DOE and BLM (U.S. Department of Energy and Bureau of Land Management), 2008, *Summary of Public Scoping Comments Received during the Scoping Period for the Solar Energy Development Programmatic Environmental Impact Statement*, prepared by Argonne National Laboratory for DOE and BLM, Washington, D.C., Oct.

NREL (National Renewable Energy Laboratory), 2010, *Solar Power and the Electric Grid, Energy Analysis (Fact Sheet)*, Golden, Colo., March. Available at http://www.nrel.gov/docs/fy10osti/45653.pdf.

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/app_so/act_getfiles.cfm?order_number=3285A1.

3 OVERVIEW OF SOLAR ENERGY POWER PRODUCTION TECHNOLOGIES, DEVELOPMENT, AND REGULATION

This chapter provides general information about the types of solar facilities that are likely to be developed in the United States over the next 20 years, along with their sizes and resource needs (Section 3.1); a general description of the phases of solar facility development (from site characterization through decommissioning) and of associated transmission line development (Section 3.2); a brief discussion of regulatory requirements pertaining to solar facilities (Section 3.3); and solar facility considerations with respect to transportation, hazardous materials and waste, and health and safety (Sections 3.4 through 3.6). A description of U.S. Department of the Interior (DOI) Bureau of Land Management (BLM) and U.S. Department of Energy (DOE) processes that are in place and are relevant for solar energy development is given in Section 3.7.

This chapter is intended to provide background information on the characteristics of solar facilities and transmission infrastructure that would be required to support them; the processes that would be employed for their permitting, construction, operation, and decommissioning; and some regulatory information and additional practical considerations for solar facilities. A detailed assessment of the possible impacts associated with solar facilities and potentially applicable mitigation measures is presented in Chapter 5.

3.1 TECHNOLOGIES

The solar technologies discussed in this chapter are those deemed most likely to be deployed at utility scale over the next 20 years. Solar facilities are likely to have an operational lifetime of 30 years or more. Utility-scale facilities are those generating electricity that will be delivered into the electricity transmission grid. For the purposes of analysis in this programmatic environmental impact statement (PEIS), facilities with capacities greater than 20 MW were considered. Utility-scale facilities with lower capacities would have similar impacts but at a smaller scale; elements of the new Solar Energy Program established through this PEIS could also be applicable to facilities with capabilities of less than 20 MW. The upper limit of power production capacity for solar facilities has not been determined; the BLM has received right-of-way (ROW) applications for facilities with nameplate ratings of up to 4,100 MW (the proposed nameplate rating is the maximum power-generating capacity of a facility). For perspective, the entire electricity generating capacity of the United States was approximately 1 million MW in 2008 (EIA 2010). The average nameplate capacity in 2008 was 233 MW for coal-fired power plants, 1,021 MW for nuclear plants, 51 MW for wind facilities, and 6 MW for the few solar thermal and PV facilities in operation (EIA 2010).

The technologies evaluated fall into two general categories—concentrating solar power (CSP) and photovoltaic (PV). CSP technologies are those that concentrate the sun's energy to produce heat; the heat then drives either a steam turbine or an external heat engine to produce electricity. Parabolic trough, power tower, and dish engine technologies fall into the CSP category. In PV technologies, the photons in sunlight are converted directly to electricity. The information contained in this section is extracted from a more detailed discussion in Appendix F

regarding the utility-scale solar energy technologies. Information that is most relevant to potential environmental impacts associated with the generation of electricity using solar technologies is presented in the following sections.

3.1.1 Parabolic Trough

The major components of typical utility-scale parabolic trough facilities are the solar field, power block, cooling system (cooling water and steam water support systems, including wells, pipelines, filtration, chemical treatment equipment, blowdown and evaporation ponds, zero-discharge facilities, and pumping stations), electrical switchyard and power conditioning facility, thermal storage facilities (where present), and various support buildings (control building, warehouse, and maintenance facilities). The solar field consists of long rows (approximately 100 to 150 ft [30 to 46 m]) of parabolic solar collectors lined with mirrors that focus the sun's energy on a central absorber tube containing a heat transfer fluid (HTF) (see Figure 3.1-1). The HTF (typically a mix of synthetic organic oils) is heated in the solar field. Efficiency in heating is achieved by using tracking systems that adjust the trough angles to follow the movement of the sun. The heated HTF flows to the power block, where its heat is transferred to steam via a heat exchanger and the steam is used to produce electricity using a steam turbine generator (STG). The power block also contains a substation where electrical equipment is used to condition the power by adjusting its voltage and phase (the frequency at

FIGURE 3.1-1 Solar Field for the Florida Power and Light Parabolic Trough Facility Known as SEGS VI, Kramer Junction, California (Source: Hosoya et al. 2008)

which alternating current [AC] changes polarity [60 cycles per second in the United States]) to match existing conditions on the transmission line segment of the power grid to which the facility is connecting. Cooling systems include a condenser, which cools spent steam leaving the STG to the liquid state, and a cooling tower, which transfers excess heat from the water to the atmosphere. The power block and cooling system components of a parabolic trough facility are generally the same as those used for other electricity-generating plants that are based on transforming heat to electricity by using HTFs, regardless of the source of the heat (i.e., coal, natural gas, and nuclear). The power block and cooling system components are also used for solar power tower technologies (see Section 3.1.2).

In the United States, there are two operating parabolic trough facilities. The first is actually a group of facilities, the Solar Energy Generating System (SEGS) I through IX facilities installed in three locations in the southern Mojave Desert in California from 1985 through 1991. These facilities have a combined power capacity of 354 MW and cover 1,600 acres (6.5 km^2). Several of the SEGS facilities also have a natural gas–fired boiler that allows them to augment power production during non-sunlight hours. The other operating United States facility is Nevada Solar One, which is located about 40 mi (64 km) southeast of Las Vegas, has a power capacity of 75 MW, and encompasses 400 acres (1.6 km^2) (Acciona 2008). An application for another facility, the 250-MW Beacon Solar Energy (BSE) Project, has been submitted and could begin operations in late 2011.[1] It will be located on approximately 2,012 acres (8.1 km^2) in Kern County, California, about 100 mi (160 km) north of Los Angeles (Beacon Solar, LLC 2008).

Parabolic trough facilities may include thermal energy storage (TES) capability, whereby any excess heat generated would be stored in a thermal storage medium (typically molten salt, but research and development [R&D] is ongoing for several alternative storage media) and used during non-sunlight hours. The daily amount of additional time that the plant could run on stored thermal energy would be dependent on the amount of additional solar field capacity included in the design; the SEGS I plant included 3 hours of TES. Several proposed parabolic trough facilities include between 1 and 6 hours of TES.

The average land area required for parabolic trough facilities (based on the existing SEGS plants, the BSE project, and the Nevada Solar One project) is about 5 acres (0.02 km^2) per MW. The BLM has received several ROW applications requesting ROW land areas substantially larger than that corresponding to 5 acres (0.02 km^2) per MW. Additional land area could be needed to allow developers to avoid sensitive areas (e.g., drainages) within the ROW. In addition, facilities using TES would require somewhat larger land areas.

A variation of the trough technologies is the compact linear Fresnel reflector (CLFR) technology. This relatively new technology uses flat mirrors rather than the parabolic mirrors typically used in trough systems. CLFR facilities can also be designed to use water as the HTF

[1] Design data from pending applications have been used in this PEIS to estimate resource requirements because they contain good engineering design data considered to be representative of actual future facilities. Also, updated information from other approved projects, particularly fast-track projects, will be included in the Final PEIS.

rather than conventional synthetic oils, producing steam directly at the solar field. Flat mirrors and water used as an HTF simplifies system design and operation and could be expected to result in savings of both capital and operating costs. Notwithstanding such design variations, the power block and cooling system options are the same for CLFR and the standard parabolic trough technology. A potential advantage of CLFR systems is a smaller land requirement. For this technology, the troughs may be built lower to the ground and spaced closer together, resulting in a lower land requirement, about 3 to 4 acres (0.01 to 0.02 km^2) per MW. This lower overall profile also offers less wind resistance, simplifying the design of the supporting superstructures. A 177-MW CLFR facility (the Carrizo Energy Solar Farm) was previously proposed for construction on 640 acres (2.6 km^2) in San Luis Obispo County, California, about 150 mi (241 km) northwest of Los Angeles (Carrizo Energy, LLC 2007). This application, although withdrawn, provides good basic engineering data for CLFR facilities.

A technical limitation for parabolic trough facilities is the need for very flat terrain. Because the piping interconnecting the troughs has a very low tolerance for change in slope, practically speaking, the slope of lands used for parabolic trough facilities needs to be less than 2%, and preferably less than 1%, in order to use the technology.

Water is needed at parabolic trough (and power tower) facilities to run the cooling systems, as well as for mirror washing and other maintenance and sanitary uses to support the workforce. The total water use of a wet-cooled parabolic trough facility is about 800 gal/h/MW (3 m^3/h/MW), of which 2% is used for mirror washing and 98% is used for cooling (DOE 2009). The amount of water used for the cooling system will depend on the type of system selected. Recirculating wet-cooling systems use the most water, estimated at about 780 gal/h/MW (3 m^3/h/MW) for parabolic trough facilities (DOE 2009) (which corresponds to a range of 4.5 to 14.5 acre-ft/yr/MW [5,500 to 18,000 m^3/yr/MW] if operations occur during 30 to 60% of annual hours). For comparison, average annual per-capita water use in the six-state study area is about 0.25 acre-ft/yr (308 m^3/yr) (USGS 2000). Dry-cooling systems would use approximately one-tenth the water of recirculating wet-cooling systems, but would require more input power to run the cooling system fans, thus reducing the overall power-generating capacity of the facility. Hybrid wet-dry cooling systems may also be used to reduce water use substantially. Depending upon the operation of a hybrid cooling system, water use requirements can be reduced by as much as 80% in comparison with wet-cooling systems (DOE 2009).

3.1.2 Power Tower

Utility-scale power tower facilities consist of a central tower surrounded by hundreds or thousands of flat-plate reflectors (heliostats) that concentrate the sun's rays on a central point at the top of the tower, where an HTF can absorb the heat (see Figure 3.1-2). The typical height of towers is about 300 to 450 ft (91 to 137 m). The HTF used in power tower facilities to date has been water, although future facilities may use molten salt as both an HTF and a TES medium. Similar to the parabolic trough systems discussed in Section 3.1.1, the heliostats are equipped with tracking systems to maximize power capture by following the daily movement of the sun. In addition to the tower and the heliostat array, power tower facilities also have a power block, cooling system components, and other major components and facilities similar to those described

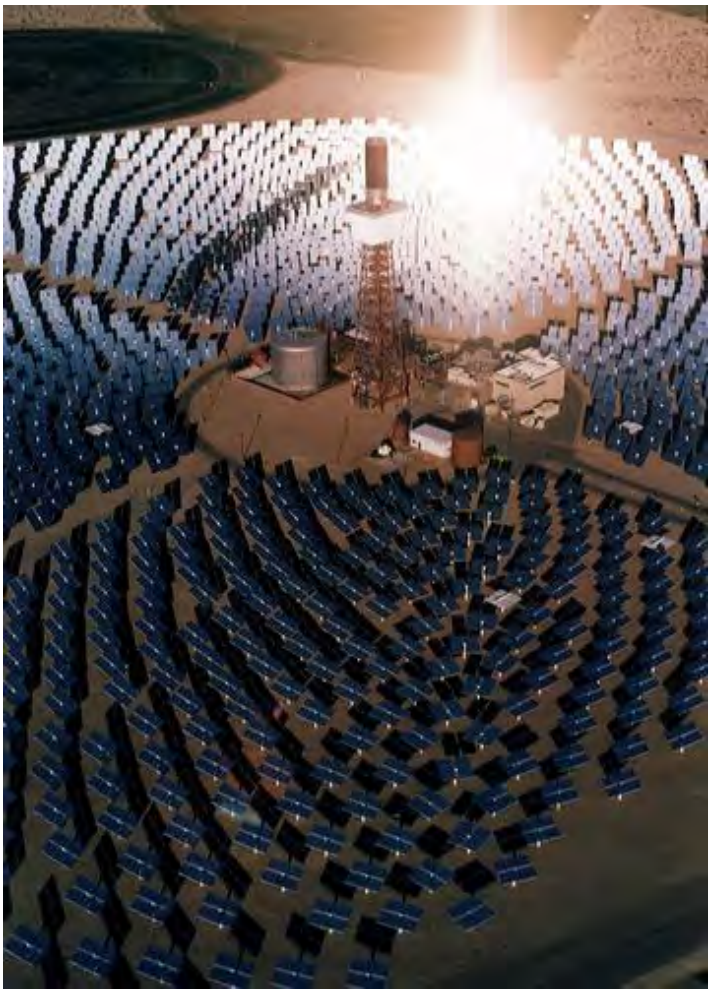

FIGURE 3.1-2 Solar Two, CSP Power Tower Facility in Daggett, California (Credit: SNL; Source: NREL 2009)

in Section 3.1.1 for parabolic trough facilities; the same types of TES systems could also be employed at power tower facilities.

A 10-MW research and demonstration power tower facility called Solar One began operations near Daggett, California, in 1982. It was later retrofitted to incorporate molten salt TES, renamed Solar Two, and operated successfully until 1997. There is also a power tower facility operating in Spain (the PS10 facility; 11 MW). An application is under review for a 370-MW power tower facility on 3,582 acres (14.5 km^2) of BLM-administered land in San Bernardino County, California, about 50 mi (80 km) southwest of Las Vegas.[2] Construction of this facility (the Ivanpah Solar Energy Generating System [ISEGS] facility) is scheduled to begin at the end of 2010 (CEC 2010). Although not utility-scale as defined in this PEIS, a 5-MW

[2] Project approved. Updated information will be included in the Final PEIS.

power tower facility built by eSolar started operations in 2009 in Lancaster, California, to demonstrate the steam power tower technology.

Because there are few data on operational power tower facilities in the United States, the land use requirements are difficult to project. The ISEGS facility proposes 3,582 acres (14.5 km^2), corresponding to approximately 10 acres (0.04 km^2) per MW. Other ROW applications for power tower facilities on BLM-administered lands request a range of land areas, from about 9 acres (0.04 km^2) per MW to areas of greater than 30 acres (0.12 km^2) per MW. However, these applications are in the preliminary stages of evaluation and the requested land area may be refined.

Relatively flat terrain is preferable for power tower facilities; developers generally prefer to limit the slope of potential sites to about 1 to 2%. However, this preference is at least partially for ease of construction, because the equipment (tower and heliostats) is fairly tolerant of slope change. If good reasons exist to use lands with higher slopes, power tower facilities may be engineered to accommodate slope change across a site.

Water use for tower facilities is for running the cooling system, heliostat washing as needed, and other maintenance and sanitary uses to support the workforce. The estimated water use is the same as was discussed for parabolic trough systems in Section 3.1.1 (i.e., recirculating wet-cooling systems are estimated to use about 780 gal/h/MW [3 m^3/h/MW], which corresponds to a range of about 4.5 to 14.5 acre-ft/yr/MW [5,500 to 18,000 m^3/yr/MW], assuming a range of 30 to 60% operational hours per year; dry-cooling systems would use approximately one-tenth of that amount; hybrid wet-dry cooling systems have the potential to reduce water use by 80% compared to wet-cooling systems, depending upon operations [DOE 2009]).

3.1.3 Dish Systems

Solar dish engine systems generate electricity through the action of an external heat engine, called a Stirling Engine, rather than through steam production. A typical dish system consists of a parabolic concentrator, a receiver, an external heat engine, and a generator (see Figure 3.1-3). Sunlight is concentrated onto the receiver, which transfers the heat to a gas (usually hydrogen or helium) contained in the sealed external heat engine. As the gas is heated, its increasing pressure drives a piston, thus powering the generator and producing electricity. Individual dish engines have been designed with power-generating capacities of 0.025 to 0.050 MW.

Individual dish engines can be grouped together into facilities with widely varying power capacities. Although the sun's energy is converted directly to electricity at each individual dish engine, TES applications that store heat for later conversion to steam are nevertheless being considered for dish engine facilities. Preliminary studies funded by the U.S. Department of Energy (DOE) are underway to investigate the feasibility of recovering heat from an operating Stirling-type dish engine for storage in a TES system by using thermally stable phase changing

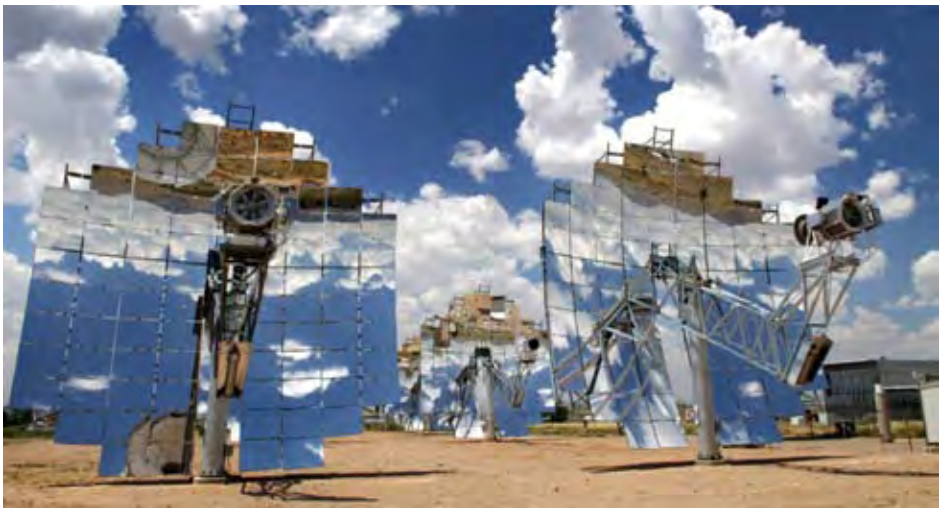

FIGURE 3.1-3 Stirling Dish Engines at the Stirling Energy Systems Test Facility in Albuquerque, New Mexico (Credit: Randy Montoya; Source: SNL 2008)

salts.[3] As with all solar technologies, electrochemical energy storage through the use of deep cycle batteries is technically available for dish engine facilities; however, no practical applications of battery storage at dish engine facilities currently exist.

Dish engines are often used as smaller sources of power for remote areas or individual facilities. They have higher concentration ratios than parabolic trough or power tower. No utility-scale solar dish engine facilities are currently in operation in the United States, although some smaller facilities are in operation (for example, the 1.5 MW Maricopa Sun project near Peoria, Arizona). The BLM has received several applications for ROWs for dish engine system facilities on BLM-administered lands. One example is the proposed Imperial Valley Solar Project (SES Solar Two, LLC 2008). If approved, the 750-MW facility will be located on 6,500 acres (26 km^2) in Imperial County, California.[4]

Because there are currently no operational utility-scale dish engine facilities in the United States, the land use requirements are difficult to project. The application for the Imperial Valley facility requests 6,500 acres (26 km^2), corresponding to approximately 8.7 acres (0.04 km^2) per MW. Other ROW applications for dish engine facilities on BLM-administered lands request a range of land areas, from about 6 to 18 acres (0.024 to 0.073 km^2) per MW. However, these applications are in the preliminary stages of evaluation and the requested land area may be refined.

Similar to the power tower facilities, the equipment required for dish engine facilities is tolerant of slope change, although construction can be more complex on steeper slopes because

[3] For additional details on this as well as other ongoing TES R&D projects, see the DOE Solar Energy Technologies Program Web site (http://www1.eere.energy.gov/solar/pdfs/csp_funding_prospectus_2008.pdf).

[4] Project approved. Updated information will be included in the Final PEIS.

of the need to optimize the geometry of the receiver tilt. If good reasons exist to use lands with steeper slopes, dish engine facilities may be engineered to accommodate slope change across a site.

Water use for dish engine facilities is for washing of mirrors when necessary and for miscellaneous industrial processes and sanitary uses to support the workforce. The amount of water needed for mirror washing is dependent upon the fugitive dust conditions and the climate of the region, as well as the time of year, which are all factors that need to be considered in a mirror washing schedule (Cohen et al. 1999). The estimated use for the SES Imperial Valley Facility would only be about 0.044 acre-ft/yr/MW (54 m^3/yr/MW) (SES Solar Two, LLC 2008).

3.1.4 Photovoltaic Systems

PV systems are based on the use of semiconductors, materials that can generate small amounts of electric current when exposed to sunlight. Semiconductors are materials that hold their bonding electrons tightly in covalent bonds (and therefore act as insulators in their pure state), but that have conducting properties when combined with small amounts of impurities called dopants. In most configurations, the solar cell material is present as a thin film. Silicon, the earth's most abundant material after oxygen, is the cheapest and most frequently used semiconductor. Boron and gallium are common dopants. Research is currently ongoing using different combinations of semiconductors and dopants to increase the efficiency of solar cells for capturing the energy in sunlight. Compound semiconductor materials such as cadmium telluride have also been used for solar cells. Currently, the silicon-based solar cells that have efficiencies of about 15% are likely to be used in utility-scale PV facilities built in the United States; however, multi-junction solar cells that contain two or more semiconductors and can increase efficiency to 30% or greater will likely be used in utility-scale PV facilities in the future. Another means of increasing efficiency is to use concentrating lenses (also known as concentrating PV technology [CPV]) and tracking systems to capture additional energy from the sun over longer periods of daylight.

To produce electricity at utility scale, many individual solar cells are connected as a module; modules are combined to make individual solar panels; and solar panels are grouped into arrays producing direct current (DC) electricity. This modular nature of PV systems allows greater flexibility in sizing facilities based on factors such as the amount of power needed or the amount of land area available.

The power-producing components of utility-scale PV facilities are the solar field, which contains the PV panels, and the power conditioning system (PCS), which contains an inverter to convert the produced DC to AC and a transformer to boost voltage for feeding into the power grid. The PCS also contains devices that can sense grid destabilization and automatically disconnect the PV facility from the grid if needed.

PV technologies can be grouped into two types of systems—flat-plate and concentrating systems. The solar cell materials can be the same in either, typically existing as a thin film in a weather-resistant enclosure. The differences between the two systems lie in the manner in

which they capture incident sunlight and direct it to the solar cell materials. In flat-plate systems, the modules are placed in the solar field, either in a fixed position optimal for capturing sunlight, or on a tracking system that follows the sun's path to optimize power production (see Figure 3.1-4). CPV systems use silicon solar cells or high-performance multi-junction solar cells (typically made of aluminum, gallium, indium, nitrogen, phosphorus, antimony) and use concentrating or reflecting optical devices to concentrate sunlight that strikes the solar cells. They also usually incorporate tracking devices. Because of their higher efficiency, CPV systems also generate excess heat; therefore, some require cooling systems to dissipate the heat. The cooling systems may be passive (e.g., cooling fins) or active (e.g., forced air cooling or water cooling).

Utility-scale PV facilities have only recently been developed worldwide; most operational plants have come online in the last 2 to 3 years. In the United States, a large PV facility (14-MW) is located at Nellis Air Force Base in Las Vegas, Nevada; this facility has been in operation since December 2007. The Nellis facility encompasses 140 acres (0.57 km^2). The BLM has also received many applications for ROWs for PV facilities to operate on BLM-administered lands. One large application is for the Topaz Solar Farm, a 550-MW facility to be located in San Luis Obispo County in California (Topaz Solar Farms, LLC 2008; updated Nov. 2009). If approved, this facility would begin operations in 2013. Both Nellis Air Force Base and the proposed Topaz Solar Farm use flat-plate PV systems.

FIGURE 3.1-4 Utility-Scale Flat-Plate PV System at the Prescott, Arizona, Airport Operated by Arizona Public Service Company (This system incorporates flat-plate non-concentrating solar panels [foreground] and concentrating flat-plate solar panels [background].) (Credit: Arizona Public Service; Source: NREL 2010)

The Topaz Solar Farm application and the Nellis Air Force Base facilities indicate a land use requirement for PV facilities of about 10 acres (0.04 km^2) per MW. Other ROW applications for PV facilities on BLM-administered lands request a range of land areas, from about 5 to 35 acres (0.02 to 0.14 km^2) per MW. Many of these applications are preliminary, and the requested land area may be refined.

The equipment required for PV facilities can be tolerant of slope change, depending on the flexibility of the interconnection between modules. In general, construction will be more complex on steeply sloped land (e.g., greater than 5%). If good reasons exist to use lands with steeper slopes, PV facilities may be engineered to accommodate slope change across a site.

Water use during operations for PV facilities is for washing of solar panels when necessary and for miscellaneous industrial processes and sanitary uses to support the workforce. The estimated water use for mirror washing is about 0.05 acre-ft/yr/MW (61.7 m^3/yr/MW; see Table 3.1-1).

Because there is no circulating HTF at PV facilities, TES systems are not applicable. Storage of electricity in batteries is possible, but the technology is not adequately developed at this time for application at utility-scale facilities.

3.1.5 Comparison of Technologies and Assumptions Used for Environmental Analyses

Some important factors for solar energy development with respect to environmental impacts include the overall size of the facilities and the size of facility structures, the water use during operations, and the type and quantity of process chemicals and/or other hazardous materials required. Assumptions used for these parameters to support analysis of impacts in this PEIS were based on the data from actual and proposed facilities presented in Sections 3.1.1 through 3.1.4, and are presented in Table 3.1-1.

The initial input needed to estimate these factors on a “per facility” basis is the nameplate capacity, or maximum output for each facility type. Because the utility-scale solar energy industry is in a developmental stage in the United States, the range of possible facility capacities is still unknown. To date, the BLM has received ROW applications that include a wide range of proposed facility power capacities for each of the technologies discussed above (from about 100 to 4,100 MW for parabolic trough and power tower facilities, and from 1 to 2,500 MW for dish engine and PV facilities); however, it is unknown whether facilities with large nameplate capacities will be approved. For parabolic trough facilities, data indicate that the optimum maximum plant size would range from about 250 to 350 MW (see Section F.2.2.3 of Appendix F). Parabolic trough and power tower facilities are not modular; they rely on interconnecting facility lines and the central power block to generate power. It also would not be cost-effective for these facilities to have a low nameplate capacity, given that the power block equipment would be required regardless of the facility capacity. In comparison, the modular nature of dish and PV components allows flexibility in planned facility capacities.

TABLE 3.1-1 Technology-Specific Assumptions for Environmental Impact Analyses

Parameter	Parabolic Trough	Power Tower	Dish Engine	PV
Facility power capacities (MW)	100–400	100–400	10–750	10–750
Land area requirements (acres/MW)[a]	5	9	9	9
Operational water use (ac-ft/yr/MW)				
Wet (recirculating) cooling[b]	4.5–14.5	4.5–14.5	NA[e]	NA
Dry cooling[b]	0.2–1.0	0.2–1.0	NA	NA
Hybrid system[c]	0.9–2.9	0.9–2.9	NA	NA
Mirror/panel washing/other[d]	0.5	0.5	0.5	0.05
Chemicals/hazardous materials present on-site	HTF, water treatment chemicals; herbicides	HTF, water treatment chemicals; herbicides	Hydrogen tanks; herbicides	Encased semiconductor materials; herbicides

[a] Land area estimates were based on areas required for existing facilities and estimated areas for proposed facilities. In some cases disturbed area estimates were not available, so values were based on total plant area (should approximate disturbed area). The estimated land use values for parabolic trough and tower facilities are minimums; the land area requirement could be higher if TES is incorporated into facilities.

[b] Wet-cooling and dry-cooling requirements are based on estimates given as gal/h/MW in DOE (2009). An assumed range of operational hours of 30 to 60% of annual hours (1 gal = ~3.1×10^{-6} ac-ft) was used to generate ac-ft/yr/MW values.

[c] Hybrid systems are assumed to use 20% of the water requirements of wet-cooling systems.

[d] The mirror washing estimates originate from the assumed 2% of total water needs of wet-cooled parabolic trough facilities from DOE (2009). This estimate equals 20 gal/h/MW, which corresponds to 0.5 ac-ft/yr/MW, with no assumption on operational time (conservative estimate). The panel washing estimate for PV facilities was assumed to be a factor of 10 less than that for CSP technologies (Appendix M).

[e] NA = not applicable.

For the purposes of analysis in this PEIS, it was assumed that parabolic trough and power tower facilities permitted on BLM-administered lands would have a nameplate capacity range of 100 to 400 MW. The upper end of the range approximately corresponds to the capacity of the proposed ISEGS power tower facility, which is well into the environmental review stage. The assumed capacity range for dish engine and PV facilities is 10 to 750 MW; the upper end of this range is based on the capacity of the proposed Imperial Valley Dish Engine facility, which is also proceeding through planning and environmental review requirement stages. These values were used as an illustration of size range for solar facilities; however, water and land use (and corresponding impacts) can be estimated for larger facilities by using the parameters given on a per megawatt basis in Table 3.1-1.

3.1.5.1 Land Requirement Assumptions

The assumptions for the land use requirements given in Table 3.1-1 were based on a review of land use for existing and proposed facilities (see Appendix F). Many applications for ROWs on BLM-administered lands request substantially more land than would correspond to the requirements stated in the table. The rationales for requesting additional acreage include allowing flexibility in project design or to avoid lands where resource conflicts might exist within the ROW. For example, it is likely to be appropriate to avoid areas within the facility footprint that serve as natural drainage swales or to avoid uneven or inappropriately sloped areas to preempt the impacts that would occur from the development of such areas.

As shown in Table 3.1-1, the various solar technologies also dictate different land use requirements. These differences result from a number of factors. The majority of land for any solar facility is devoted to the solar field. To ensure optimal operation, it is necessary to place individual sun-capturing devices in the solar field with sufficient separation to avoid shadowing of one device by an adjacent device. Providing for adequate spacing and for access roads needed for inspection, maintenance, and repair contributes substantially to land area requirements. It is also essential to provide sufficient land areas for all components of the facility in addition to the solar field, such as the power block, the power conditioning facility and substation or switchyard, steam cooling and conditioning systems (where present), waste management systems, HTF system reservoirs (where present), and TES storage facilities (where present). Land use requirements expand dramatically when TES capabilities are introduced. Not only must land be provided for the engineering elements of the TES system, such as large-volume storage tanks, transfer pumps, and heat exchangers, but the solar field area must also be expanded proportionally to the additional hours of nameplate operation expected to be provided by the TES system. Solar multiples of 2.0 (i.e., a solar field with double the area) or greater may be needed to support TES (see Appendix F, Section F.2.2.3 for discussion of solar multiples).

Buffer zones on fallow land surrounding solar facilities may be appropriate for a variety of reasons, including control of land use to prevent the erection of facilities on adjacent land areas that could interfere with the operation of the solar facility, or to provide for the attenuation of noise from industrial activities to acceptable levels at surrounding human or wildlife receptor locations. The size of ROWs for individual facilities will be established as a part of the site-specific evaluation process.

3.1.5.2 Water Use

Water use during construction is dependent on the location of a project and the specific project design. Values for water use based on the representative projects discussed in Appendix F were used to frame the impact analysis. For operations, a study estimating water use for parabolic trough, power tower, and dish engine technologies was also available (DOE 2009). The values given in that study were assumed for PEIS analyses (see Table 3.1-1). A lower value was assumed for panel washing at PV facilities based on existing applications and the difference in the mode of solar energy production between PV and CSP technologies.

Because the ideal locations for solar facilities are typically in arid areas, water use and water availability are key considerations when thermoelectric technologies (i.e., those utilizing a steam cycle) are selected. Intuitively, cooling technologies using the least amount of water are preferred. However, in practice, many more considerations enter into the selection of the steam cooling system, including institutional policies that discourage the use of freshwater for cooling purposes.

Conventional cooling systems for thermoelectric power plants, usually referred to as wet recirculating cooling or wet closed-loop cooling, provide the best performance under most weather conditions. Unfortunately, since their primary mechanism for heat dissipation is evaporation of some of the water in the recirculating system, their water demands are the greatest among the available cooling options. Dry-cooling technologies that cool steam in a condenser by passing ambient air over the condenser's surface are feasible in desert environments; however, the net power output of CSP facilities equipped with dry cooling will be less than that of a similarly sized facility using wet recirculating cooling.[5] Hybrid wet/dry systems have been developed that introduce water into the air stream passing over the steam condenser or deluge the outer surface of the condenser with water. The cooling mechanism is the same as for wet recirculating cooling systems; water flash evaporates, cooling either the air stream or the surface of the condenser as it does so. Such wet/dry hybrids are not as thermally efficient as conventional wet recirculating cooling systems; however, they use substantially less water and offer somewhat better performance than dry cooling alone, although there is still some reduction in power output. Such hybrid systems perform best in desert environments where relative humidity is typically very low. A recent variant of the hybrid wet/dry systems described above includes the use of a dual cooling system comprised of a conventional closed-loop cooling system using either a mechanical draft or natural draft cooling tower and a dry-cooling system; the facility operator has the discretion to rely on either or both, depending on prevailing conditions and the facility's heat rejection demands. Thus, in arid desert environments, the dry-cooling system with its minimal water demands would be used the majority of time, but the wet-cooling system could be put into service to augment cooling capacity and maintain the performance and maximum power output of the facility when high load demands coincide with the hottest portion of the day. With respect to visual impacts, the mechanical draft or natural draft cooling towers of wet closed-loop systems have a taller profile than do the dry condensers of a dry-cooling system. Adding demisting screens or air mixing zones to the mechanical or natural draft towers to prevent the formation of visible vapor plumes from wet closed-loop systems increases the heights of such systems even more. Mechanical draft cooling towers can have an average height of 30 to 40 ft (9 to 12 m). Natural draft towers that rely on the principle of convection to establish a counterflow of ambient air need to be much taller, often greater than 200 ft (61 m). The heights of dry-cooling system components are typically less than wet closed-loop system components. However, because heat exchange efficiencies of dry systems are typically less than those of wet closed-loop systems, dry systems would need to occupy a larger

[5] Assuming that a dry-cooling system is sized to have the same heat dissipation capacity as a wet closed-loop cooling system, the lesser amount of net power from the facility equipped with the dry-cooling system reflects the additional parasitic load for such dry systems—specifically, the power needed to operate the fans that force ambient air across the surface of the dry condenser.

overall footprint than wet closed-loop systems in order to have an equivalent heat rejection capacity.

Facilities in dry environments may reduce groundwater or surface water requirements by utilizing reclaimed water from wastewater treatment facilities. However, that will require the facility operator to develop extensive water treatment and storage capabilities, greatly increasing both the initial and operating costs of the facility. Similarly, facilities could consider alternative water sources for mirror washing, but such water would also require extensive treatment before it could perform adequately in mirror washing. Some cooling technologies use organic solvents in closed systems in place of water, although cooling systems of this design have limited capacity and have been successfully applied only to facilities with relatively small generating capacities. However, both of these water-saving systems may be utilized in future solar facilities in arid areas.

While water availability remains the primary consideration in the selection of a cooling system for CSP facilities utilizing steam, land requirements, visual resource impacts (i.e., the physical profiles of the system and, in some cases, the steam plume that may result in some weather conditions), the initial chemistry of the available water[6] and the complexity of the treatment necessary before it can be introduced into the cooling system, capital and operating costs, and the parasitic load (i.e., the amount of power needed to operate the system) also enter into the decision. Section F.2.4.2 of Appendix F provides a detailed discussion of cooling system options for CSP facilities utilizing a Rankine steam cycle, their advantages, and their drawbacks.

3.1.5.3 Chemicals/Hazardous Materials

The general types of chemicals and hazardous materials that would be present at solar energy facilities are listed in Table 3.1-1 and include HTFs, water treatment chemicals, and encased semiconductor materials. The range of materials used is discussed in detail in Section 3.5.

3.2 DEVELOPMENT PROCESS OVERVIEW FOR ALL TECHNOLOGIES

3.2.1 Site Characterization

In general, very little in the way of site modification is necessary during this phase. Required site characterization activities would vary depending on the type of technology being

[6] As discussed in greater detail in Appendix F, water introduced into a wet closed-loop recirculating cooling system must be treated to remove dissolved minerals and to control the growth of biological organisms. Failure to do so will result in biofouling and scale formation on critical parts of the cooling tower and in the recirculating plumbing system, both of which greatly reduce cooling efficiencies and result in increased maintenance downtimes or premature component failures. The amount of treatment required is dependent on the quality of the raw water source.

installed, planned water source (if any), and requirements of Power Purchase Agreements (PPAs).[7] The activities could include construction of meteorological towers (or erection of portable, trailer-mounted towers) for collection of meteorological data, surface hydrology assessment and floodplain mapping, slope evaluation, soil stability studies, due diligence assessment for lands with previous industrial uses, evaluation of seismic stability and potential storm event runoff, and soil coring (especially where substantial foundations would be required). The site characterization phase would include conducting surveys for ecological, cultural, and paleontological resources (including surveys for special status species if needed). Many of these activities would involve minimal or no site disturbance. For example, solar insolation data collection, surface hydrology assessment, floodplain mapping, slope evaluation, and due diligence assessments would primarily involve literature searches and/or on-site walkover surveying techniques and sensor placement. Most soil stability and soil coring activities would involve the use of handheld augers that could be transported to the site on existing roads. Ambient sound measurements that may be required for acoustic impact assessments are typically noninvasive and involve very little or no site disturbance.

Meteorological information (e.g., temperature, precipitation, and wind speed) might be obtained from a nearby existing monitoring station, or a meteorological tower could be erected on-site in order to collect site-specific data. The required height of a meteorological tower in most cases would likely be only 33 to 66 ft (10 to 20 m), since the main wind data required would be for estimating potential wind-shear impacts on facility equipment. (An exception might be for power tower facilities, for which site-specific data at the 164-ft [50-m] [or higher] level could be necessary.) It is estimated that it would take less than 1 day to erect a tower. Towers and instruments are relatively lightweight and often do not require belowground foundations or guy wires, especially if they are to be in service for limited periods of time. The towers typically do not require signal lights (especially the shorter 33- to 66-ft [10- to 20-m] towers). Some of the monitoring towers could remain operational throughout the life of the site and would then require a more permanent installation. In those locations where high winds or wind shear is likely, such permanent installations may require guy wires to ensure adequate structural support for the towers. For these towers, subsurface foundations may be required. Only the most remote sites require construction of a minimum-specification access road, which may be upgraded later to become the site's main access road, to support meteorological tower installation. A small crew (six or fewer individuals) would be required to erect the meteorological towers, and typically no personnel support facilities would be required. Data collected would be transmitted to remote locations; thus only infrequent human presence would be required on- site during the data collection period for equipment inspections or maintenance purposes.

[7] A Power Purchase Agreement (PPA) is executed between a solar site operator and entities such as power brokers or investor-owned or publicly owned utilities. In addition to specifying the terms of a power purchase, the PPA dictates the terms and conditions under which power from the facility will be provided to the transmission grid and typically specifies the required voltage, current, and the phase synchronization of power generated in the facility. It dictates a variety of electrical safety features and monitoring requirements that will be required to prevent destabilization of the grid during upset conditions (conditions outside pre-specified parameters) at the facility. PPA requirements also dictate the type of power conditioning and control equipment that will be present at the solar facility.

For solar projects that anticipate using groundwater obtained from on-site wells, existing area-specific data on groundwater hydrology may suffice in lieu of on-site characterization data. However, in the absence of area-specific data, more extensive ground-disturbing activities, such as installation of monitoring/sampling wells and piezometers, could be required. Large truck-mounted drilling rigs might require wider, higher-specification site-access roads and could cause extensive site disturbance. An appropriately sized and equipped drilling rig, used in conjunction with proper drilling procedures and site management, could minimize such impacts. Additional surface disturbance associated with well drilling could result from the construction of temporary impoundments for well drilling fluids and cuttings, although if closed-loop drilling systems were used, surface impoundments would not be necessary. Improper management of drilling fluids and cuttings could result in surface water and localized soil impacts.

Another activity that could result in substantial ground disturbance would be collecting deep soil corings to gather information necessary for the design of large structure foundations (e.g., for power towers). This type of characterization may also require larger equipment with higher access road requirements and the potential for extensive ground disturbance.

As the above paragraphs suggest, impacts from site characterization activities could range from insignificant to moderate, depending on what specifically needs to be accomplished. However, in most instances, and especially if the selected site meets the minimum slope requirements of the selected solar technology, site characterization will result in only small or negligible impacts. Site characterization is nevertheless critical to the overall success of the project in avoiding or minimizing adverse impacts. Surveys of existing ecosystems and identification of other important resources or features completed during site characterization provide data that are critical in supporting facility designs and development plans that minimize overall impacts.

3.2.2 Site Preparation and Construction

The components and activities required for construction are dependent on both the technology and the location. However, construction of any solar energy development project is likely to involve the following major actions: establishing site access; performing site grading; constructing laydown areas and an on-site road system; removing vegetation from the solar field and construction and laydown areas (primarily for fire safety); and constructing the solar field, power block area (for parabolic trough and power tower facilities), central control building, a weatherproof area for minor maintenance and for storage of equipment and parts (which may be separate or combined with the control building), electrical substations, and meteorological towers (if not done during site characterization). Additional activities may also be necessary at some facilities, including pile driving (for the type of foundation expected for individual dish engines), constructing a concrete batching plant, constructing sanitary facilities and temporary offices, and landscaping. Construction would generally be divided into two phases, which would include a site preparation phase of relatively short duration (e.g., a few months) followed by a much longer assembly, testing, and start-up phase.

Development strategies and construction schedules are also site dependent. Although smaller solar facilities in the range of 10 to 50 MW may be constructed in 1 year or less, larger facilities may have construction periods of several years and may be developed in phases. Developers would likely develop sites in accordance with economies of scale whenever possible. For example, where possible, similar activities would likely be completed at the same time throughout the entire site. Specialty crews could be brought to the site to complete all of their functions throughout the site, such as grading, excavating, installing foundations, or installing electrical equipment and substations, at one time.

3.2.2.1 Site Preparation

Site preparation consists of establishing site access, site clearing, and grading. Major heavy equipment that may be used in the site preparation phase would include bulldozers, graders, excavators, scrapers, front-end loaders, trucks, cranes, rock drills, chain saws, chippers, trenching machines, and equipment for blasting operations if required. Note that some construction techniques are available that minimize the land surface disturbance, such as disking and compacting, or leaving natural contours in place.

In general, the heavy equipment and materials needed for these activities are typical of road construction projects and would not pose unique transportation considerations for existing roads (see Section 3.4.1 for further details on transportation). However, off-site road construction or improvements may be required if local roads necessary for site access are not designed for gross vehicle weights of up to 80,000 lb (36,000 kg), the federal limit for tractor-trailer trucks on most U.S. highways. State-specific and local limits may also apply. Contact with local transportation authorities would be made to assure proper signage is placed to notify the public of traffic hazards.

Although some solar facilities could be accessed through gravel roads, in general the primary on-site access road(s) connected to the local road system would be a paved two-lane road because it would need to accommodate a large daily construction workforce and delivery traffic flow (as discussed in Section 5.9.1.2). Such an access road would reach as far as parking areas (paved or nonpaved) for construction workers, laydown areas for equipment and supplies, or other major site locations. On the basis of design standards for local roads and streets, these primary access roads may have lane widths of 10 ft (3 m), with graded 5-ft (1.5-m) shoulders as recommended for average daily traffic volumes greater than 400 vehicles (AASHTO 1994) for an overall road width of 30 ft (9 m). A ROW approximately twice the final width of an access road would be required. Therefore, if access road construction were required, the construction ROW width would likely be less than 60 ft (18 m), corresponding to a two-lane highway with 12-ft (3.7-m) lanes and 3-ft (1-m) shoulders. A 60-ft (18-m) ROW would result in a disturbed area of about 7 acres (0.03 km^2) per mile of road constructed. In contrast, the majority of the on-site roads are expected to be one-lane dirt or gravel roads that provide access to such areas as the locations of the individual solar facilities and transmission lines. Typically, these on-site access roads would be a minimum of 10 ft (3 m) wide (PBS&J 2002).

All ground disturbances would likely be confined to the ROW. Road specifications would be dictated by the weights of the heaviest components, for example, electrical transformers, or, in the case of parabolic trough or tower facilities, the STG. While straight-line access roads would minimize distance and cost, heavy loads may dictate a maximum grade of 10%, and while the areas for solar facilities are expected to be generally flat, access roads to the site may need to follow circuitous routes to meet grade requirements. Other factors, such as streams, areas of particular environmental sensitivities, and immovable obstacles, would also affect access road location. Nearby rail access may necessitate the establishment of a temporary equipment storage area at an off-site railhead, but it may also dramatically reduce truck transport requirements. Water transport is not expected to occur within the six-state study area; however, components constructed elsewhere may be brought to the vicinity by water transport.

Construction of the access road would require removing vegetative cover. Although most of the study area does not encompass forested areas, clearing the road path may involve tree removal in some locations. Depending on subsurface stratigraphy, surface soils may need to be excavated, and gravel and/or sand may need to be imported to establish a sufficiently stable road base. Topsoil should be removed and stockpiled for subsequent use to meet the needs of any identified or required interim reclamation. Access roads (other than the primary access road) would be expected to have all-weather capability but would not likely be paved. Aside from asphalt, compacted gravel is the most likely finishing material. In arid zones, compacted gravel roads may cause fugitive dust problems (e.g., PM_{10} and $PM_{2.5}$). Best management practices to mitigate road dust could include the application of soil palliatives. Engineered stormwater control may be necessary, and natural drainage patterns could be altered, at least on a local scale.

Vegetation must be cleared from electrical substation and power block areas to eliminate fire and electrical safety hazards. In addition, proposals for solar facilities generally specify vegetation removal for the entire solar field area, to reduce fire hazards and simplify construction. While some of the solar technologies could potentially be tolerant of native vegetation naturally re-establishing around or under the solar field components during the operating period, most current plans call for complete vegetation removal from the solar field and other industrial areas during construction.[8] The biomass removed during site and road clearing would require disposal; it could be burned on-site if applicable permits could be obtained. Controls regarding the disposition of biomass would be established on a site-specific basis.

While the scope of this PEIS analysis considers development on lands with less than 5% slope, in the near-term (e.g., the next 10 years), most solar energy projects probably would be located on ground with less than 1 to 2% slope to facilitate construction and simplify facility operations. Some localized grading might be necessary in limited portions of such solar sites.

Soils in certain portions of the solar facility sites would be expected to be compacted as a result of construction and vehicle traffic. It is possible that some areas cleared for construction

[8] Certain portions of the solar facility may be altered to the extent that revegetaion of native species would not naturally occur. A vegetation management program is likely to be needed throughout the operating period to control invasive species.

purposes could be revegetated with indigenous vegetation once construction is completed, although revegetation of desert areas is not readily achieved (see Section 5.10.1). Areas around control buildings and electrical substations would have to be maintained free of vegetation throughout the operating life of the solar facility for electrical safety and access purposes. These areas are likely to be covered in rock or gravel to ensure all-weather accessibility and proper drainage, and to reduce fugitive dust.

3.2.2.2 Site Construction (Assembly, Testing, and Start-Up)

The major equipment used in the construction phase would include cranes, front-end loaders, backhoes, bulldozers, trucks, and a temporary concrete batching plant if substantial amounts of concrete are needed and/or premixed concrete is unavailable from nearby vendors (e.g., for foundations for solar power towers or power block structures). In general, the vehicles, equipment, and materials needed for construction would not pose unique transportation considerations or impacts on existing roads.

3.2.2.2.1 Foundation Excavation and Installation. With the exception of towers at power tower facilities and the steam turbines at CSP facilities, the foundations required for permanent structures at solar facilities (e.g., control and administrative buildings and storage tanks) would require only slab-on-grade foundations. Wind loading and the structure weight of towers, and the weight and vibration of steam turbines, dictate more robust foundations that would typically require excavations to varying depths, depending on existing subsurface conditions. Foundations for towers and turbines would also likely utilize high-strength, steel-reinforced concrete, and extend to depths as great as 35 ft (11 m), depending on subsurface conditions; the diameter of the excavations would be approximately the same as that for the tower base. Geotechnical surveys involving numerous soil borings may be needed to establish foundation specifications. Depending on prevailing subsurface conditions, foundation excavations may also require drilling or blasting. Excavated materials would likely be stockpiled on site and re-applied in disturbed areas.

Most components of the solar field, such as parabolic troughs or PV panels, would require only minimal foundations, with many simply having preformed concrete feet resting on the ground surface. Dish engines are expected to rest on pile-driven foundations. Electrical transformers would require concrete pads.[9]

The concrete for foundations could be trucked to the site, or a temporary concrete batching plant could be constructed. Constituents of the concrete (aggregate, sand, cement, and water) would need to be hauled to the batching plant. Electrical power for the batching plant would likely be provided by a portable diesel engine/generator set (nominally, from 125- to 1,250-kW capacity). The land area required for a typical batching plant and associated material storage areas can be expected to be on the order of 10 acres (0.04 km^2) or less. Surface

[9] All but the largest of electrical equipment is expected to arrive on-site sealed and in a fully operational state. Larger transformers and equipment may need to be filled with dielectric fluid after placement on their pads.

vegetation would need to be removed, and some re-grading of surface soils in the batching plant area might be required. Soils would be expected to be heavily compacted as a result of batching plant activities and associated truck traffic. The batching plant and any excess concrete constituents would likely be removed at the end of the concrete-placing phase.

3.2.2.2.2 Other Construction Activities. Additional construction activities would include the construction of the control/electrical building, power block–related structures (including cooling towers, water treatment facilities, and evaporation ponds), placement of tanks, installation of electric substations, and trenching for power and signal cables. Conventional construction methods are expected to be sufficient for these activities.

Construction of the control building would involve either conventional construction techniques or the placement of a prefabricated building on a slab-on-grade concrete foundation. An additional storage building for parts and equipment might also be constructed. Some limited amount of maintenance or repair for solar array components might also be provided for, in conjunction with parts and equipment storage. Ambient conditions within the control building would need to be maintained to meet equipment operating requirements and/or to support the presence of facility personnel.

Power-conducting cables and signal cables would interconnect the power block or solar field (for dish engine and PV facilities) with the control building and the electrical substation. Where the soil mantle permits, the preferred method would involve burial of these cables to a nominal depth of 4 ft (1.2 m).[10] Standard trenching techniques are expected to be sufficient. However, on rocky sites where trenching is not possible or is too difficult, it may be necessary for the cables to be suspended in overhead cable trays.

No major maintenance is expected to be performed on-site on construction equipment; however, fluid levels would be maintained on-site for vehicles and equipment that are not roadworthy. Fuel for construction vehicles and equipment would be stored in portable aboveground tanks throughout the construction period. Lubricants to support equipment would likely be stored in portable containers inside the power block building or storage building.

During the construction phase, potable water and sanitary facilities would need to be established to support the construction crews. Potable water probably would be provided from off-site sources. Sanitary facilities would most likely be provided through portable latrines.

Throughout the construction phase, fugitive dust may have a significant impact on various resources (e.g., vegetation, wildlife, air quality, surface water, and visual resources). Fugitive dust may result from the disturbance of ground surfaces, removal of vegetative cover, vehicle traffic, and material handling (e.g., materials handled in an on-site concrete batching plant). Such impacts are typically mitigated by keeping disturbed surface areas to an absolute minimum and by the regular application of water or other approved dust palliatives to access

[10] Burying the cables can greatly reduce maintenance demands, reduce vandalism, eliminate obstructions for bird strikes, improve site safety, and virtually eliminate weather-related downtime.

roads and on-site roads and other disturbed areas throughout the construction phase. The water could be purchased from a nearby municipality and trucked daily to the site. Where no such sources are readily available, it is possible that water may be obtained from nearby surface water features or on-site wells. Surface drainage diverted to on-site impoundments and water excavated from deep foundations that intercept saturated subsurface zones are also potential sources of water for dust control. Precisely coordinated construction schedules, prompt installation of on-site roads, posted and enforced maximum on-site speed limits, and limitations on certain activities during windy periods could also be employed to mitigate the effects of fugitive dust from surface-disturbed areas. However, depending on the meteorological conditions at a site, fugitive dust generation during construction may be difficult to control because of the large areas to be cleared for solar fields.

Temporary construction facilities would be removed when no longer required, and the areas reclaimed. The footprints of solar energy development projects (solar field, power block if present, control buildings, transformer pads, electric substations, roads, and other ancillary structures) would encompass a large percentage of the sites, unless some areas are purposefully avoided or reserved as buffer areas. Proposals received to date indicate that the entire project area, including solar fields, would be fenced. In particular, electrical substations, power blocks, and control buildings would require fencing for security and safety. Various fence designs can be expected. High-hazard areas such as electrical substations may be enclosed with 8-ft (2-m) chain-link fence topped with barbed wire or razor wire to control unauthorized entry. Perimeter fencing may be low-maintenance barbed wire fencing or chain-link fencing, with some applications including fabric inserts. Some developers may install animal passages in their facility's perimeter fence to allow small animals that are not likely to cause damage to facility components to pass through. Temporary fences or barricades may need to be erected during some periods of the construction phase in accordance with applicable Occupational Safety and Health Administration (OSHA) regulations in Title 29, Part 1910.26 of the *Code of Federal Regulations* (29 CFR 1910.26) or as a result of the application of "safe work" practices in order to prevent unauthorized entry of individuals or animals into hazardous active construction zones and to provide for the safety of the construction workforce during periods when open excavations are present.

3.2.3 Operations

Operation of solar facilities would require varying numbers of on-site personnel, depending on the technology and the capacity of the facility. For example, some smaller PV facilities might require only one individual on-site daily to monitor controls and inspect equipment, or they could even be monitored remotely with no staff present on a daily basis. Larger facilities, particularly those with power block facilities utilizing steam cycles, would require an operations workforce on the order of 100 individuals (BrightSource Energy, Inc. 2007; SES Solar Two, LLC 2008). All facilities would require facility control staff to monitor solar array, power block, and substation operations. For "solar-only" facilities, such monitoring may be required only during daylight hours. For facilities with thermal storage or hybrid facilities that also involve a conventional fossil fuel–powered generation source, monitoring would need to occur whenever power is being generated.

A common maintenance requirement would be reflector/mirror washing. Some technologies require frequent washing to maintain energy conversion efficiency (e.g., parabolic trough), whereas others may require very infrequent washing (e.g., PV systems). In general, developers plan for at least annual washing. At large facilities, this would be a continuously ongoing operation. Dish engines also require periodic replacement of hydrogen that has leaked from the engine. The on-site electrolyzer that would be used for in situ production of this hydrogen, as well as high-pressure hydrogen storage tanks and distribution systems that could be used to deliver the hydrogen to the individual dish engines, would also require maintenance.

Facilities utilizing steam cycles and circulating both steam water and HTFs would have additional maintenance activities. Preventive maintenance on steam turbines, pumps, and compressors would result in the generation of spent lubricating fluids that would be expected to be stored on-site temporarily before transport to off-site treatment or disposal facilities. HTFs are not expected to require wholesale replacement during the facility's expected life; however, spills and leaks, or the repair and refurbishment of certain segments of the solar field may result in waste HTFs, all of which would be expected to be temporarily containerized and eventually sent to off-site treatment and disposal facilities. Spent lubricating oils and cleaning agents would be generated as a result of routine maintenance of the industrial plant. Spent lubricating oils, battery electrolytes, and coolants can also be expected to be generated from the preventive maintenance of emergency and backup power systems. Steam cycles would require continuous attention, including regular treatment of steam water to control total dissolved solids and prevent scale formation in the heat exchangers and other steam system components. Similar treatment of cooling water in recirculating closed-loop cooling systems would also be required, including the introduction of biocides to prevent algae formation in wet recirculating closed-loop cooling systems. Blowdown waters from the steam cycle and the cooling system may be disposed of on-site or containerized for eventual transport to off-site treatment or disposal facilities.

As with HTFs, dielectric fluids in electrical devices are expected to last the entire projected operating life of the facility. However, malfunctions, especially arcing in some devices, may necessitate drainage and replacement of dielectric materials.

3.2.4 Decommissioning/Reclamation

Decommissioning is expected to proceed in accordance with a pre-approved plan that would include removal of most if not all equipment, removal of permanent structures and improvements (including on-site and access roads), proper closure of all on-site wells, removal of all hazardous materials and wastes and closure of related storage areas according to applicable requirements (including a separate closure plan for hazardous waste storage areas), remediation of all spills or leaks of chemicals that may occur during emptying or dismantlement of components (e.g. removal of HTF from a parabolic trough solar field), closure of all off-site material storage areas, and return of the site to its native state to the greatest extent possible, including re-establishment of the native vegetative communities. All components of solar fields would be dismantled and recycled, sold for scrap, or disposed of off-site as solid waste after removal of fluids and hazardous constituents. During the facility decommissioning phase, Resource Conservation and Recovery Act of 1976 (RCRA) permits may be required to allow for

on-site treatment to perform such tasks. PV panels are expected to be removed from the solar array and sent to special recycling facilities without further disassembly at the site. Inadvertent breakage of some PV panels during dismantlement may require remediation of hazardous constituents released to the environment. Electrical power management and conditioning equipment, including backup batteries, would be recycled or disposed of (in some cases as hazardous waste because of the heavy metals present). Transformers and electrical control devices would either be reused in other applications or sold as scrap after fluid removal. Belowground cable runs are expected to be left in place, provided their presence would not intrude on agreed-upon site revegetation plans.

The access road, on-site roads, rock or gravel in the electrical substations, transformer pads, and building foundations would be removed and recycled if no longer needed. Concrete slab foundations would be broken up. Broken concrete could be used by highway departments for road base or bank stabilization. Disturbed land areas covered in rock or gravel or building/tower footprints would be adjusted for their degrees of soil compaction, restored to original grade to the greatest extent possible, and reseeded or replanted with indigenous vegetation.

Dismantlement of electrical substations and storage buildings would be accompanied by inspection for and documentation of the presence of industrial contamination in the soil or surface water (if applicable) from minor spills or leaks, and decontamination as necessary. Soil testing and surface water testing should be conducted after decommissioning any site.

3.2.5 Transmission Lines

Construction and operation of transmission lines to tie solar energy facilities into the main power grid would be required for most new solar energy facilities. The length of transmission line required would depend on the distance from the site to existing lines having sufficient uncommitted capacity to accept power from the facility. An analysis of the distance from all eligible solar facility locations in the six-state study area to the existing transmission grid or to federally or locally designated transmission corridors showed that few locations are greater than 25 mi (40 km) from these existing lines or corridors[11] (see Appendix G). If transmission line construction is required to support solar facility development, the ROW width would likely be less than 250 ft (76 m), including additional width needed for construction (see Appendix F, Section F.4.2.1 for discussion of transmission ROW widths), which

[11] Subtitle F of the Energy Policy Act of 2005 required various federal agencies, led by the DOE and the BLM, to designate corridors for energy transmission in the 11 western states, including the six-state study area of this PEIS. Local BLM offices have also designated corridors under separate authorities. Both federally and locally designated corridors are addressed in the *Programmatic Environmental Impact Statement, Designation of Energy Corridors on Federal Land in the 11 Western States (Corridor PEIS)* (DOE and DOI 2008). The Corridor PEIS, as well as various state and regional initiatives, such as California's Renewable Energy Transmission Initiative (RETI) (see http://www.energy.ca.gov/reti/index.html and Appendix D of this PEIS), should help to facilitate solar development by creating corridors through which power from remotely located solar facilities can be efficiently delivered to customers with minimum adverse impacts.

corresponds to a disturbed area of about 30 acres (0.12 km^2) per mile of transmission line constructed.

The transmission analysis for this PEIS did not evaluate the available capacity on existing lines (i.e., the analysis assumed lines could be upgraded if needed).[12] Upgrading of existing lines would result in variable additional land disturbance, depending on the extent of upgrades needed. Upgrading existing lines would be advantageous to transmission operators because there would be no need to obtain new ROWs on federal, state, or private lands. Analysis of the impacts of transmission line construction and line upgrades is provided in Chapter 5. For the solar energy zone (SEZ)-specific PEIS analyses (Chapters 8 through 13), transmission construction land disturbance was analyzed for the distance from SEZs to existing transmission lines; if additional construction or line upgrades are necessary for specific solar projects within SEZs, developers will need to analyze those environmental impacts.

The voltage of transmission lines that would be built to connect solar facilities to the existing transmission grid is not known; however, transmission line ratings in the range of 230 to 500 kV would likely be used for interconnections from larger solar facilities or larger SEZs (500 kV is a predominant high voltage for transmission lines in the western states). Regardless of the voltage of the connecting transmission lines, the solar facility operator would be required to condition the electricity being produced by the facility with respect to voltage and phase so that it would be compatible with the conditions on that portion of the grid to which the facility is connected, and as directed by the transmission system operator. As stated previously, for SEZ-specific analyses, it was assumed that transmission line construction to connect to the nearest existing transmission line would be required and that a substation would be constructed at the point of interconnection of solar facility power.

Transmission line construction times are very much dependent on such factors as accessibility to the ROW, the need to build roads over difficult terrain, or the need to significantly amend topography for staging erection cranes and cable-pulling equipment.[13] For simple projects requiring minimal access road construction and ROW amendments (i.e., vegetation clearing and grade amendments would be the main activities), construction of 5 mi (8 km) of transmission line would likely require a minimum of 6 months, assuming the availability of multiple crews. Actual construction time could exceed 1 year for more constrained projects on steeply sloped lands.

A good description of the activities required for construction, operation, and decommissioning of transmission lines can be found in Appendix G of the West-Wide Energy

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[12] Site-specific upgrades and modifications to existing lines and substations to increase current carrying capacities (additional circuits, voltage upgrades, or both) or to otherwise accommodate power from solar facilities are not assessed in this PEIS because the locations and magnitude of such upgrades are unknown, the upgrades would not be controlled by solar facility developers, and the upgrades may not be solely connected to solar facilities. However, the potential impacts of line upgrades are discussed in Chapter 5.

[13] Given the terrain in the anticipated locations for solar facilities, it would likely be unusual that construction of a 25-mi (40-km) or less interconnecting line would encounter difficult terrain, and instances of significant grade amendments are expected to be rare.

Corridor PEIS (DOE and DOI 2008); this material is summarized in Appendix F (Section F.4) of this PEIS. The general sequence of activities for placing electricity transmission lines would involve surveying, site clearing, construction of access roads, drilling or excavation for support structures and concrete footings, and backfilling. Tower structures would be carried to the site by truck in sections, assembled in laydown areas, and lifted into place with a crane. Depending on environmental and/or logistical factors (e.g., rugged, mountainous terrain), helicopters could be used for tower transport and erection, which would significantly reduce the construction period. Towers would require from one to four or more concrete foundations, depending on the type of tower and the subsurface conditions.[14] Once towers were in place, truck-mounted cable-pulling equipment would be used to string the conductors onto the support structures. Although substantively more expensive, conductors can also be installed with helicopters, a technique especially suited to rugged or steeply sloped terrain.

Construction of transmission lines would also require the establishment of tower assembly areas, laydown areas, and temporary roads. These areas would be reclaimed at the end of the construction period.

During the operation of transmission lines, inspection and maintenance of the cables and towers would be required. Inspections may be accomplished by personnel walking or driving the ROW and/or by aircraft. In addition, to prevent ground faulting, vegetation management using a combination of herbicides and physical clearing could be required along the ROW; however, in the semiarid environments in which solar facilities and their transmission grid interconnections would be located, tall vegetation that would threaten the operability of the transmission line is not likely to exist, so neither herbicides nor physical clearing would likely be necessary.

Decommissioning of transmission lines and substations would include removal of all equipment and permanent structures, remediation of all spills or leaks of chemicals, and return of the ROW to its native state to the greatest extent possible, including re-establishment of native vegetative communities. Metal and wooden tower components and conductors could be reclaimed for similar use, or recycled if appropriate recycling facilities could be identified.

3.3 LAWS AND EXECUTIVE ORDERS POTENTIALLY APPLICABLE TO SOLAR ENERGY AND TRANSMISSION LINE PROJECTS

This section discusses in very general terms the existing major laws, Executive Orders (E.O.s), and policies that may impose environmental protection and compliance requirements on the siting, construction, operation, and decommissioning phases of utility-scale solar energy and transmission line projects. Because solar energy and transmission line projects may 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, federal and state laws, and county ordinances that may be applicable are provided in Appendix H.

[14] Concrete footings would not be required in all instances; some towers can be directly buried when subsurface soil conditions are acceptable.

With respect to solar energy projects located on BLM-administered lands, the BLM conducts its operations in accordance with the Federal Land Policy and Management Act (FLPMA) and numerous statutes, regulations, and standards related to environmental protection, hazardous materials transportation, ecological resource requirements, and cultural and paleontological resource requirements. The BLM also conducts its operations in compliance with other applicable land use laws, including the Wild and Scenic Rivers Act of 1968, the National Trails System Act of 1968, the Wilderness Act of 1964, and the National Park Service Organic Act of 1916.

In addition to these federal laws, state laws and county ordinances may also be applicable to solar energy and transmission line projects. States may have simply adopted federal laws as their own or they may have modified them somewhat. States and counties may also have developed laws or ordinances to address concerns specific to their locations and resources.

The potentially applicable laws have been divided into general categories, as described below. Although several of the following descriptions only cite federal laws, state laws and county ordinances also fall into these categories. Appendix H provides a list of federal and state laws, E.O.s, and county ordinances in the following categories:

- *Air quality*—Air emissions from a solar energy and transmission line development project are subject to the requirements of the Clean Air Act of 1990 (CAA), as amended (typically, air emissions of most concern for solar facilities would be particulate matter emissions, of most concern during construction but also of potential concern during operations; see Section 5.11). 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. The CAA also requires that federal actions conform to the appropriate SIPs. 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. Depending upon their annual greenhouse gas (GHG) emissions, stationary sources may be required to obtain CAA permits. Solar energy facilities would not exceed the threshold limits for such permits.

- *Cultural resources*—Cultural resources that may be affected by federal undertakings such as issuing ROWs are subject to various requirements under Section 106 of the National Historic Preservation Act, as amended for identification and consideration, in consultation with Tribal, state, and/or federal entities. Mitigation actions may be required.

- *Ecological resources*—Development located on BLM-administered or other federal land must be conducted in accordance with requirements for the 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 Endangered Species Act, Migratory Bird Treaty Act, and Bald and Golden Eagle Protection Act are among the nation's ecological resource protection laws.

- *Energy projects*—Siting, constructing, operating, and decommissioning solar energy and transmission line projects may require approvals from energy and environmental permitting authorities.

- *Floodplains and wetlands*—If solar energy and transmission line project facilities are located in or adjacent to wetland areas or other water bodies, they would be subject to all applicable statutory requirements, such as Section 404 of the Clean Water Act of 1997 (CWA), and associated regulations.

- *Groundwater, drinking water, surface water, and water rights*—The provision of drinking water from wells or surface water to a transient non-community water system at project facilities would require compliance with the Safe Drinking Water Act of 1972 (SDWA). Alterations of jurisdictional waters of the United States and discharges of stormwater and wastewater require compliance with the CWA. In addition, the withdrawal and use of groundwater for industrial, including power plant cooling, or drinking water purposes may require approvals or permits.

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

- *Hazardous waste*—Hazardous wastes generated during the construction, operation, and decommissioning of solar energy and transmission line projects (e.g., used solvents and paints) must be accumulated, collected, transported, and disposed of in accordance with the RCRA and other applicable hazardous waste laws.

- *Land use*—Depending on the location of solar energy projects and transmission lines, special land use determinations may need to be made, particularly if projects or transmission lines are sited in or affecting environmentally sensitive or protected areas.

- *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. The guidelines state that annoyance and undue interference with activity will not occur if outdoor levels of noise are

maintained below an energy equivalent of 55 decibels (dB). However, these levels are not legally enforceable standards.

- *Paleontological resources*—Fossils of scientific value could be affected through project construction, operation, and decommissioning. The FLPMA prohibits the collection of significant vertebrate and invertebrate fossils without a valid permit. Fossils on federal land are managed and protected pursuant to the Paleontological Resources Preservation Act of 2009, which allows for prosecution of theft and damage of federal paleontological resources.

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

- *Solid waste*—Solid wastes generated during the construction, operation, and decommissioning of solar energy and transmission line projects must be managed in accordance with the Solid Waste Disposal Act of 1976 and all 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) from the construction or operation of a project 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 they 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 would require a Section 404 or Section 10 permit, respectively, from the U.S. Army Corps of Engineers.

In addition to these categories, the construction and operation of a solar energy and transmission line project on public land that has valid mining claims must not materially interfere with the claimants' rights to mine, remove, or sell the minerals from the claim (*United States Code*, Title 30, Chapter 2 [30 USC Chapter 2]). Solar energy projects and their associated transmission projects may also be subject to the health and safety standards of OSHA. The Federal Aviation Act may also apply.

Requirements to consider the impacts of issuing ROWs on local populations, pursuant to E.O. 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" (*Federal Register*, Volume 59, page 76297, Feb. 11, 1994), and E.O. 13045, "Protection of Children from Environmental Health Risks and Safety Risks" (*Federal Register*, Volume 62, page 19885, April 23, 1997) may arise, depending on the activities, locations, and other circumstances of the project.

3.4 TRANSPORTATION CONSIDERATIONS

Solar energy development would require a variety of transportation operations over the lifetime of a project. The majority of transportation operations would involve movement of workers, material, and equipment to the site during the construction phase. The types and amounts of material and equipment required for construction of the solar energy development project would depend on site characteristics as well as the design selected. During solar plant operations, worker commutes and deliveries of supplies would be supported. Decommissioning activities would be expected to result in activities similar to construction. The following discussion provides a general overview of the expected transportation requirements during construction, operations, and decommissioning.

3.4.1 Construction

Construction activities are expected to occur over a period of 1 or more years depending on the size of a solar energy project, with anticipated daily workforces possibly reaching 1,000. The number of workers required during different phases of development would vary, but increased commuter traffic in the vicinity of the project may require road improvements or other measures to alleviate congestion or traffic hazards. Depending on the relative locations of the worker population and the site, the use of carpools and shuttle buses may be options for reducing the number of vehicles entering or departing the site during the morning and evening rush hours.

As stated in Section 3.2.2.1, the heavy equipment and materials needed for site access, site preparation, and solar array foundation construction are typical of road construction projects

and do not pose unique transportation considerations. Road improvements could be required if local roads necessary for site access were not designed for gross vehicle weights of up to 80,000 lb (36,000 kg). State-specific and local limits may also apply. The types of heavy equipment required would include bulldozers, graders, excavators, front-end loaders, compactors, and dump trucks. Typically, the equipment would be moved to the site by flatbed combination truck and would remain on-site through the duration of construction activities. Typical construction materials hauled to the site would include gravel, sand, and water, which are generally available locally. Ready-mix concrete might also be transported to the site, if available. Concrete batch plants may also be set up on-site. Peak truck deliveries of materials and supplies, including solar array components, might be expected to be on the order of 50 trucks per day. Construction wastes (such as excess concrete) would be shipped from the solar energy facility.

Once the foundations are in place, construction of the different types of solar projects would be similar with respect to transportation needs. Solar collectors would be assembled on-site, and materials would be delivered to the project location by regular truck shipments without the need for oversize or overweight permits. The total number of shipments over the course of the construction period would be dependent on the type of solar technology and the size of the facility. Oversize exceptions would include the delivery of STGs and main transformers. Such equipment is typically shipped by rail to the nearest intermodal facility where transfer to specially designed tractor trailers would occur for transport to the project location. These latter shipments may require times of more than 1 day, escorts, temporary road closings, and transport during off-peak hours, but they would be one-time events.

3.4.2 Operations

Transportation activities during solar energy production would involve commuting workers, material shipments to and from the facility, and on-site work and travel. Larger facilities, particularly those with power block facilities, would require an operations workforce on the order of 100 individuals. Generally, a few daily truck shipments to or from a site would be expected. With facility sizes on the order of thousands of acres (tens of kilometers), on-site operations would include travel to various locations for repairs and maintenance, including dust suppression and cleaning operations. If on-site water is not available for these latter operations, shipments of water to the facility location would be required. Deliveries of materials during operations could also include hazardous materials such as fuels or ammonia. Shipments from facilities would include wastes for disposal.

3.4.3 Decommissioning/Reclamation

With some exceptions, transportation activities during site decommissioning would be similar to those during site development and construction. Heavy equipment and cranes would be required for dismantling solar arrays, breaking up array foundations, and re-grading and re-contouring the site to the original grade. Oversized and/or overweight shipments are not

expected during decommissioning activities because the major steam turbine components can be disassembled, segmented, or size-reduced prior to shipment.

3.5 HAZARDOUS MATERIALS AND WASTES ASSOCIATED WITH SOLAR ENERGY FACILITIES

The following sections discuss the types and estimate the quantities of hazardous materials and wastes associated with the construction, operation, and decommissioning of a solar energy facility. Component manufacturing or assembly facilities are not within the scope of this assessment and are not addressed (see Section 2.5.3). Similarly, facilities that support the solar facility by supplying necessary chemicals and materials to support operations, or by providing treatment and disposal of facility-related wastes, are not addressed.

3.5.1 Construction

3.5.1.1 Hazardous Materials

Except for some notable differences, construction activities among the various solar energy technologies are generally similar, as are the array of hazardous materials and wastes associated with such activities.

Hazardous materials associated with the construction of solar energy facilities would be generally similar in nature to the hazardous materials associated with construction of any major industrial facility. However, hazardous materials unique to the CSP solar energy technology selected (e.g., HTFs, TES media, and water treatment chemicals) would also be present near the completion of the construction phase as assembled components containing such hazardous materials are filled. Table 3.5-1 lists the major types of hazardous materials expected to be present on-site during the construction phase.

3.5.1.2 Construction Wastes

Wastes associated with the construction of renewable energy facilities would be similar to wastes resulting from the construction of any large industrial facility. Wastes are likely to include both hazardous and nonhazardous industrial solid wastes as well as nonhazardous domestic solid wastes and both industrial and sanitary wastewaters. Potentially hazardous industrial solid wastes might include wastes resulting from the use of listed solvents[15] and

[15] Spent solvents listed in federal regulations at 40 CFR 261.31 are, by definition, hazardous waste. EPA-authorized state hazardous waste regulatory programs adopt the federal listings by reference and may, in some cases, add additional solvents to the state's hazardous waste list.

TABLE 3.5-1 Hazardous Materials Used during Construction of Solar Energy Facilities

Material	Purpose	Remarks
Vehicle and equipment fuels, including diesel fuel, gasoline, kerosene, and propane[a]	Fuel for off-road construction vehicles and various construction equipment	• Diesel fuel and gasoline are expected to be stored in manufactured aboveground storage tanks with capacities of 2,000 gal (7,600 L) or less. • Propane stored in aboveground pressure tanks, 2,000 gal (7,600 L) or less. • Removed after completion of the construction phase.
Propane	Comfort heating of temporary buildings and trailers	• Expected to be stored in aboveground pressure tanks of 2,000 gal (7,600 L) or less. • Excess removed after completion of the construction phase.
Vehicle and equipment fluids, including lubricating oils, hydraulic fluids, brake fluids, glycol-based coolants, battery electrolyte, and dielectric fluids	Maintenance and support of construction vehicles and equipment, including compressors and emergency/ standby generators	• Expected to be present in minimal quantities only sufficient to maintain fluid levels of construction vehicles and equipment, primarily in container sizes of 55 gal (210 L) or less. • Excess removed after completion of the construction phase.
Compressed gases: oxygen, acetylene, and nitrogen	Welding, cutting, brazing, and purging	• Expected to be removed after completion of the construction phase.
Solvents, chemical cleaning agents	Cleaning of equipment after assembly, preparation of surfaces for application of paints or other corrosion control coatings	• Expected to be present in minimally necessary quantities only, primarily in container sizes of 55 gal (210 L) or less.
Paints, primers, thinners, and corrosion control coatings; sealants and adhesives	Weatherproofing equipment and superstructures; component assembly	• Expected to be used throughout the construction phase; likely to be present in container sizes of 55 gal (210 L) or less. • Components are expected to arrive on-site with final coatings applied; only field dressing after assembly will likely be necessary. • Excess hazardous materials removed after completion of the construction phase. • Some materials may exhibit hazardous characteristics (e.g., flammability) or contain toxic ingredients (e.g., chromium in certain paints and primers).

TABLE 3.5-1 (Cont.)

Material	Purpose	Remarks
Pesticides and herbicides	Vegetation and insect control	• Expected to be limited to EPA- and state-approved commercial products, present only in minimally necessary quantities. • Wholesale applications of pesticides (e.g., for vegetation control over the active construction zone) may be performed by a contractor, with no pesticides stored on-site.
Technology-specific hazardous materials	HTF, TES, water treatment chemicals, etc.	• See the discussion in Section 5.20 and Table 3.5-2 for more details.

[a] Depending on the site, fueling of construction vehicles and equipment may be accomplished directly from a vendor's fuel delivery truck, thus eliminating the need for on-site storage of some fuels.

corrosion control coatings, spent vehicle and equipment fluids and components (e.g., used oil,[16] used hydraulic fluids, spent filters, oily rags and wipes, and spent lead acid or nickel-cadmium batteries and battery electrolyte), and hazardous materials containers that do not meet the federal or state regulatory definition of "empty." All such hazardous waste is expected to be generated in limited quantities and would likely be accumulated in portable containers of 55-gal (210-L) capacity or less on-site for brief periods before being transported by a registered transporter to off-site permitted hazardous waste treatment, storage, or disposal facilities (TSDFs). Energy recovery or recycling opportunities may also be identified for some hazardous industrial wastes.

Nonhazardous industrial solid wastes would include waste packaging and dunnage (scrap wood, steel, glass, plastic, paper, and empty metal containers) as well as excess concrete, broken equipment, or components. There may be recycling or energy recovery opportunities for some of this material, provided adequate segregation is practiced. Otherwise, disposal of all such wastes would likely be in properly permitted off-site landfills.

Nonhazardous domestic solid wastes would be generated as a result of on-site administrative activities and in support of the workforce and would primarily include such materials typically found in office waste streams, including wastepaper and food scraps.[17] All such wastes are expected to be containerized until removal by local solid waste contractors to permitted sanitary landfills or recycling centers (when such options exist).

[16] Used oil is not categorically a hazardous waste in federal regulations but may be characterized as such because of the presence of certain contaminants. Also, used oil may be categorized as hazardous waste in EPA-authorized state-level hazardous waste programs.

[17] When the facility utilizes an on-site treatment system for domestic sewage, the sludge resulting from that activity would also qualify as a nonhazardous domestic solid waste.

Industrial wastewaters resulting from equipment and component cleaning and system purging activities would be containerized and transported to properly permitted wastewater treatment or disposal facilities. Plumbing and system components that would contain fluids are also expected to undergo one-time hydrostatic testing for system integrity once assembly is completed. The wastewaters from such tests may contain small amounts of contaminants from system assembly, and some may also exhibit hazardous characteristics.[18] Other wastewaters may include stormwater contaminated with sediment, which would be managed in accordance with a stormwater pollution prevention permit, and excavation dewatering waste streams that may be allowed to be discharged to surface drainage in the absence of contamination or allowed to evaporate in lined on-site impoundments. Water from dewatering operations may also be used for control of fugitive dust on unpaved access and on-site roads.[19] If on-site wells were installed to supply water for industrial processes, some small amounts of well development fluids and borehole cuttings would be produced. Drilling muds are likely to be captured in temporary lined impoundments near the drilling site and ultimately recovered for re-use.[20] Drill cuttings would likely be disposed of on the surface in areas adjacent to the wells (provided no prior contamination was encountered). Small amounts of wastewater from equipment washing associated with concrete production are likely to be produced if an on-site concrete batching plant is used. Such wastewaters would typically be discharged to the ground surface. Sanitary wastewaters resulting from workforce support may either be containerized in portable facilities before being removed to off-site sewage treatment facilities or disposed of on-site in septic systems under the auspices of appropriate permits when local soil and subsurface conditions allow.

3.5.2 Operations

3.5.2.1 Hazardous Materials

The amounts and variety of hazardous materials present on-site would depend on numerous factors, including the operational demands of the solar energy technology employed, the size and power-producing capacity of the facility, and the remoteness of the facility's location from commercial suppliers. Reasonable estimates of hazardous materials volumes are provided in the following discussions; however, those volumes can vary greatly on the basis of the aforementioned factors.

Hazardous materials required for routine maintenance of components and support equipment would be generally the same for both CSP (i.e., parabolic trough, power tower, and

[18] Similar hydrostatic testing wastes may also be generated periodically during the operation phase before fluid-containing systems that have been disassembled for repair or replacement are put back into service.

[19] Except in the case of a solar power tower, excavations for foundations, footings, and cable trenches are expected to be relatively shallow and not likely to intercept groundwater; in most instances, dewatering of excavations would be unnecessary.

[20] If closed-loop drilling systems were used, surface impoundments would not be necessary.

dish engine facilities) and PV facilities. All facilities that use water for washing reflecting surfaces or PV panels would need to use demineralized water which, in most cases, would require some on-site water treatment capability, probably involving ion-exchange resins or reverse osmosis. CSP technologies utilizing a steam cycle can be expected to have more extensive on-site water treatment capabilities for both the steam cycle and the cooling system (if a wet recirculating or hybrid wet-dry system is used), which would result in large quantities of hazardous chemicals stored on-site. Cooling system and steam cycle blowdown water is expected to be discharged to lined surface impoundments. It may be necessary to remove salts accumulating in these impoundments during the period of facility operations. At the end of facility operation, water and any precipitated salts would be removed, containerized, and delivered to appropriate off-site treatment or disposal facilities and the surface impoundment closed. Wastewaters and salts from blowdown impoundments are not expected to exhibit any hazardous character, but must nevertheless be appropriately managed to avoid adverse environmental impacts. All technologies can also be expected to have large amounts of dielectric fluids (mineral oils and/or sulfur hexafluoride gas) contained in electrical equipment in the PCS and management systems. In general, larger quantities and a greater variety of hazardous materials are required to support the operation of parabolic trough and power tower CSP facilities than are needed for any type of PV technologies. Hazardous materials needed for solar dish facilities are unique from all other solar technologies, due to the unique operational requirements of the Stirling engine. Parabolic trough and power tower CSP facilities would have large volumes of HTFs and TES materials present in addition to the lubricants and chemicals needed to maintain STGs, combustion turbine generators (CTGs) (when present), and steam and cooling water cycles. Tables 3.5-2 and 3.5-3 display the major hazardous materials present in CSP facilities and PV facilities, respectively.[21, 22]

3.5.2.2 Operations Wastes

3.5.2.2.1 CSP Facilities. Solid wastes generated during operation of CSP facilities would include both nonhazardous and potentially hazardous industrial wastes and nonhazardous domestic wastes. Industrial wastes might include metal scraps, machine parts, defective or broken electrical equipment, and other miscellaneous components that have been taken out of service. Industrial wastes would also include wastes resulting from general facility maintenance and repair, such as spent cleaning agents, paints, corrosion control coatings, oily rags, spent solvent wipes, and spent fluids and components from the preventive maintenance or repair of

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[21] Very hazardous materials (toxic heavy metals) are contained in the semiconductor materials of some solar cells. However, although their presence is acknowledged, hazardous semiconductor materials arrive at the facility contained in fully fabricated, sealed solar cells that present no potential for hazardous materials release to the environment or exposure to the workforce or the public, unless the integrity of the cell is compromised. Even in such events, the amounts of hazardous materials present in individual solar cells would be very limited. Consequently, hazardous semiconductor materials are not explicitly listed or discussed here.

[22] Depending on the nature, volume, and frequency of the operational wastes being generated at a solar facility and the management strategy for that waste, federal RCRA or state hazardous waste regulations would apply to the storage, treatment, shipment, and/or disposal of those wastes.

TABLE 3.5-2 Hazardous Materials Associated with the Operation of CSP Facilities

Material	Purpose	Remarks[a]
Therminol or Dowtherm	HTF	• Synthetic oil typically composed of a mixture of biphenyl and diphenyl oxide. • Depending on the size of the solar array and its location relative to the steam heat exchanger, volumes of HTF may be in excess of 1.3 million gal (4.9 million L), depending on the size of the solar field and facility configuration. (HTF systems are not expected to include a reservoir and are not expected to be supported by external, separate on-site storage of HTF.)
Molten salt TES medium	TES (for facilities so equipped), HTF	• Most typically, a mixture of sodium nitrate and potassium nitrate. • Depending on the design basis for hours of TES capacity, amounts present could be substantial.
Operating fluids for ICEs and miscellaneous equipment: lubricating oil, transmission oil, hydraulic fluid, and glycol-based coolant	Preventive maintenance of diesel engine(s) on emergency generator(s) and other equipment using ICEs	• Amounts on-site only sufficient to maintain fluid levels and perform preventive maintenance. • Expected volumes on hand to support maintenance may range from 500 to 2,000 gal (1,900 to 7,600 L), depending on system and component designs and recommended maintenance intervals.
Fluids in STGs, CTGs, compressors, pumps, and other support equipment: lubricating oils, glycol coolants, compressor oils, hydraulic fluids, and hydrogen	Internal component lubrication, heat rejection, cooling, replacement of working fluid lost through leaks	• Most fluids replaced periodically in preventive maintenance. • Some power generators may be cooled by hydrogen (in a closed-loop system). • For Stirling dish facilities, a central facility would produce hydrogen by electrolysis for distribution to each solar dish engine to replace hydrogen working fluid that escapes from the external heat engines through leaks.[b] • Stirling dish engines are also supported by a closed-loop glycol coolant system. • The volume of lubricating oil to support each turbine/generator can exceed 10,000 gal (38,000 L).[c]
Hydrogen gas	On-site generation by electrolysis in a central location and distributed to each dish engine	• Required to replace hydrogen working fluid lost to leakage in Stirling dish engines.[b]

TABLE 3.5-2 (Cont.)

Material	Purpose	Remarks[a]
Compressed gases	Instrument and equipment purge, calibration gases; equipment repair (welding, brazing, and soldering), comfort heating, fire control, and cooling/refrigeration	• Nitrogen, air, oxygen, and argon for instrument purge and calibration. • Acetylene, MAPP gas[d] for welding, heating, cutting, brazing, soldering, etc. • Propane for comfort heating. • CO_2 for portable and installed fire extinguishers. • EPA-approved non-ozone-depleting compound refrigerants are expected to be used in building heating, ventilation, and air-conditioning (HVAC) systems.
Vehicle and equipment fuels and fluids: diesel, gasoline, kerosene, propane,[e] natural gas, lubricating oil, hydraulic fluid, and glycol-based coolants	Fuel for emergency generators, emergency fire-water pumps, air compressors, and other equipment containing ICEs, and on-site vehicles	• Fuel is likely to be stored in and dispensed from aboveground tanks with capacities in the range of 500 to 2,000 gal (1,900 to 7,600 L). • Natural gas would be obtained through pipelines. • Lubricating oil in equipment may total >10,000 gal (>38,000 L) with as much as an additional 5 to 10% in on-site storage in 55-gal (210-L) drums.[f]
Battery electrolyte	Backup power source for DC loads and maintenance of vehicle and equipment batteries	• Majority contained in lead-acid batteries in vehicles and equipment. • Only sufficient quantities of electrolyte will be on hand to maintain fluid levels in lead acid storage batteries.
Steam cycle and cooling system water treatment chemicals, including surfactants, concentrated mineral acids and bases for pH control, and ion-exchange resins; brines that are a by-product of the water purification process	Maintain chemical quality of water in steam cycle and wet open-loop cooling system; control scale and biological organisms in recirculating cooling water	• Types and amounts of chemicals needed would depend on the quality of the raw water introduced into the cooling system and the rate of loss due to evaporation and drift. • Chemicals most typically used include sodium hydroxide (>8,500 gal [>32,000 L]; 50% solution), sodium hypochloride (>16,000 gal [>61,000 L]; 10 to 20% solution), cyclohexylamine, monoethanolamine, methoxypropylamine, phosphoric acid (30% to 100% solution), sodium bromide, and sulfuric acid (>17,000 gal [>64,000 L]; 93% solution). • Other chemicals might include ammonium hydroxide, calcium oxide, ferric sulfate, magnesium chloride, organic phosphate inhibitor, and trisodium phosphate.[g] • Brines may be treated on-site, sent to on-site lined evaporation ponds for volume reduction, or containerized and transported to off-site treatment facilities.

TABLE 3.5-2 (Cont.)

Material	Purpose	Remarks[a]
Miscellaneous cleaning agents and solvents,[h] HVAC refrigerants (chlorofluorocarbons)	Equipment cleaning and maintenance, scale control on heat exchangers and cooling systems, building maintenance	• Typical janitorial supplies; minimal quantities would be present on-site. • Work may be performed periodically by an outside contractor, with no cleaning agents stored on-site.
Paints, primers, thinners, and corrosion control coatings	Protection of equipment and superstructures against corrosion	• Expected to be used throughout the operations phase on an as-needed basis; likely to be present in container sizes of 55 gal (210 L) or less. • Some materials may exhibit hazardous characteristics (e.g., flammability) or contain toxic ingredients (e.g., chromium in certain paints and primers).
Pesticides and herbicides, fertilizers	Vegetation and insect control, control of biological organisms in cooling water	• Expected to be limited to EPA- and state-approved commercial products, present only in minimally necessary quantities. • Wholesale applications of pesticides (e.g., for vegetation control over the active industrial zone) or fertilizers may be performed by a contractor, with no pesticides stored on-site.
Dielectric fluids	Electrical insulating fluid for electrical devices such as transformers, switches, capacitors, and bushings	• Large transformers may contain >1,000 gal (>3,800 L) of dielectric fluid. • Dielectric fluids are expected to be free of polychlorinated biphenyls (PCBs). • Some devices may contain sulfur hexafluoride gas as a dielectric medium. • Dielectric fluids typically last the life of the electrical device but may need to be replaced if electrical arcing occurs to a significant degree inside the device due to a malfunction or failure. • Total volume of dielectric fluids in electrical equipment can range from 32,000[f] to 50,000 gal (120,000 to 190,000 L)[i] to >100,000 gal (>380,000 L),[j] depending on system configurations and facility nameplate capacity.
Laboratory reagents	Chemical quality analysis of steam water and cooling water	• Limited quantities (<1 gal [<3.8 L] in all cases) are expected be present on-site.

Footnotes on next page.

TABLE 3.5-2 (Cont.)

[a] Although the amounts listed are representative, the volumes can vary dramatically depending on system design requirements. Quantities cited are those derived from Kelly (2006) as well as from Applications for Certification submitted to the California Energy Commission (SES Solar Two, LLC 2008; Beacon Solar, LLC 2008; BrightSource Energy, Inc. 2007; Inland Energy, Inc. 2007). Volumes and types of water treatment chemicals would be dictated by the chemical quality of the raw water initially introduced into the steam cycle and cooling systems.

[b] In its initial Application for Certification submitted to the California Energy Commission, SES Solar Two, LLC, initially proposed a compressed gas cylinder of hydrogen would be located at each dish engine. However, in a supplement submitted to the California Energy Commission on June 12, 2009 (SES Solar Two, LLC 2009), modifications were proposed that now involve in-situ generation of hydrogen by electrolysis with distribution to each dish engine. The electrolyzer will have a capacity of 1,065 ft^3 (30 m^3) of hydrogen per hour and is likely to operate at off-peak times using power from the grid. The electrolyzer will also consume 184 gal (697 L) of water per day.

[c] For example, a two-stage turbine rated at 265 MW would be supported by a turbine oil system that includes a reservoir of more than 10,000 gal (38,000 L) (Kelly 2006).

[d] MAPP gas, a stabilized mixture consisting primarily of methylacetylene and propadiene with lesser amounts of propane and other low–molecular weight flammable organic gases, enjoys widespread industrial applications for heating, cutting, soldering, and brazing. MAPP gas is not suitable for welding, however. A Material Safety Data Sheet (MSDS) exists for a typical commercially available formulation (Airgas 1999).

[e] Fossil fuel external combustion devices that may be used to augment steam or power production or HTF lines during downtime (e.g., boilers or CTGs) would most likely use natural gas that would be supplied by a commercial vendor via a pipeline.

[f] See, for example, the Beacon Solar Energy Project's Application for Certification to the California Energy Commission (Beacon Solar, LLC 2008).

[g] See, for example the Application for Certification submitted to the California Energy Commission for the Victorville 2 Hybrid Power Project (Inland Energy, Inc. 2007).

[h] A wide variety of cleaning agents could be used for such activities as reflector and equipment washing. Aqueous detergent solutions are the likely choice. Their use would result in wastewaters high in dissolved and suspended solids with pH values ranging between 5.0 and 8.0, depending on the detergent selected.

[i] See, for example, the Imperial Valley Application for Certification submitted by Stirling Energy Systems to the California Energy Commission (SES Solar Two, LLC 2008).

[j] See, for example, the Ivanpah Solar Electric Generating System Application for Certification submitted by BrightSource Energy, Inc., to the California Energy Commission (BrightSource Energy, Inc. 2007).

internal combustion engines (ICEs) (e.g., used oil and filters, used hydraulic and transmission fluids, spent glycol-based coolants, spent battery electrolyte, and spent lead-acid batteries). Preventive maintenance of solar dish engines would also produce used oil and filters and spent glycol-based coolants. Industrial wastes would also result from the maintenance of STGs and CTGs, and the operation of steam and cooling water systems. Domestic solid wastes would include administrative wastes (primarily wastepaper) and wastes associated with workforce support (e.g., aluminum cans, food scraps, cardboard, glass, plastic containers, and other nonhazardous solid wastes).

TABLE 3.5-3 Hazardous Materials Associated with the Operation of PV Facilities

Material	Purpose	Remarks
Compressed gases	Instrument and equipment purge, calibration gases; equipment repair (welding, brazing, and soldering), comfort heating, fire control	• Nitrogen, air, oxygen, and argon for instrument purge and calibration. • Acetylene, MAPP gas[a] for welding, heating, cutting, brazing, soldering, etc. • Propane for comfort heating. • CO_2 for portable and installed fire extinguishers.
Vehicle and equipment fuels: diesel, gasoline, kerosene, and propane[b]	Fuel for emergency generators, emergency fire-water pumps, air compressors, and other equipment containing ICEs, and on-site vehicles	• Fuel is likely to be stored in and dispensed from aboveground tanks with capacities in the range of 500 to 2,000 gal (1,900 to 7,600 L).
Fluids required to support equipment and vehicles with ICEs: lubricating oil, transmission oil, hydraulic fluids, and glycol-based coolant	Preventive maintenance of diesel engine(s) on emergency generator(s) and other equipment using ICEs	• Amounts on-site only sufficient to maintain fluid levels and perform preventive maintenance.
Battery electrolyte	Contained in vehicle and equipment batteries and in batteries that compose the backup power source for DC loads	• Majority contained in lead-acid batteries that are in service. • Only sufficient quantities of electrolyte will be on hand to maintain fluid levels in lead acid storage batteries.
Water treatment chemicals	Demineralize water used for panel washing	• Most probably ion-exchange resins.
Miscellaneous cleaning agents and solvents	Equipment cleaning and maintenance, scale control on heat exchangers and cooling systems.	• Minimal quantities would be present on-site. • Work may be performed periodically by an outside contractor, with no cleaning agents stored on-site.
Paints, primers, thinners, and corrosion control coatings	Protection of equipment and superstructures against corrosion	• Expected to be used throughout the operations phase on an as-needed basis; likely to be present in container sizes of 55 gal (210 L) or less. • Some materials may exhibit hazardous characteristics (e.g., flammability) or contain toxic ingredients (e.g., chromium in certain paints and primers).

TABLE 3.5-3 (Cont.)

Material	Purpose	Remarks
Pesticides and herbicides, fertilizers	Vegetation and insect control	• Expected to be limited to EPA- and state-approved commercial products, present only in minimally necessary quantities. • Wholesale applications of pesticides (e.g., for vegetation control over the active industrial zone) may be performed by a contractor, with no pesticides stored on-site.
Dielectric fluids	Electrical insulating fluid for electrical devices such as transformers, switches, capacitors, and bushings	• Large transformers may contain >1,000 gal (>3,800 L) of dielectric fluid. • Depending on power conditioning equipment present and facility power production capacity, >100,000 gal (>380,000 L) of dielectric fluid may be present. • Dielectric fluids will be PCB-free. • Dielectric fluids typically last the life of the electrical device but may need to be replaced if electrical arcing occurs to a significant degree inside the device due to a malfunction or failure.[c]

[a] MAPP gas, a stabilized mixture consisting primarily of methylacetylene and propadiene with lesser amounts of propane and other low-molecular weight flammable organic gases, enjoys widespread industrial applications for heating, cutting, soldering, and brazing. MAPP gas is not suitable for welding, however. An MSDS exists for a typical commercially available formulation (Airgas 1999).

[b] Fossil fuel external combustion devices that may be used to augment steam or power production or heat HTF lines during downtime (e.g., boilers or CTGs) would most likely use natural gas that would be supplied by a commercial vendor via a pipeline.

[c] See, for example, the original Conditional Use Permit application submitted by Optisolar to the County of San Luis Obispo, California, for its Topaz Solar Farm (Topaz Solar Farms, LLC 2008) and revisions to portions of the original application (Hoffman 2008).

All industrial solid wastes would be containerized and undergo characterization before being transported to off-site properly permitted disposal or recycling facilities. Domestic solid waste would be containerized and collected by a waste hauler for delivery to permitted sanitary landfills or segregated during on-site accumulation to facilitate delivery to recycling centers when such options exist. Some industrial solid wastes, such as spent lubricating oils, spent fluorescent lightbulbs, spent corrosive cleaning agents (both strongly acidic and strongly

alkaline), and spent cleaning solvents, may be federally or state-listed hazardous wastes or display hazardous characteristics, requiring them to be managed as hazardous wastes in accordance with prevailing regulations. Although critical fluids such as HTFs, TES media (e.g., molten salts), and dielectric fluids would be present in substantial quantities, they are expected to last the life of the facility or the component in which they are installed. However, repairs and replacements of system components, as well as spills and leaks, may result in the generation of some wastes consisting of these fluids.

Wastewaters would include wastes from industrial activities (spent aqueous cleaning/washing solutions, cooling system and steam cycle blowdowns, brines from water treatment, and spent glycol coolants), sanitary wastewaters from support of the workforce, and stormwater runoff from industrial areas. Industrial wastewaters such as blowdown from steam cycles and cooling systems and brines from water softening may be treated on-site, sent to on-site lined evaporation ponds for volume reduction, or containerized and transported to off-site treatment facilities. Because the workforce during operation is expected to be small, sanitary wastewaters are likely to be containerized and ultimately removed by a contractor to wastewater treatment facilities. In some instances, sanitary wastewater may be managed on-site through approved septic systems[23] or delivered to on-site packaged treatment plants. Stormwater runoff is expected to be managed in accordance with a site-wide stormwater pollution prevention permit but may require special handling if contaminated by contact with spilled chemicals.

3.5.2.2.2 PV Facilities. Some wastes associated with the operation of PV facilities would be analogous to wastes generated during CSP facility operation. However, not all CSP wastes would have PV analogs. Wastes related to the cleaning and maintenance of major PV system components and support equipment would be similar to wastes of such origins resulting from CSP facility operation. Spent solvents and aqueous cleaning solutions, spent oils, hydraulic fluids, and coolants, and wastes typical of building maintenance would all be generated, as well as domestic solid wastes from administrative activities and sanitary wastewaters associated with workforce support. However, PV facilities would not generate any wastes associated with the operation and maintenance of a steam cycle or cooling water systems. Management protocols for PV wastes are expected to be similar to those used for similar wastes generated at CSP facilities discussed previously.

Finally, routine operation of a PV facility should not result in waste solar panels. However, malfunctions or damage sustained in accidents or as a result of weather extremes may result in some panels needing to be replaced. In those instances, if the integrity of the panel is compromised, semiconductor material containing hazardous components may be released and would have to be managed as hazardous waste. The release of cadmium (Cd) and other heavy metals from broken modules (especially cadmium telluride [CdTe], copper-indium-diselenide [CIS], and copper-indium gallium selenide [CIGS]) and during fires constitutes an

[23] See, for example, the Conditional Use Permit Application for the Topaz Solar Farm, submitted to San Luis Obispo County, California (Topaz Solar Farms, LLC 2008).

area of concern (Nieuwlaar and Alsema 1997; EPRI and CEC 2003; Fthenakis and Zweible 2003).[24] Otherwise, it is anticipated that malfunctioning or damaged panels would be sent to recycling facilities where semiconductor material would be recovered, and the nonhazardous portions of the panel would be disposed of as solid waste.

3.5.3 Decommissioning Wastes

Decommissioning of a facility, whether it occurs prematurely or at the end of the facility's planned active life would be addressed in detail in an approved closure plan. Approved decommissioning is expected to include complete dismantlement of the facility and recycling of the individual equipment and components to the greatest extent practical. Equipment laydown areas established initially for facility construction may be reactivated during decommissioning to provide for interim storage of equipment and components awaiting recycling. Fluids removed from equipment would be characterized to determine appropriate disposal or evaluated for potential reuse. In either case, containerization and brief on-site storage would occur before ultimate disposition. Some pieces of equipment (e.g., large electrical equipment containing dielectric fluids), although recyclable, may need to be emptied of fluids before being moved; however, the fluids removed may be re-introduced into the equipment after evaluation for quality and contamination when that equipment is put into service at a different location. After emptying, components would be purged and cleaned with appropriate cleaning agents, and the resulting wastes characterized and disposed of in off-site facilities. Wastes associated with component cleaning and dismantlement include preventive maintenance wastes for the various construction equipment employed during decommissioning. Decommissioning wastes would also include contaminated soils and spent absorption media resulting from recovery and remediation of spills and leaks that occurred during facility operation or as a result of dismantlement activities. Such remediation wastes would be containerized and characterized for disposal in appropriately permitted off-site facilities. Road-building materials (sand gravel, clean fill) and removed concrete foundations and pads would be stockpiled for recycling, most likely for road building or fill operations elsewhere.

It is reasonable to expect that buried components would be removed to sufficient depths to facilitate revegetation of the site in accordance with a BLM-approved revegetation plan. Components at greater depths may be cleaned (when necessary) and abandoned in place. Buried pipes would be evacuated and cleaned and pipe segments capped before abandonment in place.

Special care must be exercised in the disposal of PV cells composed of high-performance solar cell materials that contain toxic metals (Fthenakis and Zweibel 2003; EPRI and CEC 2003). Where possible, those solar panels would be dismantled and delivered intact to off-site recycling facilities where the hazardous constituents would be removed and reprocessed. Damaged or broken panels that could not be recycled would need to be containerized and characterized for

[24] See Section 5.20 (Health and Safety) for more detailed discussions regarding the hazards associated with some semiconductor materials used in high-performance solar panels.

proper disposal, and areas surrounding their installed locations surveyed and remediated, if necessary, of any toxic metal contamination.

If lined surface impoundments are used during operation, remaining liquids, accumulated sludge, and any synthetic liner materials would be removed, containerized, and characterized for proper disposal, and the impoundment area re-graded with indigenous soils.

3.6 HEALTH AND SAFETY ASPECTS OF SOLAR ENERGY PROJECTS

Potential human health and safety issues related to solar energy projects are summarized in this section and discussed in greater detail in Section 5.21. Physical hazards to workers and potential safety and health issues for the general public are discussed. The potential for elevated exposures to electromagnetic fields is also discussed.

3.6.1 Occupational Hazards

Occupational health and safety programs associated with construction, operations, and decommissioning of solar facilities and associated transmission lines are regulated under the federal Occupational Safety and Health Act (29 USC 651 et seq.). A special consideration at solar facilities would be protection of vision from potentially damaging glare from the solar field; this would be addressed in the facility Health and Safety plan. Occupational noise exposure standards for workers must comply with the regulatory requirements of 29 CFR1910.95. The States may have additional laws and regulations that build on that law. Workers at any solar facility are subject to risks of injuries and fatalities from physical hazards. These occupational hazards can be minimized when workers adhere to safety standards and use appropriate protective equipment. However, fatalities and injuries from on-the-job accidents can still occur. Detailed project-specific health and safety plans and adequate worker training would minimize the likelihood of injuries and fatalities.

Most of the occupational hazards associated with solar energy projects are similar to those of the heavy construction and electric power industries. There is additional hazard associated with the fact that many construction activities would take place outdoors in remote locations. Accident rates have been tabulated for most types of work, and risks can be calculated on the basis of historical industry-wide statistics. The National Safety Council (NSC) maintains statistics on the annual number of injuries and fatalities by industry type (NSC 2006). The expected annual number of worker fatalities and injuries for specific industry types can be calculated on the basis of NSC rate data and the number of annual fulltime equivalent workers required for construction and operations activities at a solar energy project (see Section 5.21).

The risk of occupational heat stress or stroke is likely to be high during construction of solar facilities and associated transmission lines, given the desert location of much of the study area. Health and safety plans will need to address this risk. Chemical exposures during construction and operation of a typical solar energy project are expected to be routine and minimal and mitigated by using personal protective equipment (PPE) and/or engineering controls

to comply with OSHA permissible exposure limits (U.S. Department of Labor 1997) that are applicable for construction activities.

At PV facilities, infrequent damage to solar panels could result in the accidental release of small quantities of hazardous metal compounds to the ground surface. Cleanup procedures for these accidental releases would require the use of PPE; thus actual worker exposures to these substances would be low.

3.6.2 Public Safety

A potential public safety issue is unauthorized or illegal access to solar facilities. During such unauthorized access, individuals could disturb electrical equipment (e.g., attempt to open electrical panels, which could result in electrocution) or encounter other hazards. Such access is minimized through the use of fencing around the entire site and around electrical equipment, but it may still occur occasionally.

There is some potential for members of the general public to be exposed to reflected light from solar facility mirrors at an intensity that could cause eye injury, particularly for brief periods when mirrors are being rotated. Measures to prevent such exposures would be established during project-specific planning.

Dry vegetation and/or high winds may cause a potential fire hazard around solar facilities and transmission lines. Under these conditions, fires could start for a variety of reasons, such as electrical shorts, insufficient equipment maintenance, contact with power lines, and lightning. A potential impact from construction and operation of solar facilities and transmission lines could include an increased risk of fires because of the use of flammable fuels and hazardous materials, as well as the operation of internal combustion sources (e.g., vehicle engines) and external combustion sources (e.g., boilers) during the construction and decommissioning phases and, to a lesser extent, during operations.

The clearing of native vegetation that is subsequently replaced by invasive species in a ROW could also increase the risks of both initiation and spread of fires. For example, if invasive annual grasses were allowed to invade and populate a ROW, the risk of fires in that ROW might be more than the risks in the undisturbed ROW. However, clearing and maintaining a ROW could also result in the creation of a man-made firebreak. Clearing mainline ROWs and certain functional areas, such as electrical substations and pump and compressor stations, for operational safety can also reduce the amount of fuel available within the ROW for fires.

Fire risks might increase because of the presence of certain structures associated with transmission lines. Tall electricity transmission towers represent an increased potential for lightning strikes (however, standard practice would require that all such structures be grounded). Ground faults or arcing from energized electricity conductors and substation equipment also

represent increased potential for fire.[25] Fire-fighting personnel face increased risk of electrocution where high-voltage lines are present. The transmission lines and their support towers could represent obstacles to safe staging of firefighting equipment (including air tankers). However, maintenance access roads along transmission lines often provide critical access points for effective firefighting.

Because smoke increases the conductivity of the air, smoke from wildfires can cause flashover between conductors. Damage to towers or power conductors due to exposure to intense heat from an adjacent fire could cause wholesale failure of the transmission system, involving electrical arcing to ground that would jeopardize firefighting personnel and equipment in the immediate vicinity. For this reason, high-voltage lines near active wildfires are often de-energized. Lines are almost always de-energized before fires actually reach the transmission facilities themselves.

3.6.3 Electric and Magnetic Fields

Power lines and electrical equipment generate both electric and magnetic fields. Because of the presence of electrical substations at solar energy facilities, and the transmission lines associated with these facilities, the potential hazards to human health and safety from electric and magnetic fields (EMFs) must be considered. Wherever electric currents flow, EMFs are produced. These fields rapidly decrease in strength with distance from the source. Electric field strengths directly beneath high-voltage power lines can reach up to several thousand volts per meter (V/m); typical electric field strengths in homes associated with the 60-Hz AC sources used in the United States range from about 0 to 10 V/m (NIEHS 2002). The electric field strength along the edge of the ROW for a 230-kV transmission line is about 1.5 kV/m. The potential for adverse health effects from magnetic fields has been the focus of research because a few studies have shown associations between magnetic field exposure and some types of cancers (further discussed below). No such associations have been observed for electric fields. A voluntary occupational exposure guideline of 8.3 kV/m and a general public exposure guideline of 4.3 kV/m for electric fields have been developed by the International Commission on Non-Ionizing Radiation Protection (as cited in NIEHS 2002).

Sources of magnetic fields include aboveground and underground power lines. At the edge of a 150-ft (45-m), 230-kV aboveground transmission line ROW, the magnetic field strength is about 20 milligauss (mG); at 300 ft (91 m) from the centerline, the magnetic field strength is about 0.8 mG (BPA 1993), which is the approximate background level. For a 500-kV aboveground transmission line ROW, the magnetic field strength is about 29 mG at 150 ft (45 m) and 1.4 mG at 300 ft (91 m). The actual field strengths depend on line design and current levels.

For comparison, magnetic fields associated with electrical appliances are highly variable, typically ranging from less than 10 mG up to about 1,000 mG, at about 0.5 ft (0.2 m) from an

[25] Most high-voltage transmission lines have static lines or shielding cables strung above the conductors to deflect lightning strikes to grounds on the structures. In addition, ground faults will automatically cause line lock-outs until the fault is investigated and repaired. These procedures limit risks of fire or electrocution.

operating electrical appliance such as a can opener (EPA 1992). At 4 ft (1.2 m) from the source, almost all magnetic field strengths associated with electrical appliances drop to 10 mG or less.

Exposures of the general population are most accurately measured as 24-hour averages, using personal exposure meters. Most people in the United States are exposed to 24-hour average magnetic field strengths of less than 2 mG (Zaffanella and Kalton 1998). Some types of work lead to increases in magnetic field exposures, especially for electrical workers, persons working near machines with electric motors, and welders. Time-weighted average exposures for these workers range from about 1 to 40 mG (NIEHS 1999).

Acute exposure to high-level external extremely low frequency (ELF) magnetic fields induces electric fields and currents in individuals, causing nerve and muscle stimulation and changes in the central nervous system (WHO 2007). These effects occur at magnetic field levels above 1,000 mG.

Concern in the United States over possible adverse health effects associated with exposure to low-level magnetic fields started in 1979, with a publication showing an association between childhood leukemia and proximity of homes to power lines (Wertheimer and Leeper 1979). Since then, hundreds of epidemiological and laboratory studies have been conducted. Closeness to power lines has not been found to be a valid risk factor for increased childhood leukemia. However, a weak association, based on epidemiological studies, has been found between measured magnetic field exposures and both childhood and adult leukemia. In 1999, the National Institute of Environmental Health Sciences (NIEHS) completed a review of the data and concluded that there was weak scientific evidence that exposure to ELF EMFs could pose a leukemia hazard (NIEHS 1999). In 2002, the International Agency for Research on Cancer (IARC) classified ELF magnetic fields as possibly carcinogenic to humans (IARC 2002). A 2002 California Department of Health Services report also classified exposure to magnetic fields as possibly carcinogenic to humans, as well as possibly causative in adult brain cancer, amyotrophic lateral sclerosis, and miscarriage (Neutra et al. 2002).

Electrical workers, with their higher 24-hour average magnetic field exposures, might be expected to have an elevated rate of leukemia, brain cancer, or other cancers if magnetic fields cause cancer. Many large epidemiological studies, including tens of thousands of electrical workers, have been conducted. Of five large studies discussed in a NIEHS (2002) report, only one reported a small but statistically significant increase of lung cancer and all cancers combined for electrical workers. The other four studies showed no consistent association between magnetic field exposures and cancer.

Because of the inconclusive nature of the association between cancer and exposure to magnetic fields, there are no United States standards applicable for long-term, low-level exposures of the general public or workers. Given the uncertainties, the World Health Organization states that the adoption of arbitrary low exposure limits is not warranted, but recommends that simple and low-cost ways of reducing exposure when constructing new facilities should be implemented.

3.7 EXISTING AGENCY PROCESSES AND GUIDANCE

3.7.1 Current BLM Process for Issuing Solar Development ROWs

The BLM's existing Solar Energy Policies (BLM 2007; 2010a,b) are presented in their entirety in Appendix A, Section A.1. Applications for commercial solar energy facilities, both PV and CSP, are processed as ROW authorizations under Title V of FLPMA and 43 CFR Part 2804. Applicants must submit a complete and acceptable application and provide a cost-recovery payment before the BLM will initiate processing of a ROW application.

The application process begins with a pre-application meeting with a BLM authorized officer. During this meeting, potential issues and land use conflicts affecting the BLM's decision to issue or not issue the ROW authorization can be identified. The pre-application process identifies any environmental or cultural resource studies that may be needed, assesses public interest and concerns, identifies other authorized uses within or near the area, allows consideration of potential alternative site locations, and outlines arrangements for paying the costs associated with processing a ROW.

The ROW authorization contains appropriate stipulations relating to all aspects of project development, including, but not limited to, road construction and maintenance; vegetation removal; natural, cultural, and biological resources mitigation and monitoring; and site reclamation. When a ROW is issued, the ROW holder is encouraged, through terms and conditions of the ROW authorization, to work with the BLM to increase public acceptance and awareness of the benefits of solar energy development by providing information and public viewing areas at safe locations near the development. Other compatible uses for the ROW area may be authorized by the BLM but are unlikely due to the intensive use of the site for PV or CSP facility equipment.

An approved Plan of Development for construction and operation of a solar facility must be completed prior to beginning construction. When possible, the ROW authorization and the Plan of Development are processed simultaneously. A bond is also required for solar energy development ROWs to ensure compliance with the terms and conditions of the authorization and the requirements of the regulations, including reclamation. The reclamation provisions within the Plan of Development include removal of solar collectors and other structures, and the reclamation of access roads and disturbed areas.

The term length of authorizations would typically be 30 years, which is the general design life of utility-scale solar facilities. The authorization could be renewed consistent with the regulations (43 CFR 2807.22(a)); the ROW would be renewed if the applicant showed compliance with the terms, conditions, and stipulations of the original ROW and with applicable laws and regulations. Under the current ROW authorization process, the holder of a ROW authorization pays an annual rent established by the BLM on the basis of an established Rental Schedule (as described in BLM's interim rental policy issued in June 2010 [BLM 2010a]). Under this policy, the rental payment reflects the full use of the public land for solar facilities, similar to

a lease for industrial purposes. A portion of the rental payment will be phased in over a 5-year period once the facility begins generating electricity.

ROW applications for solar energy development are generally accepted and processed on a first-come, first-served basis. The BLM discourages applicants from holding ROW authorizations for the purposes of speculating, controlling, or hindering development of solar energy on public lands, through ensuring that applicants meet qualification requirements, including providing information on their technical and financial capabilities to construct, operate, maintain, and terminate the solar energy facilities. The regulations provide the authority to deny an application if the applicant cannot demonstrate adequate technical ability to construct, operate, and maintain the solar energy facilities. The BLM may also deny an application if the applicant does not provide, in a timely manner, additional information requested by the BLM to process an application or the required cost recovery funds.

Solar energy development ROW authorizations include a due diligence requirement for installation of facilities consistent with an approved Plan of Development, with construction to begin within 2 years of the ROW being issued. If construction has not been started within this time frame, the ROW holder must provide the BLM good cause as to the nature of any delay, evidence of progress toward beginning construction, and the anticipated date of start-up operations, or the authorization may be terminated.

Environmental analyses are required for solar energy development projects in accordance with the National Environmental Policy Act of 1969 (NEPA) and must address potential direct, indirect, and cumulative effects of the project. The scope of the NEPA analysis must include the installation and maintenance of solar collectors, water for steam generation and cooling purposes, oil or gas used by backup generators, thermal or electrical storage, turbines or engines, access roads and electrical inverters, and transmission facilities. The NEPA analysis must also include assessment of land disturbance, water use, and potential impacts on natural, cultural, and biological resources.

The BLM is using the 2007 Solar Energy Development Policy as updated by instruction memoranda issued in 2010 (BLM 2010a,b) to continue processing applications while this PEIS is being developed. As of December 1, 2010, the BLM had approved eight utility-scale ROW authorizations in the six-state study area under these policies.

3.7.2 Options for ROW Processing

As stated previously, ROW applications for solar energy development are generally accepted and processed on a first-come, first-served basis. However, the ROW regulations in 43 CFR 2804.23(c) provide authority for offering public lands under competitive bidding procedures for solar energy ROW authorizations. The BLM can initiate a competitive process if a land use planning decision has specifically identified an area for competitive leasing. The BLM may also consider other public interest and technical factors in determining whether to offer lands for competitive leasing. Competitive bidding follows the procedures required by 43 CFR 2804.23(c).

Another option for facilitating solar energy development would be a land withdrawal, under which a tract of land would be withdrawn to establish a solar energy zone. The withdrawal of land for a solar energy zone could be for BLM administration[26] or for administration by another federal agency, bureau, or department. Withdrawals are governed by regulations issued under the FLPMA, contained in 43 CFR Part 2300. A withdrawal is defined as

> "…withholding an area of Federal land from settlement, sale, location, or entry under some or all of the general land laws, for the purpose of limiting activities under those laws in order to maintain other public values in the area or reserving the area for a particular public purpose or program; or transferring jurisdiction over an area of Federal land, other than property governed by the Federal Property and Administrative Services Act (40 U.S.C. 472), from one department, bureau or agency to another department, bureau or agency" (see 43 CFR 2300.0-5[h]).

The FLPMA gives the Secretary of the Interior the authority to make, modify, extend, or revoke certain land withdrawal actions. Withdrawal proposals exceeding 5,000 acres (20 km^2), however, are subject to congressional consideration and review. To effect a land withdrawal, the agency receiving jurisdiction must follow a series of steps involving detailed initial consultation with the BLM, comprehensive environmental impact reviews (e.g., NEPA analyses), and consultations with other federal, state, and local agencies as well as other stakeholders. Ultimately, the process would result in issuance of either a public land order that would implement the land withdrawal, or a denial. The withdrawal application process can take several years. The lands would be set aside (segregated) from sale or other claims for a period of 2 years once the withdrawal application was accepted by the Secretary. This segregation would protect the land from being committed to other, competing uses; however, actions proposed as part of the withdrawal application could not be implemented during this time.

The BLM could also decide to dispose of land that could then be used for solar energy development. Land disposals can be exchanges or sales of BLM-administered lands with or to state government, local government, or private entities. The BLM must confirm that the lands being considered for exchange or sale have been identified as potentially suitable for disposal in an approved land use plan or plan amendment (BLM 2008a). If the lands have not been identified for potential disposal in an existing land use plan, the BLM has the discretion of completing a plan amendment to assess and determine whether disposal of the land would be in the public interest. The BLM must coordinate disposal actions with the appropriate state and local governmental entities, authorized users, adjoining land owners, and other parties that have expressed an interest. In most cases, this coordination occurs at the beginning stages of a proposed land disposal action, and again at the conclusion when a Notice of Realty Action is published and presented to the appropriate governing authorities. The BLM must also complete an environmental analysis to assess the potential impacts of a proposed disposal action. If the analysis concludes that disposal of the land would result in impacts on resources and/or existing uses that cannot be properly mitigated, the lands would not be made available for exchange or sale.

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[26] See the BLM's Notice of Proposed Withdrawal (Volume 73, page 31308 of the *Federal Register* [73 FR 31308]) to protect and preserve solar energy study areas for future solar energy development.

3.7.3 Existing Mitigation Guidance Relevant or Applicable to Solar Energy Development

Federal agencies with jurisdiction over proposed projects often utilize mitigation measures, best management practices (BMPs), guidelines, or stipulations to keep the impacts of specific activities on the surrounding environment to a minimum. For utility-scale solar facilities, some guidance has already been developed by the BLM and by other agencies. In the development of mitigation measures for inclusion in BLM's proposed Solar Energy Program and DOE's proposed guidance, existing agency guidelines have been reviewed (Engelhard 2009; Scofield 2009; CEC, CDFG, BLM, and USFWS 2009), and relevant and appropriate elements have been incorporated. While some existing guidelines have been incorporated into the proposed BLM Program, the specific requirements have been defined on the basis of reviews and analyses conducted in the course of this PEIS and, therefore, may vary from those put forth by other organizations.

While some of the potential impacts associated with solar energy development projects described in Chapter 5 are unique to this type of activity, several of the potential impacts (e.g., road construction and habitat fragmentation) are common to other types of development activities, and the BLM has existing guidance for the environmentally sound conduct of these activities. Such existing BLM guidance and planning documents established for other types of development activities have also been reviewed and considered for inclusion as proposed guidance and mitigation measures for solar energy development.

3.7.3.1 BLM Guidance

The BLM has developed many program-specific guidance documents that establish mitigation requirements for a variety of activities. This guidance comes in many forms—manuals, handbooks, instruction memoranda (IMs), environmental memoranda, technical references, BMPs, standards, directives, land use plans, and other such documents. The existing Solar Energy Development Policy (BLM 2007) (Appendix A) directly addresses solar energy development and was summarized in Section 3.7.1. The BLM's proposed Solar Energy Program, developed in this PEIS, includes policies and design features requiring that relevant BLM mitigation guidance be incorporated into individual solar energy development project Plans of Development, as appropriate, to address site-specific issues.

Two BLM guidance documents have been identified that contain mitigation guidance for solar energy development projects: the first is the BLM's Revised Wind Energy Policy IM (BLM 2008b), and the second is the BLM's IM for Compensatory Management (BLM 2008c). In addition, BLM land use plans may contain stipulations that are relevant to solar energy development. These items are discussed below.

The Wind Energy Development PEIS (BLM 2005) developed a wind energy program for the BLM, similar to the proposed BLM program for solar energy development provided in this PEIS. The wind program was updated somewhat with the release of the BLM's revised Wind Energy Development Policy, IM 2009-043 (BLM 2008b) in December 2008. The Wind Energy Development Policy established new policies specific to wind energy development, including

requirements to avoid National Landscape Conservation System lands; consult with appropriate federal, state, and local agencies and Tribal governments; amend land use plans to address wind energy development; provide a Plan of Development for each project incorporating all appropriate BMPs; obtain bonds for projects; consider habitat conservation; consider visual resource values; and incorporate adaptive management strategies and monitoring programs for wind energy projects. The BMPs include requirements for Plan of Development content (specifying, for example, use of existing roads and infrastructure as much as possible and inclusion of monitoring programs); protection of wildlife, other ecological resources, cultural, paleontological, and visual resources; control of noise, hazardous materials and waste, and noxious weeds; and protection of water resources and human health and safety. BMPs are specified for the siting, construction, operations, and decommissioning phases of project development. These policies and BMPs were considered for applicability in establishing the proposed Solar Energy Program for BLM and for the DOE's proposed guidance (Section 2.2).

The BLM has also issued IM 2008-204, Interim Offsite Compensatory Mitigation for Oil, Gas, Geothermal and Energy Rights-of-Way Authorizations, which outlines policy for the use of off-site mitigation for authorizations issued by the BLM (this IM replaces IM WO-2005-069), including solar energy development (BLM 2008c). Compensatory mitigation is defined in the memorandum as mitigation actions that are undertaken off-site to compensate for an impact by replacing or providing substitute resources or environments. This off-site mitigation can be immediately adjacent to the area affected but can also be located anywhere in the same general geographic area.

The BLM's land use plans are planning and management documents that define how resources will be managed within a specific planning area, and they establish restrictions on activities to be undertaken in that planning area. The land use planning process is the key tool that the BLM uses to protect resources and designate uses on federal lands that it manages. These plans help ensure that public lands are managed in accordance with applicable laws and regulations under the principles of multiple use and sustained yield. The BLM develops land use plans in accordance with federal requirements and BLM regulations and planning policies. Depending on when a land use plan was written or last revised, it may exist as a Management Framework Plan, the original format, or as a newer Resource Management Plan. Land use plans are typically organized according to the resources present in the planning area. For each identified resource (e.g., wildlife, minerals, or recreation areas), the plan will identify management objectives and management actions. Often the management actions establish restrictions or stipulations regarding the use or development of the given resource. Many resources are common to virtually all BLM planning areas, and the corresponding land use plans establish management actions to ensure appropriate resource management. Many of these are resources that might be affected by solar energy development projects: wildlife (including federally and state-protected species), wildlife habitat, soils, water resources, cultural and historic resources, visual resources, recreation areas, and forestry resources. In addition, many land use plans establish restrictions or stipulations specific to relevant management issues, such as hazardous materials management, fire management, and wild horse management.

Stipulations from individual land use plans have not been incorporated into the guidance, policies, and required mitigation measures presented as BLM's Solar Energy Development

Program in this PEIS. However, stipulations from the applicable land use plans will be addressed at the time of site-specific NEPA reviews for individual solar energy facilities.

Finally, the BLM has issued many program-specific documents addressing environmental issues relevant to solar energy projects. The topics covered by these documents that can reasonably be identified as relevant include the NEPA, visual resource management, road construction and maintenance, wildlife management (including special status species, Endangered Species Act of 1972 [ESA] species, threatened and endangered species, and sage-grouse management), Areas of Critical Environmental Concern; hazardous materials and waste management, cultural resource management, Native American consultations, pesticide use and integrated pest management, and occupational health and safety. Relevant BLM program-specific mitigation documents were used and referenced in developing design features applicable for solar energy development (see Appendix A, Section A.2.2). Readers may obtain the complete guidance documents if they wish to obtain more information. Electronic copies of some of the BLM regulations, manuals, handbooks, IMs, and bulletins are available at http://www.blm.gov/wo/st/en/national_page/site_maps/site_map_index/washington_office.html.

3.7.3.2 DOE Guidance

Guidance is available for developers seeking aid through DOE's Loan Guarantee Program regarding the types of projects that would require NEPA documentation, and the level of documentation required (DOE 2010). In addition, the Western Area Power Administration has developed standards (Western 2008) that would be relevant for the construction and operation of transmission interconnects built in association with solar energy facilities. These standards address many potential impacts, including the management and disposal of hazardous materials and wastes, landscape preservation, noxious weed control, prevention of air and water pollution, and the protection of habitat. These standards have been considered for applicability in establishing the proposed Solar Energy Program for BLM and for DOE's proposed guidance (Section 2.2).

3.7.3.3 Other Guidance

The United Nations Environmental Programme (UNEP) has developed environmental due diligence guidelines for solar thermal energy systems (UNEP undated-a) and for solar PV energy systems (UNEP undated-b). These guidelines discuss the potential for soil and groundwater contamination, biodiversity protection, visual impacts, land use, and public health and occupational hazards associated with the technologies, and were reviewed for applicability to the proposed Solar Energy Program for BLM and for DOE's proposed guidance.

State wildlife agencies have also developed guidelines for avoidance and mitigation for wildlife impacts. State Wildlife Action Plans can be used as guidance to help avoid impacts on wildlife resources. In addition, State Heritage Data Management Systems are available to identify wildlife species status and distribution. For the SEZ-specific PEIS analyses (Chapters 8

through 13), state-specific guidelines for avoidance and mitigation of wildlife impacts have been considered and referenced, as applicable.

3.8 REFERENCES

Note to Reader: This list of references identifies Web pages and associated URLs where reference data were obtained for the analyses presented in this PEIS. 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. The original information has been retained and is available through the Public Information Docket for this PEIS.

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4 AFFECTED ENVIRONMENT

4.1 INTRODUCTION

Chapter 4 presents a general description of the existing conditions and trends of resources and resource uses in the six-state study area that may be affected by implementing BLM's and DOE's proposed alternatives. While the description in general covers the six-state area, with respect to certain resources the discussion of the affected environment on BLM-administered lands receives additional focus. For instance, ecological resources are varied in their distribution, and some that occur in the six-state area are not present on BLM-administered lands. The description of the affected environment in this chapter provides the basis for identifying potential impacts and is of sufficient detail to support the programmatic nature of the Solar PEIS. Detailed descriptions are provided for individual proposed solar energy zones (SEZs) in Chapters 8 through 13 of the PEIS. Factors such as climate change that may have an influence on the current conditions and potential trends of individual resources and resource uses have been incorporated as appropriate under individual resource sections that follow.

The U.S. Department of the Interior (DOI) Bureau of Land Management (BLM) manages large acreages of diverse public lands within the six-state study area, with topography ranging from low deserts to high mountains. The land uses are as varied as the terrain and include livestock grazing; fish and wildlife habitat; oil, gas, and mineral exploration and development; right-of-way (ROW) authorizations; a wide range of outdoor recreation activities; and timber production. These uses are managed within a framework of numerous public land laws, the most comprehensive of which is the Federal Land Policy and Management Act of 1976 (FLPMA). The FLPMA establishes several fundamental policies regarding the management of public lands (Section 102(a)), including the policy directing that lands be managed "...on the basis of multiple use and sustained yield unless otherwise specified by law." "Multiple use" means management so that "public lands and their various resource values … are utilized in the combination that will best meet the present and future needs of the American people" (Section 103(c) of FLPMA). "Sustained yield" means the achievement and maintenance in perpetuity of a high level or regular periodic output of the variable renewable resources of the public lands consistent with multiple use (Section 103(h) of FLPMA).

The uses to which public lands are dedicated and the allocation of those uses are identified in BLM land use plans called Resource Management Plans (RMPs). RMPs are periodically prepared and revised through an open process that encourages input from public land users and other interested individuals and groups regarding the mix of potential uses of the public lands. About 90 land use plans cover the lands within the six-state study area that are being analyzed in this programmatic environmental impact statement (PEIS) and that could be affected by decisions related to activities evaluated in the PEIS.

The status of public lands in the six-state study area is constantly changing with the approval of new ROWs, land exchanges, withdrawals, and the implementation of land use plan and management decisions. Some of these changes could be very large including the proposed 29 Palms Marine Base Expansion; the proposed legislation to preserve additional lands between

the Mojave National Preserve, Joshua Tree National Park, and the San Bernardino National Forest; and the ongoing consideration of applications for solar energy development on BLM-administered lands.

Figures 2.2-1 through 2.2-6 in Section 2 show the BLM-administered lands proposed as being available for application for solar energy development in this PEIS. This chapter provides much of the basic land use and resource information that will be used in shaping the decisions regarding potential development of utility-scale solar energy production on the public lands within the six-state study area.

4.2 LANDS AND REALTY

The BLM administers approximately 245 million acres (more than 1 million km^2) of land in 11 western states and Alaska. These lands, which are generally known as "public lands," are often intermingled with other federal, state, or private lands. The BLM also administers about 700 million acres (2.83 million km^2) of subsurface mineral estate; some of these mineral estates underlie the BLM-managed lands mentioned above, some underlie lands administered by other federal agencies, and some underlie state or private lands.[1] Within the six-state PEIS study area, the BLM manages almost 120 million acres (486,000 km^2) of public lands. Table 4.2-1 lists the total surface acreage of the six-state study area as of FY 2007, as well as the acreages of all federal lands and BLM-administered lands. The acreage data used in the table were current at the time of assembly and are still generally representative.

The public lands included in the PEIS study area experience some of the highest levels of solar insolation in the United States. The existence of blocks of public land that could physically accommodate utility-scale solar development naturally has drawn attention to these areas; however, there also are large blocks of both private and state lands in the same areas with the same solar energy potential that could support utility-scale solar development.

ROWs are authorized under FLPMA. Section 103(l) FLPMA identifies ROWs as one of the principal or major uses of the public lands. A ROW conveys a legal right to occupy, use, or traverse public lands. The BLM grants or renews ROWs on public lands for a variety of uses, including reservoirs; pipelines; electrical generation, transmission, and distribution systems; and roads (BLM 2005a, 2006). Once granted, a ROW conveys a right to occupy public lands and, depending on the specific ROW grant, provides a priority for use of the public land for the specified term of the ROW. ROWs are typically issued for 20 to 30 years, but some may be granted in perpetuity. Through the land use planning process, the BLM may identify areas that are available for application for various types of ROWs and, in some areas, may identify where ROWs are either to be avoided or excluded. Through its land use planning process, the BLM has identified and continues to identify transmission corridors that are intended to provide locations on federal lands for future electrical and pipeline construction. These corridors would be available to provide for transmission facilities to support renewable energy developments. The

[1] Unless specifically noted otherwise, references in this PEIS to lands administered are for surface only and do not include mineral estates.

TABLE 4.2-1 Acreage and Percentage of BLM-Administered Public Lands in the Six-State Study Area

State	Total State Acreage (million acres[a])	Federal Surface Land Acreage (million acres[a])	BLM-Administered Public Lands (million acres[a])	% BLM Lands (of total state acreage)
Arizona	72.7	33.0	12.2	16.8
California	100.2	45.0	15.2	15.2
Colorado	66.5	24.1	8.3	12.5
Nevada	70.3	58.4	47.8	68.0
New Mexico	77.8	26.5	13.3	17.1
Utah	52.7	34.0	22.8	43.3
Total	440.2	221.0	119.6	27.2

[a] To convert acres to km^2, multiply by 0.004047.

Sources: BLM (2007c); percentages calculated.

PEIS entitled *Energy Corridors on Federal Land in the 11 Western States* (DOE and DOI 2008) (see Section 1.6.2.1), is an example of the ongoing nature of the transmission corridor planning and designation process.

Applications for utility-scale solar and transmission facilities would be processed as ROW authorizations under Title V of FLPMA and Title 43, Part 2804 of the *Code of Federal Regulations* (43 CFR Part 2804).

4.3 SPECIALLY DESIGNATED AREAS AND LANDS WITH WILDERNESS CHARACTERISTICS

Specially designated areas include a variety of types of areas that have received recognition or designation because they possess unique or important resource values. While these areas would not be available for development of solar energy resources, they could be located near solar development areas and could be affected by solar development.

Examples of BLM-administered specially designated areas include components of the BLM National Landscape Conservation System (NLCS), areas of critical environmental concern (ACECs), special recreation management areas (SRMAs), and areas with wilderness characteristics.[2] These areas may have been designated by Executive Order, an Act of Congress, or by the BLM through its land use planning process. The majority of specially designated areas

[2] Such an area is a category of land that has been recognized by the BLM as possessing wilderness characteristics but that has not been identified as a Wilderness Study Area (WSA). If the BLM has made a decision in a RMP to manage lands to protect these wilderness characteristics, they are not open to application for solar energy development.

discussed in this PEIS are located on BLM-administered public lands; however, some specially designated areas managed by the U.S. Forest Service (USFS), U.S. Fish and Wildlife Service (USFWS), and National Park Service (NPS), as well as areas designated by states and localities, also are included in the analysis when they could be affected by solar development on public lands. The specially designated areas on public lands are shown in the individual state maps in Figures 4.3-1 through 4.3-7.

In Fiscal Year (FY) 2007, about 42.7 million acres (173,000 km^2) of BLM-administered lands in the six-state study area were managed as part of the NLCS. NLCS lands include National Monuments and National Conservation Areas, Designated Wilderness, Wilderness Study Areas (WSAs), Wild and Scenic Rivers (WSRs) and national historic and scenic trails (Table 4.3-1).[3] Other conservation designations within the NLCS are Instant Study Areas[4] (ISAs), Forest Reserves, National Recreation Areas, Research Natural Areas, and Outstanding Natural Areas.

BLM land use plans within the six-state study area identify 528 areas, incorporating about 9.3 million acres (37,665 km^2), as Areas of Critical Environmental Concern (ACECs) (BLM 2007c).These areas are managed to protect the relevant and important resource values for which the areas were designated. Resource values protected can be quite varied; examples include important wildlife and plant habitat, scenic resources, recreation areas, cultural resources, and areas with natural hazards.

4.4 RANGELAND RESOURCES

4.4.1 Livestock Grazing

Livestock grazing is a major and widespread use of public lands. About 105 million acres (424,920 km^2) (Pack 2009) are included within grazing allotments located on public lands being considered in this PEIS. Grazing that occurs on public lands is authorized either through a grazing permit or lease. BLM grazing regulations governing such use of public lands are contained in 43 CFR 4100. In FY 2007, the BLM issued 6,439 grazing permits and leases in the six-state study area.

4.4.2 Wild Horses and Burros

Wild horses and burros occur on public lands within the six-state study area. The Wild Free-Roaming Horses and Burros Act (*United States Code*, Title 16, Section 1331 et seq.

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[3] The NLCS acreage cited includes substantial "double counting." For example, areas of wilderness are included within National Monuments and National Conservation Areas.

[4] Section 603(a) of FLPMA requires that areas identified as natural or primitive areas at the time of FLPMA's passage in 1976 be studied for suitability for wilderness designation. These areas became known as Instant Study Areas (ISAs), and are managed as WSAs.

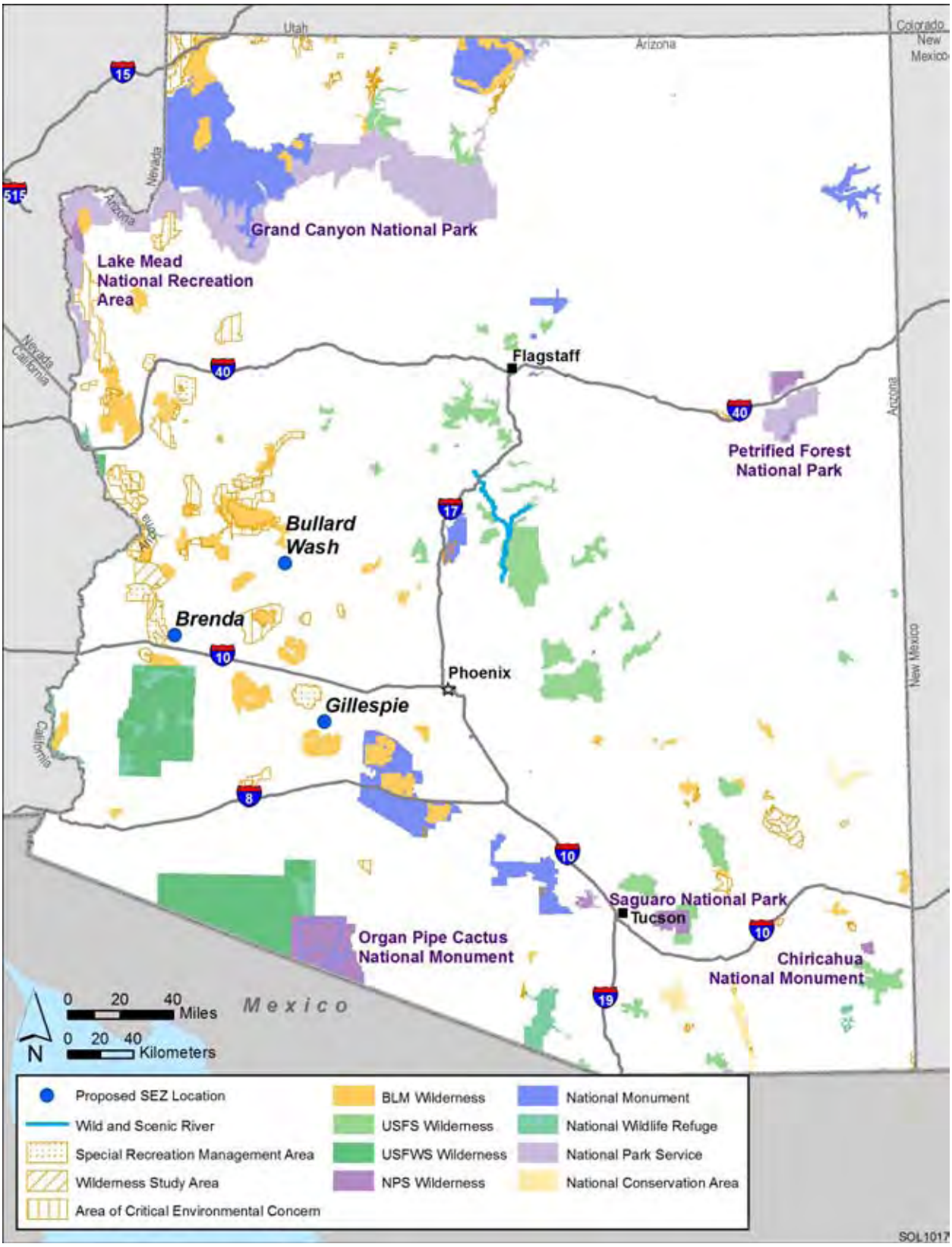

FIGURE 4.3-1 Specially Designated Areas on Public Lands in Arizona

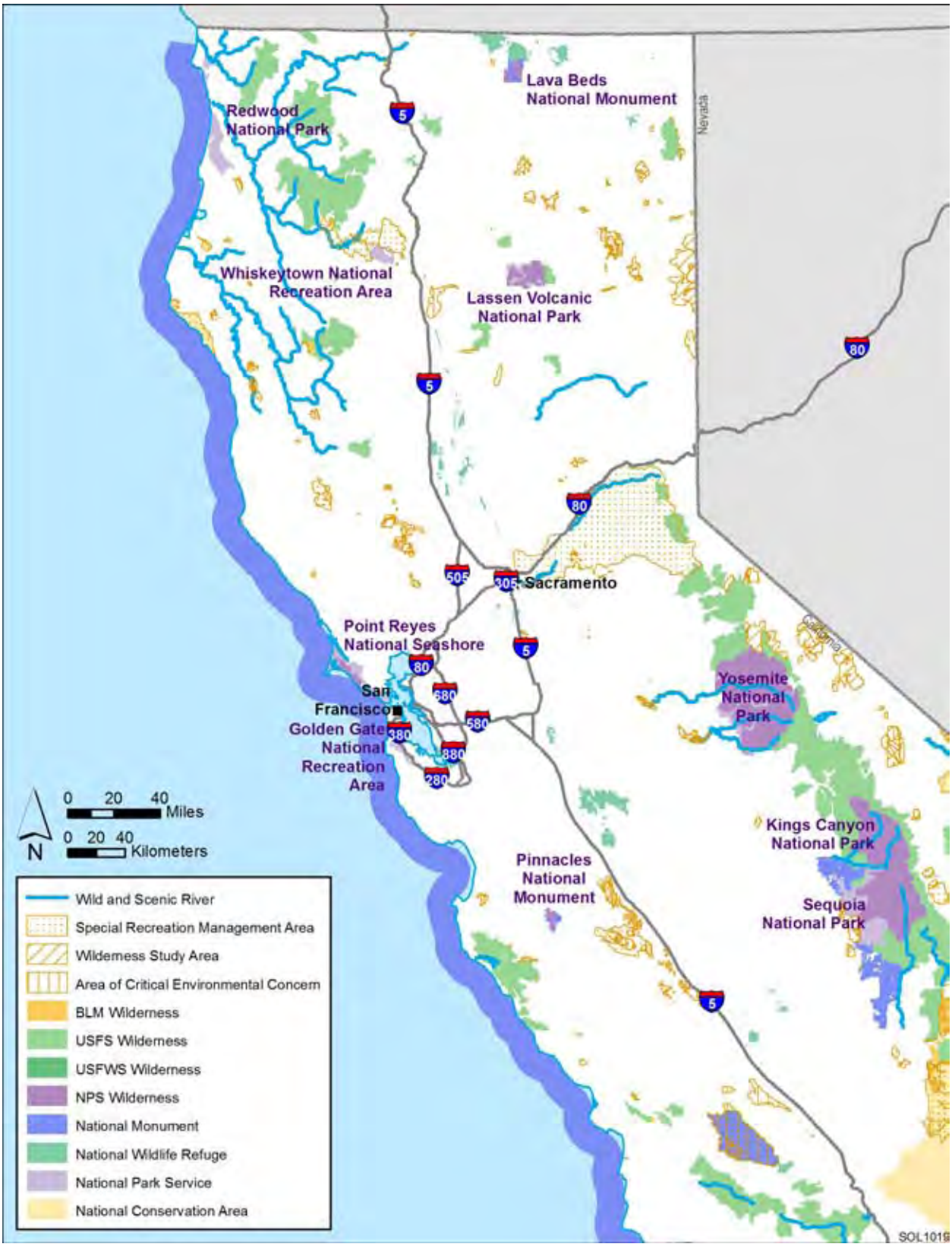

FIGURE 4.3-2 Specially Designated Areas on Public Lands in Northern and Central California

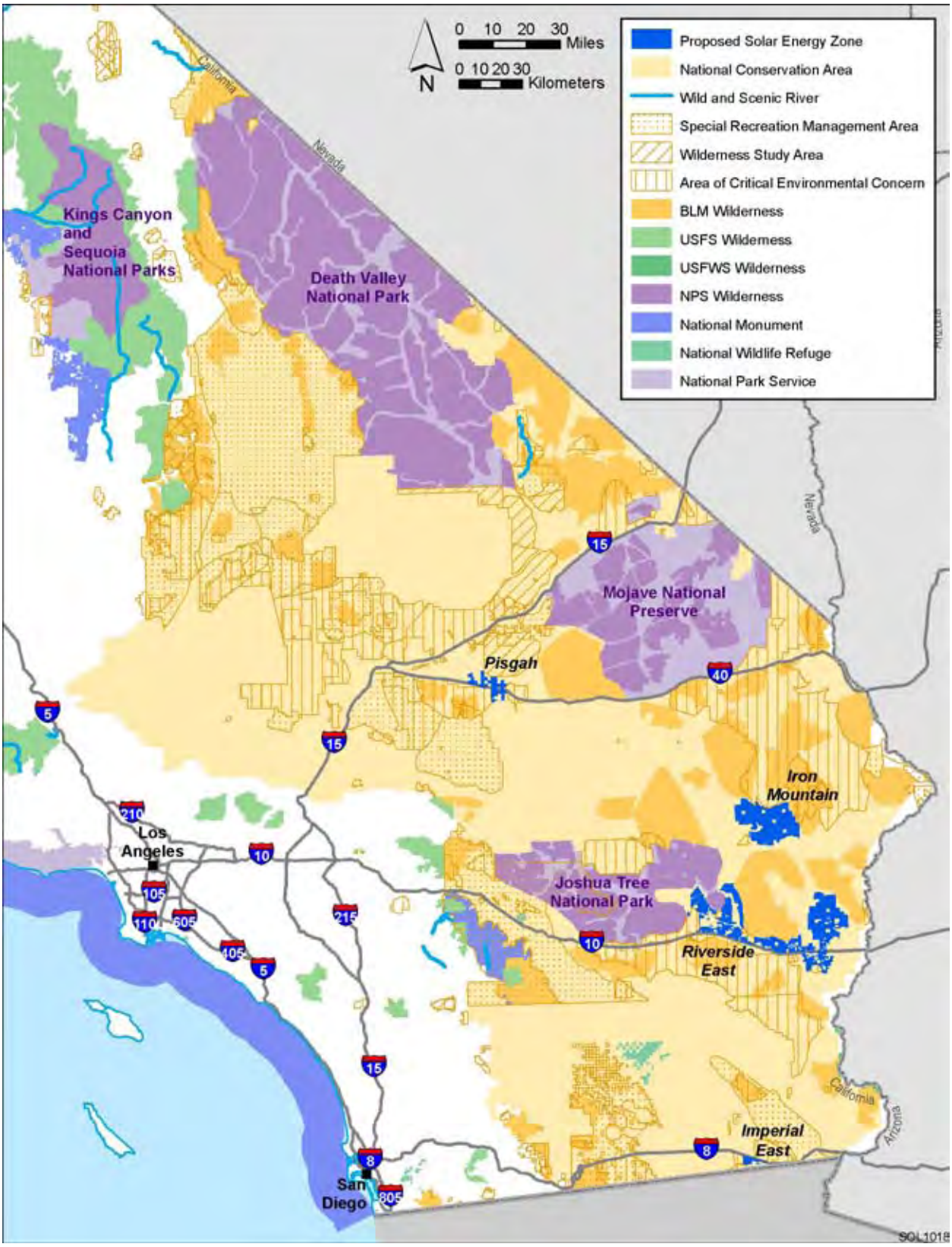

FIGURE 4.3-3 Specially Designated Areas on Public Lands in Southern California

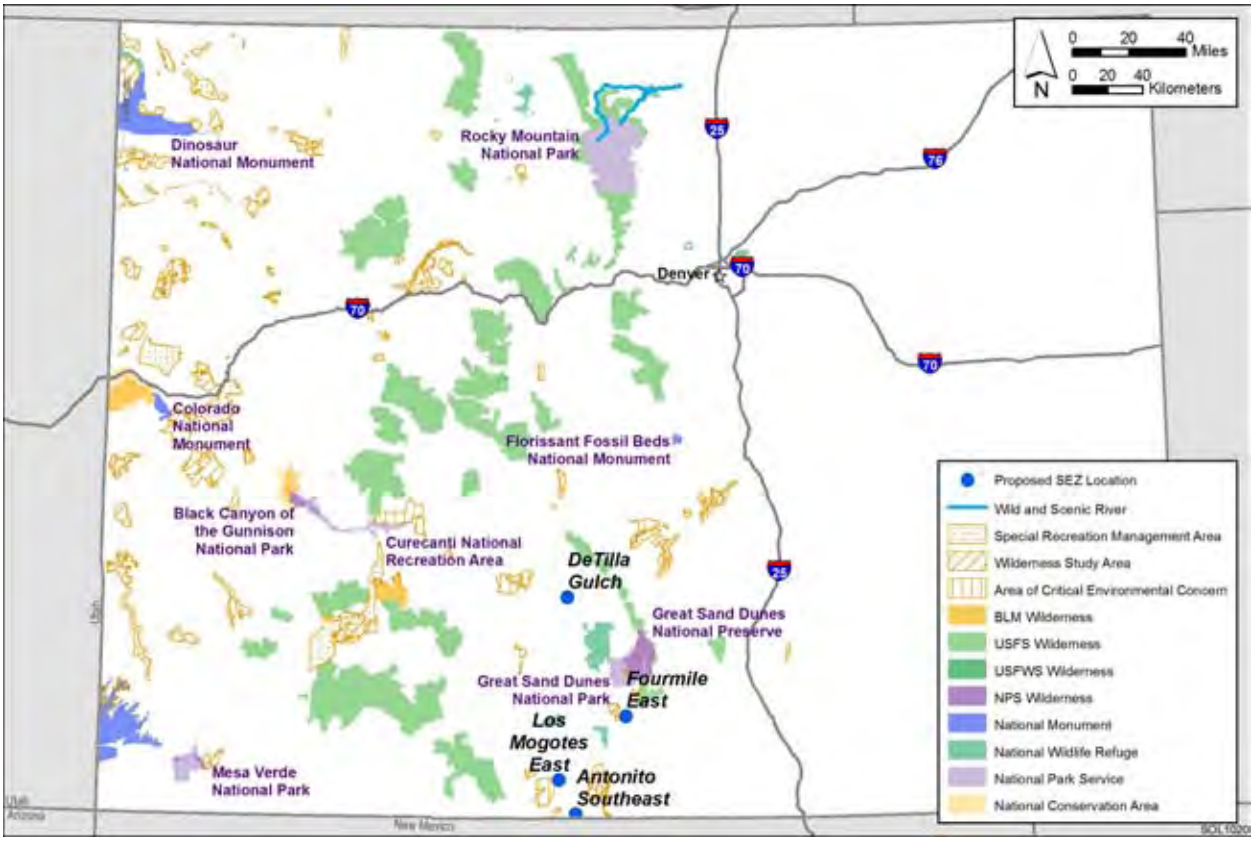

FIGURE 4.3-4 Specially Designated Areas on Public Lands in Colorado

[16 USC 1331 et seq.]) of 1971 (the Act) gave the BLM and other federal land management agencies the responsibility to protect, manage, and control wild horses and burros. The general management objectives for wild horses and burros are to (1) protect, maintain, and control viable, healthy herds with diverse age structures while retaining their free-roaming nature; (2) provide adequate habitat through the 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 burros; and (5) protect wild horses and burros from unauthorized capture, branding, harassment, or death.

Wild horses and burros are managed within herd management areas (HMAs) with the goal of maintaining the natural ecological balance of public lands as well as the ability to support multiple herds (BLM 2008a). HMAs are usually subsets of an area known as a herd area (HA), which is an area that at the time of the passage of the Act was wild horse or burro habitat but has not been designated for long-term management of wild horses or burros. The exterior boundaries of both HAs and HMAs can include private or state lands, but BLM has management authority only over public lands. Herd population management is important for balancing herd numbers with forage resources and with other uses of the public and adjacent private lands.

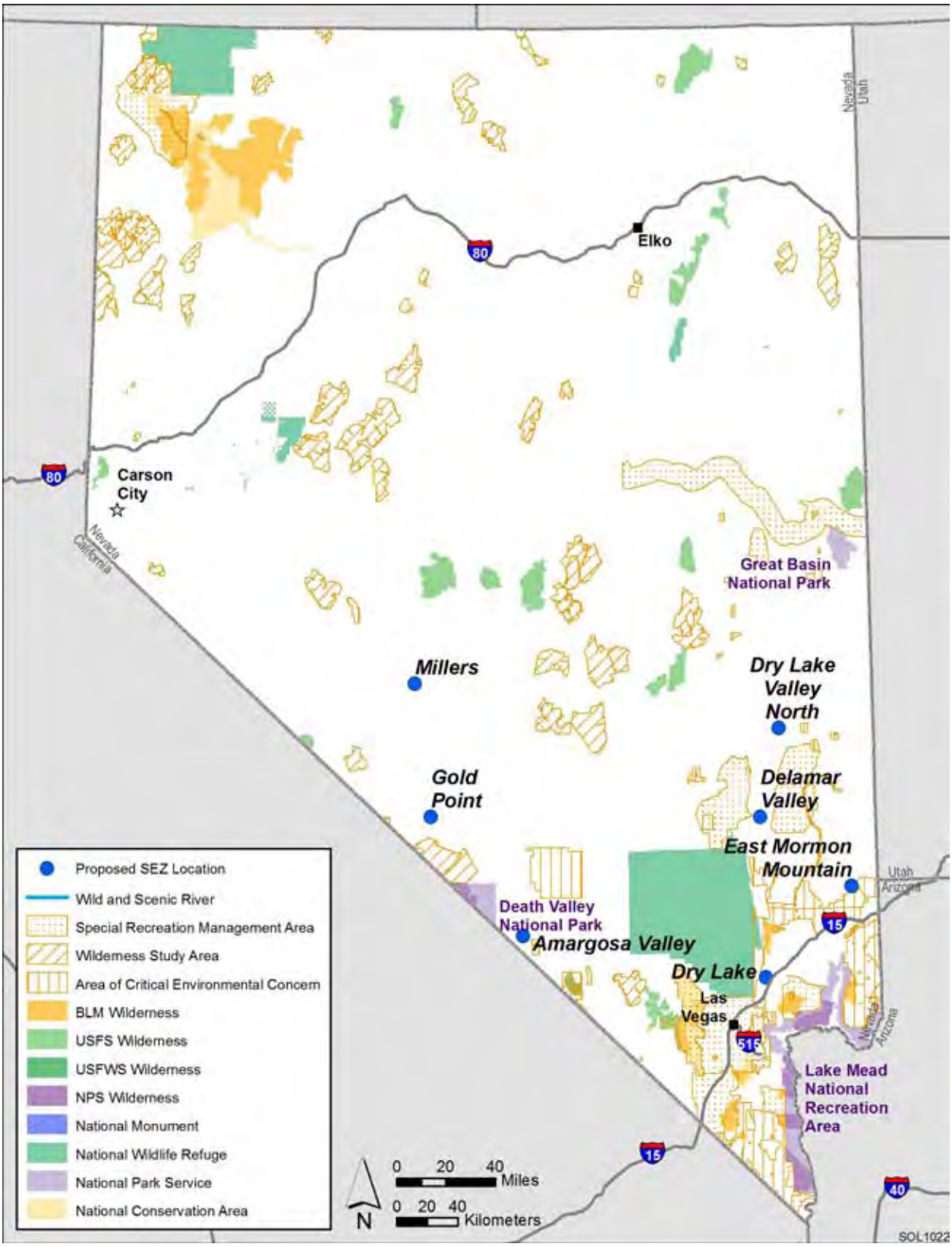

FIGURE 4.3-5 Specially Designated Areas on Public Lands in Nevada

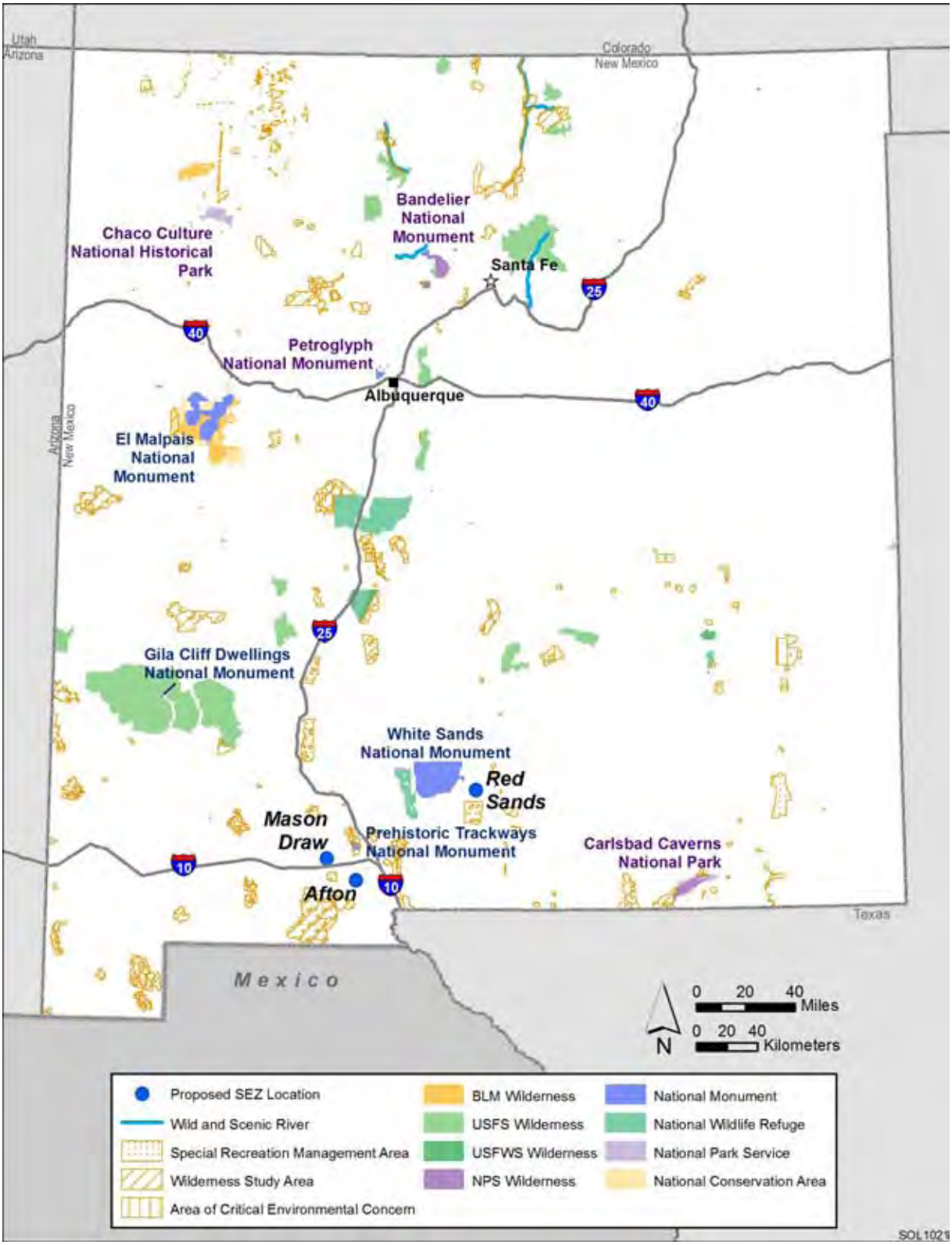

FIGURE 4.3-6 Specially Designated Areas on Public Lands in New Mexico

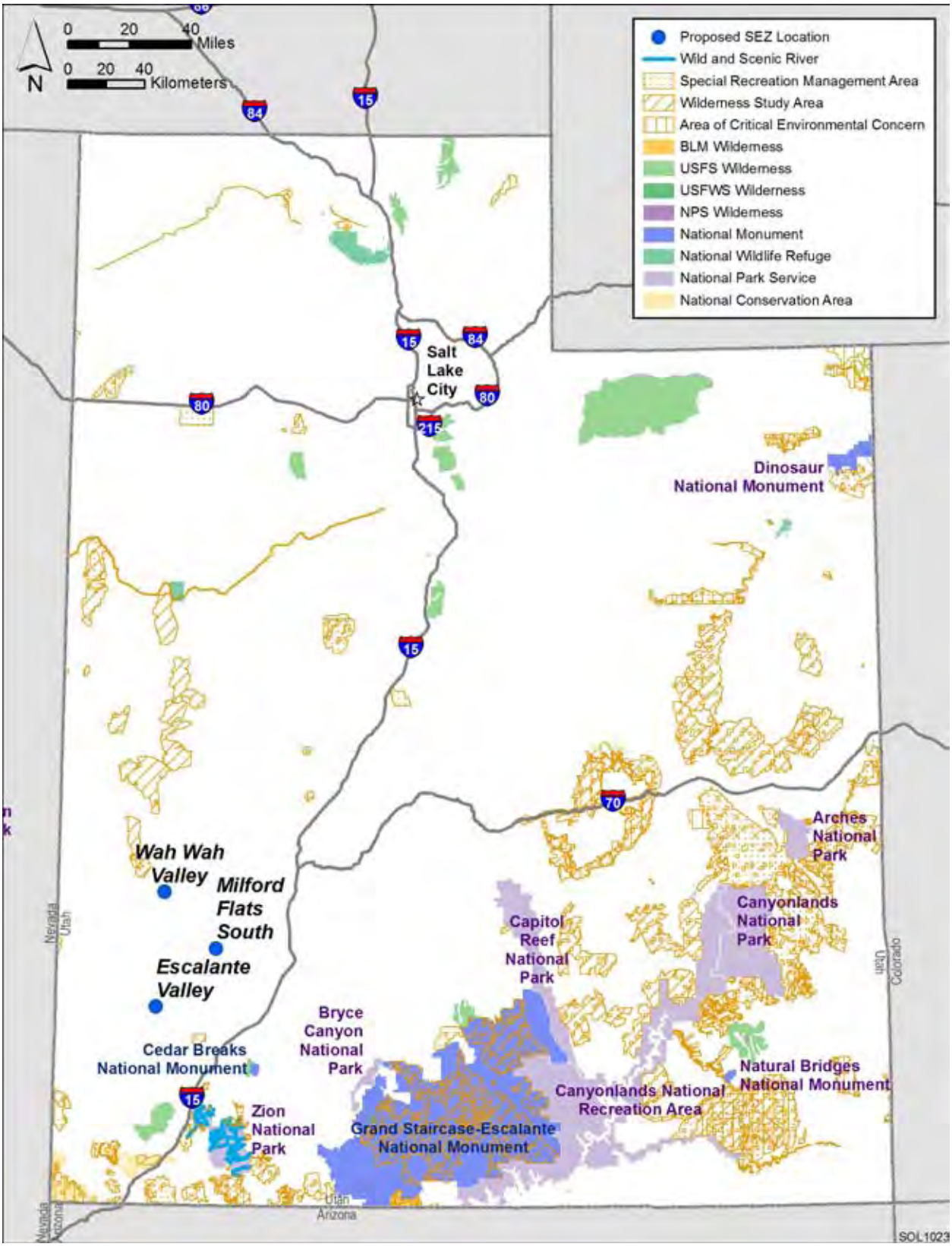

FIGURE 4.3-7 Specially Designated Areas on Public Lands in Utah

TABLE 4.3-1 BLM National Landscape Conservation System (NLCS) Units in the Six-State Study Area[a]

State	National Monuments (acres)	National Conservation Areas (acres)	Wilderness Areas (acres)	Wilderness Study Areas (acres)	National Wild, Scenic, and Recreational Rivers[b] (acres)	Other[c] (acres)	National Historic and Scenic Trails (mi)[d]	Totals[e] (acres)
Arizona	1,774,213	119,234	1,396,466	63,930	–[f]	–	990	3,354,833
California	291,390	10,729,231	3,659,800	880,175	19,360	7,472	1,716	15,589,144
Colorado	163,892	185,773[g]	139,524	621,737	–	–	389	1,111,315
Nevada	–	1,045,668[h]	2,056,545	2,552,457	–	–	596	5,655,266
New Mexico	4,124	227,100	151,190	953,087	22,720	–	60	1,358,281
Utah	1,870,800	–	129,120	3,207,364	–	–	–	5,207,284
Total	4,104,419	12,307,006	7,532,645	8,278,750	42,080	7,472	3,751	32,276,123

[a] To convert acres to km^2, multiply by 0.00405. To convert mi to km, multiply by 1.609.

[b] The congressionally authorized wild and scenic study rivers are not included. See Section 4.9.1.2 for details on this classification.

[c] Headwaters Forest Preserve (California).

[d] Values presented are in units of linear miles and therefore are not included in the total acreages for each state. Historic and scenic trails cross many states; values are assigned to the first state listed for each trail in Table 5-7 of the source document (BLM 2007c).

[e] Totals include double counted areas (e.g., some wilderness areas are included within a National Monument or National Conservation Area). As a result, the sum total of conservation acres listed is greater than the actual number of acres managed.

[f] A dash indicates no acreage.

[g] Acreage includes land in Utah.

[h] Acreage includes land in California.

Source: BLM (2007c).

As shown in Table 4.4-1, in FY 2009 the six states had a total of 28,293wild horses and burros, although the appropriate management level (i.e., the maximum number of animals sustainable on a year-long basis) is 19,416 animals (BLM 2010).

4.4.3 Wildland Fire

The six states in the PEIS study area have a wide range of climates and fuel types, and wildland fire is a factor to be considered as part of the site-specific planning for solar energy facilities. As a general rule the areas of highest interest for solar development (the southern portions of California, Nevada, and Arizona) support vegetation that while flammable, usually is not sufficiently dense to represent a large fire danger. Exceptions to this are precipitation related and occur when above-average amounts of rainfall spur the growth of annual plants, including invasive species, that provide a ready fuel source once a fire starts. The causes of fires can be either lightning (natural) or man-made, with lightning fires being more common in the states of Colorado, Nevada, and Utah while human caused fires are ubiquitous. Fire management and protection may be provided by BLM or cooperator organizations that could include private, state, or other federal agency fire organizations.

4.5 RECREATION

The vast majority of the American public's interaction with BLM-administered lands is through outdoor recreation activities. In FY 2007, more than 57 million visitors participated in such activities as rafting, hiking, biking, back-country driving, hunting, fishing, and camping in the six- state study area. Other activities include visits to heritage sites, national monuments, wild and scenic rivers, wilderness areas, national trails, and national conservation areas (BLM 2005a, 2007c). BLM manages 469 recreation sites within the six-state study area (Recreation.gov 2008).

Many BLM offices have also completed Transportation Management Plans that classify public lands as either closed, limited, or open for motorized vehicle use. The "limited" category is further broken down as being limited either "to existing roads and trails" or "to designated roads and trails." Many of these plans also address whether, and under what conditions, commercial or competitive vehicle events are allowed.

Recent BLM RMPs identify areas with high-value recreation resources as special recreation management areas (SRMAs). A SRMA is a unit of public land identified for the purpose of directing available recreation funding and personnel to fulfill commitments made to provide specific, structured recreation opportunities. Both RMP decisions and subsequent implementing actions for recreation in each SRMA are geared to one of three identified primary user markets: destination, community, or undeveloped recreation-tourism market (BLM 2005c). About 264 SRMAs are located within the six-state study area.

TABLE 4.4-1 Wild Horse and Burro Statistics for the Six-State Study Area, FY 2009

	Herd Area[a,b]			Herd Management Area[b,c]				Populations			
State	BLM Acres	Other Acres[d]	Total Acres	No. of HMAs	BLM Acres	Other Acres	Total Acres	Horses	Burros	Total	Total AML[e]
Arizona	2,019,932	1,617,998	3,637,930	7	1,756,086	1,327,777	3,083,863	390	1,967	2,357	1,676
California	4,810,248	1,813,228	6,623,476	22	1,946,590	471,855	2,418,445	4,057	895	4,952	2,201
Colorado	658,119	76,572	734,691	4	366,098	38,656	404,754	772	0	772	812
Nevada	19,076,183	3,073,205	22,149,388	85	13,580,401	1,688,864	15,249,265	16,642	819	17,461	12,688
New Mexico	88,653	37,874	126,527	2	24,505	4,107	28,612	114	0	114	83
Utah	3,150,220	676,855	3,827,075	19	2,174,850	310,747	2,485,597	2,495	142	2,637	1,956
Total	29,803,355	7,295,732	37,099,087	139	19,848,530	3,842,006	23,690,536	24,470	3,823	28,293	19,416

[a] Herd area is the geographic area identified as having been used by wild horse or burro herds as their habitat in 1971.

[b] To convert acres to km^2, multiply by 0.00405.

[c] Herd management area is the herd area or portion of the herd area that has been designated for special management, emphasizing the maintenance of an established wild horse or burro herd.

[d] Other acres include other federally administered lands (e.g., USFS, U.S. Department of Defense [DoD], NPS) and private lands.

[e] AML = appropriate management level. Number listed is the maximum number of animals sustainable on a year-long basis.

Source: BLM (2010).

4.6 MILITARY AND CIVILIAN AVIATION

Many military training routes (MTRs) and special use airspace (SUA) are used by the military and other agencies in the six-state study area. Their specific locations and operational needs must be considered when siting utility-scale solar energy facilities and related transmission facilities. Rather than just being individual routes or training areas, this military airspace forms a complex system that supports the training of military flight crews from all parts of the western United States. This interconnected system represents an important national defense asset.

The U.S. military uses airspace for its training operations, some of which occur at low altitudes (from 1,000 ft [305 m] to as low as ground surface). The National Aeronautics and Space Administration (NASA) uses military airspace near Edwards Air Force Base to support its space shuttle operations, and civilian military aircraft contractors also use military airspace to support their test programs. Airspace restrictions for MTRs and SUAs (SUAs also include military operating areas) cover about 37% of the public land in the western states. Public lands overlain by MTRs and SUAs are found throughout the six-state study area, with New Mexico and California having the largest amount of coverage. Figure 4.6-1 shows the extent of military airspace restrictions at altitudes of 1,000 ft (305 m) or less within the six-state study area. Solar development in proximity to these training areas would require consultation with the U.S. Department of Defense (DoD) during project planning to ensure that solar projects do not conflict with DoD training activities.

The presence of civilian airports and their operational airspaces also must be considered when siting utility-scale solar energy facilities and related transmission facilities. About 577 public airports are located in the six-state study area: Arizona, 81; California, 261; Colorado, 77; Nevada, 52; New Mexico, 59; and Utah, 47 (AirNav.com 2006). The numerous private and military airports in these states are not included in these numbers.

The Federal Aviation Administration (FAA) has jurisdiction over air traffic and must be contacted for any proposed construction or alteration of objects within navigable airspace under the following categories (FAA 2000):

- Proposed objects more than 200 ft (61 m) above ground level (AGL) at the structure's proposed location;

- Within 20,000 ft (6,100 m) of an airport or seaplane base that has at least one runway longer than 3,200 ft (975 m), and the proposed object would exceed a slope of 100:1 horizontally from the closest point of the nearest runway;

- Within 10,000 ft (3,048 m) of an airport or seaplane base that does not have a runway more than 3,200 ft (975 m) in length, and the proposed object would exceed a 50:1 horizontal slope from the closest point of the nearest runway; and/or

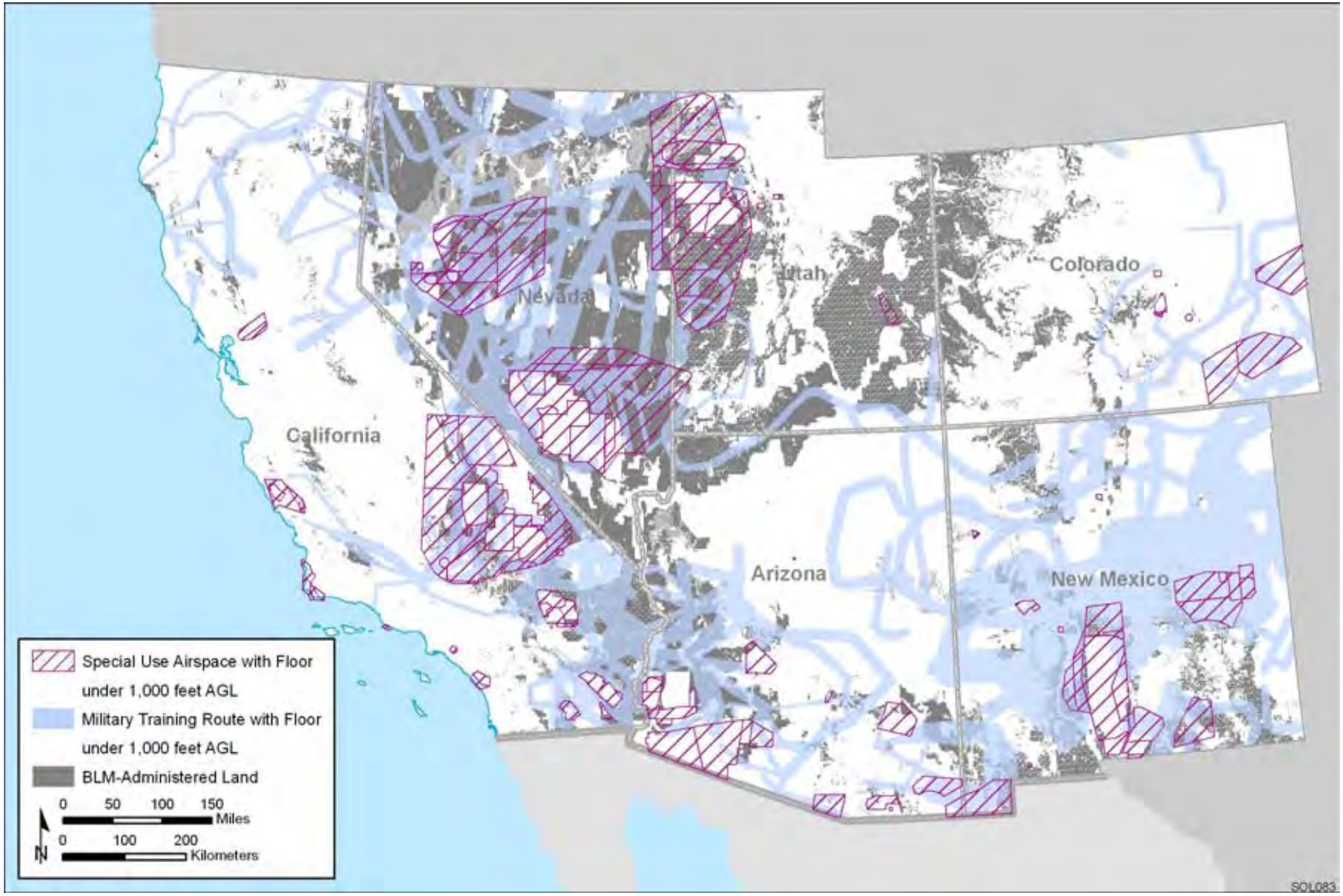

FIGURE 4.6-1 Locations of Restricted Military Airspace (including MTRs and SUAs) over the Six-State Study Area

- Within 5,000 ft (1,524 m) of a heliport, and the proposed object would exceed a 25:1 horizontal slope from the nearest landing and takeoff area of that heliport.

The FAA could recommend marking and/or lighting a structure that does not exceed 200 ft (61 m) AGL or that is not within the distances from airports or heliports mentioned above, because of its particular location (FAA 2000).

4.7 GEOLOGIC SETTING AND SOIL RESOURCES

4.7.1 Geologic Setting

The six-state study area encompasses several physiographic provinces, which are areas with similar terrain, rock types, and geologic structure and history (Burchfiel et al. 1992). From west to east (Figure 4.7-1), the physiographic provinces are (1) the Pacific Border and the Lower California provinces; (2) the Cascade–Sierra Mountains province; (3) the Basin and Range province; (4) the Columbia–Snake River Plateau (mostly in Oregon and Idaho, but with a small portion overlapping northern Nevada); (5) the Colorado Plateau; (6) the Middle and Southern Rocky Mountains provinces; (7) the Wyoming Basin; and (8) the Great Plains province, covering eastern Colorado and New Mexico. The characteristics of these physiographic provinces are summarized in Table 4.7-1.

4.7.2 Geologic Hazards

4.7.2.1 Seismicity

Seismic activity and related hazards, such as surface rupture, ground-shaking, and liquefaction, pose a moderate to high risk to solar energy development in some portions of the six-state study area. The following sections describe these hazards in terms of their probability and location in the study area. It is important to note that the scales of the accompanying maps are small because their purpose is to show the general locations of hazardous areas (not individual faults or landslides) and how they correlate to the physiography described in Table 4.7-1. The risks of local seismic hazards are discussed in later chapters of this report (under individual SEZs) and will be assessed more thoroughly during the site characterization phase of specific solar energy projects.

4.7.2.1.1 Quaternary Faults and Earthquake Activity. Quaternary faults (i.e., preexisting faults with evidence of movement or deformation within the past 1.6 million years) are thought to be the probable sources of past, current, and future earthquakes with magnitudes greater than 6.0. The U.S. Geological Survey's (USGS's) Quaternary fault and fold database contains information on these faults and fault-related folds, such as geologic setting,

FIGURE 4.7-1 Physiographic Provinces of the Six-State Study Area (Sources: Modified from USGS 2004; National Atlas 2006)

TABLE 4.7-1 Physiographic Provinces in the Six-State Study Area

Physiographic Province	Section	Geographic Location	General Terrain	Rock Types
Pacific Border	California Coast Ranges	California, running parallel to the coast.	A series of ridges and valleys with a northwest trend. One of the main faults controlling the Coast Ranges is the San Andreas Fault. Elevations range from sea level to more than 11,483 ft (3,500 m). Earth flows and complex landslides are active in mountainous areas.	Folded and faulted formations of sedimentary, igneous, and metamorphic bedrock are common.
	Transverse Ranges	California, between the Coast Ranges to the north and the Lower California Province to the south.	Consists of ranges and basins trending nearly east and transverse to the southeasterly trend of adjoining areas (e.g., the Sierra Nevada, the Great Valley, and the Coast Ranges at the north, and the Lower California province at the south). Highest ranges reach elevations greater than 10,000 ft (3,048 m).	Mountains consist of marine formations; those to the east consist mostly of older rocks, including granite, and metamorphosed sedimentary and volcanic rocks. Basins are filled with thick terrestrial deposits buried under marine fill.
	Klamath Mountains	Situated between the Coast Ranges of California and Oregon.	Similar rock structures as the Sierra Nevada (see below).	Deformed and metamorphosed sediments intruded by granite.
	Great Valley of California	Situated between the Sierra Nevada and the Coast Ranges (and south of the Klamath Mountains) in central California.	A flat geological trough with elevations ranging from below sea level to more than 1,000 ft (305 m). Alluvial fans slope westward along the foot of the Sierra.	Thick sequence of sedimentary deposits derived from erosion of the Sierra Nevada.
Lower California		Situated between the Salton Trough and the coast on the northern end of Baja California.	The province is a westward-dipping plateau. Elevations range from 11,000 ft (3,353 m) at San Jacinto Peak on the north end to below sea level at the Salton Sea trough. Terraces along the coast are as high as 1,300 ft (396 m) above sea level.	Granitic batholith forms the plateau.

TABLE 4.7-1 (Cont.)

Physiographic Province	Section	Geographic Location	General Terrain	Rock Types
Cascade–Sierra Mountains[a]	High Cascade Mountains	Southern Washington, Oregon, and northern California.	Best known for their high, snow-capped volcanoes. The mountains are part of the circum-Pacific volcanic belt characterized by younger, active volcanoes (such as Mount St. Helens, Mount Rainer, and Glacier Peak). Overlooks the Columbia–Snake River Plateau.	Volcanic, sedimentary, and metamorphic rocks.
	Sierra Nevada Mountains	Eastern California, east of California's Great Central Valley.	Uplifted by faulting along the east, tilting westward exposing granitic and metamorphosed sedimentary formations. About 350 mi (563 km) long and 60 mi (97 km) wide with a maximum elevation of about 9,000 ft (2,743 m) along the east fault scarp and overall maximum elevation of 14,505 ft (4,421 m) at Mount Whitney. Lava flows.	Primarily granitic rocks with some older metamorphic rock; volcanic rocks along the eastern scarp.
Basin and Range		South of the Columbia Plateau, extending from southern Idaho and Oregon through most of Nevada and parts of western Utah, eastern California, western and southern Arizona, and southwestern New Mexico.	Consists of more than 400 evenly spaced, nearly parallel block-faulted mountain ranges and intervening basins. Jagged crests are generally abrupt, steeply sloping, and deeply dissected with elevations from 3,000 to 5,000 ft (914 to 1,524 m) above the intermountain basins. Basins are typically broad, gently sloping, and largely undissected with elevations ranging from below sea level to about 5,000 ft (1,524 m). Basins in the north are internally drained.	Mountain ranges composed of complexly deformed Precambrian and Paleozoic rocks. Mesozoic granitic rocks are found in the western province. Cenozoicvolcanic rocks are widespread. Intermontane basins filled with Tertiary rocks overlain by Quaternary sediments (e.g., alluvium, dune sand, and playa deposits).
Columbia–Snake River Plateau	Snake River Plain	Southern Idaho, extending into northern Nevada.	A flat and geomorphically featureless area surrounded by mountains and highlands.	The eastern part of the plateau is characterized by rhyolitic volcanic rocks covered by basaltic lava; the western plateau is a basin filled with sedimentary deposits over a thick slab of basalt.

TABLE 4.7-1 (Cont.)

Physiographic Province	Section	Geographic Location	General Terrain	Rock Types
Colorado Plateau		At the intersection of Colorado, Utah, Arizona, and New Mexico, covering 130,000 mi^2 (336,698 km^2) between the Rocky Mountain and Basin and Range provinces.	The plateau is an uplifted surface greater than 5,000 ft (1,524 m) in elevation, with peaks reaching to 11,000 ft (3,353 m). Extensive areas of horizontal sedimentary formations with structural upwarps and igneous structures (e.g., volcanoes, cinder cones and volcanic necks, lava-capped plateaus and mesas, and dome mountains caused by intrusion of stocks and laccoliths).	Mostly sedimentary rocks. Volcanic rocks and volcanic plugs are common in some areas.
Middle and Southern Rockies		Northwestern Wyoming and Colorado.	Before the Laramide mountain-building period, the Middle and Southern Rockies were part of a stable platform composed of Precambrian crystalline rocks. The platform received sediments that were transformed into sedimentary rocks, which were then uplifted and eroded during the mountain-building period. Later, volcanic activities produced mountains and high plateaus in many places. Separated from the Middle Rockies by the Wyoming Basin in Wyoming, the Southern Rockies have summits between 10,827 and 14,436 ft (3,300 and 4,400 m).	Sedimentary, metamorphic, and volcanic rocks.
Wyoming Basin		Located in northwestern Colorado, the basin provides a connection between the Colorado Plateau and the Great Plains (through a “break” in the Rocky Mountain range).	Consists of elevated semiarid basins and isolated low mountains with elevations ranging from 6,000 to 8,000 ft (1,829 to 2,438 m). Basins have a bowl-like structure with sedimentary deposits resting unconformably on older sedimentary formations. Cuestas and hogbacks formed around the rims of basins create topographic relief in those areas.	Sedimentary formations, with volcanic and intrusive rocks.

TABLE 4.7-1 (Cont.)

Physiographic Province	Section	Geographic Location	General Terrain	Rock Types
Great Plains		Located east of the Rocky Mountains and the Basin and Range province in the eastern parts of Montana, Wyoming, Colorado, and New Mexico.	A large region of generally low relief, sloping eastward from about 5,500 ft (1,676 m) at the foot of the Rocky Mountains to about 2,000 ft (610 m) at the eastern boundary of the province.	Marine sediments covered with more recent sedimentary deposits derived from the Rocky Mountains.

[a] The Cascade–Sierra Mountains province consists of the north-trending Cascade Mountains (in Oregon and Washington), the High Cascade Mountains, and the Sierra Nevada. However, only the sections falling within California are described here.

Sources: Burchfiel et al. (1992); Dohrenwend (1987); Madole et al. (1987); Wayne et al. (1991).

fault orientation, fault type and sense of movement, slip rate, recurrence interval, and the time of the most recent movement. The database is the USGS's primary source for seismic hazards information on Quaternary faults in the United States (Machete et al. 2004).

In the six-state study area, Quaternary faults occur predominantly in fault zones associated with the San Andreas Fault system (western California), the Eastern California Shear Zone (eastern California), the Central Nevada Seismic Zone (west-central Nevada), the block fault systems throughout the Basin and Range province (Nevada), the Intermountain Seismic Belt (northern Arizona and Utah), and the Rio Grande Rift system (New Mexico and Colorado) (Figure 4.7-2). Historically, the most active seismic regions have been along the San Andreas Fault system and within the Eastern California Shear Zone and the Nevada Seismic Zone. Earthquake-prone areas are subject to various hazards, including surface rupture, ground shaking, liquefaction, and landslides, that may cause severe damage to buildings and infrastructure.

4.7.2.1.2 Ground-Shaking. Seismic waves during an earthquake cause ground shaking that radiates outward from the rupturing fault. Shaking intensity is mainly a function of an earthquake's magnitude and the distance from the fault, but can be amplified by other factors, such as the softness of the ground (soft rocks and sediments versus hard rock) and the total thickness of sediments below the area. Shaking tends to be stronger in soft rocks and sediments and increases with increasing thickness of underlying sediments. Other factors affecting the pattern of shaking include the orientation of the fault, irregularities of the rupturing fault surface, and the scattering of waves as they intercept underground structures (Field et al. 2001).

The USGS's National Seismic Hazard Map series provide estimates of likely shaking for regions throughout the United States and are used as a basis for the seismic design provisions of building codes, insurance rate structures, earthquake loss studies, retrofit priorities, and land-use planning (USGS 2008b). On these maps, ground-shaking is expressed as a percentage of acceleration of a falling object due to the force of gravity (g)[5]. Figure 4.7-3 presents the peak horizontal acceleration in the six-state area as a percentage of g that has a 10% probability of being exceeded over a 50-year period. The peak horizontal acceleration ranges from 0 g (insignificant ground-shaking) to 1 g (strong ground-shaking). The highest ground-shaking hazard in the study area occurs in parts of California, with the highest probable peak acceleration (greater than 0.40 g or 40% of g) occurring along the trace of the San Andreas Fault system. In the Basin and Range, Colorado Plateau, and Great Plains provinces to the east, the probable peak acceleration is low, in the range of 0 g to 0.1 g (equal to or less than 10% of g), since seismically active areas are at some distance away. Table 4.7-2 provides a scale that relates peak horizontal acceleration to perceived shaking and potential damage to structures on the ground.

[5] Gravity (g) is a common value of acceleration equal to 9.8 m/s^2 (the acceleration due to gravity at the earth's surface).

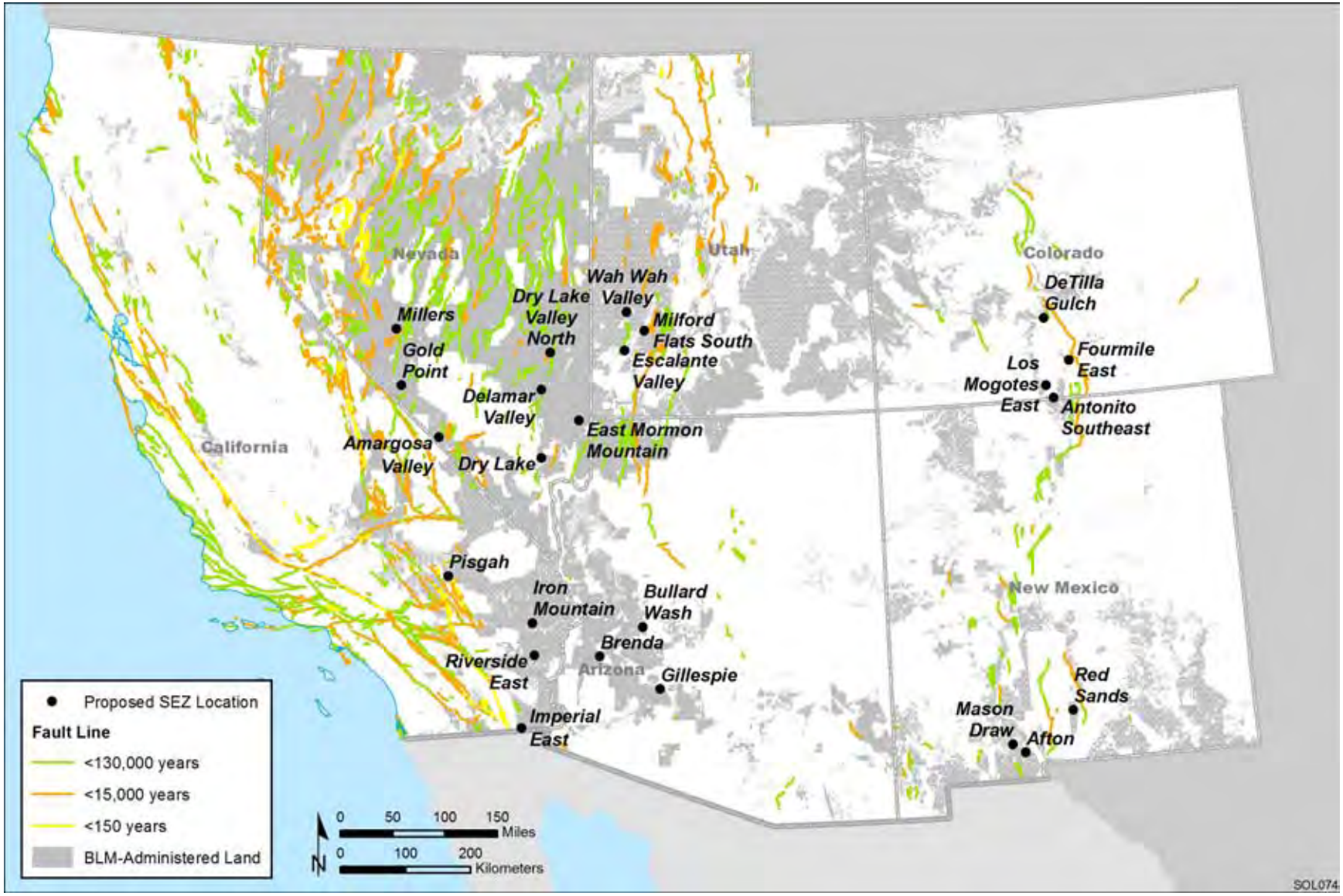

FIGURE 4.7-2 Quaternary Faults in the Six-State Study Area (Source: USGS 2010c)

FIGURE 4.7-3 Peak Horizontal Ground Acceleration within the Six-State Study Area with a 10% Probability of Exceedance in 50 Years (Source: USGS 2008c)

TABLE 4.7-2 Relationship between Peak Horizontal Acceleration, Perceived Shaking, and Potential Structural Damage

Peak Horizontal Acceleration (%g)	Perceived Shaking	Potential Damage
<0.17	Not felt	None
0.17 to 1.4	Weak	None
1.4 to 3.9	Light	None
3.9 to 9.2	Moderate	Very light
9.2 to 18	Strong	Light
18 to 34	Very strong	Moderate
34 to 65	Severe	Moderate to heavy
65 to 124	Violent	Heavy
>124	Extreme	Very heavy

Source: Wald (2000).

4.7.2.1.3 Liquefaction and Landslide Susceptibility. Liquefaction refers to a sudden loss of strength and stability in loose, saturated soils, causing them to behave like a fluid. Liquefaction of soils results in ground failure of various types, including lateral spreads (landslides), flow failures, ground oscillation, and loss of bearing strength. Sand blows or boils (small eruptions) commonly accompany these types of ground failure, forming sand dikes in subsurface sediment layers and sand volcanoes at the ground surface. Liquefaction hazards occur during or immediately following large earthquakes and are associated with sandy and silty soils with low plasticity (i.e., low clay content); therefore, the potential to liquefy tends to be higher in recent deposits of fluvial, lacustrine, or eolian origin than in glacial till and older deposits. Saturated soils are more susceptible to liquefaction, and the hazards of liquefaction are most severe in near-surface soils (less than 50 ft [15 m] below the ground surface) and on slopes (SCEC 1999; Matti and Carlson 1991). Given the relatively low incidence of historic seismicity in most of the six-state study area, liquefaction is not a hazard of great concern. However, some earthquake-prone areas in parts of California (e.g., parts of the San Francisco Bay area) and along various inland water bodies (e.g., the shoreline of the Great Salt Lake) are highly susceptible to liquefaction.

Steeply sloping areas underlain by loose sediment or soft rocks are most susceptible to earthquake-induced landslides.

4.7.2.2 Volcanic Activity

Major volcanoes or volcanic fields in the six-state study area occur primarily in California along the Cascade-Sierra Nevada Mountains (Figure 4.7-4). In California, more than 75 volcanic vents have been active during the last 10,000 years. More than 10 have erupted during the past 600 years; these include Medicine Lake, Mount Shasta, and Lassen Peak, and

FIGURE 4.7-4 Active Volcanoes and Areas of Unrest Potentially Affecting the Six-State Study Area

Mono-Inyo volcanic chain near the Long Valley Caldera. The tectonic settings of California's volcanic centers include those related to subduction in the Cascade-Sierra Nevada Mountains (Mount Shasta and Lassen Peak), crustal thinning along the Sierra Nevada escarpment (Mono-Inyo volcanic chain and Long Valley Caldera), and active crustal spreading in the Salton Sea Trough (Salton Buttes rhyolite domes) (Miller 1989). Other potentially active volcanoes in the study area occur within the Southern Colorado Plateau (Uinkaret, Arizona), the Southern Rocky Mountains (Jemez Mountains, New Mexico), and the Basin and Range (Lavic Lake, California) provinces (USGS 2010a).

Active volcanoes and areas of unrest located outside of the study area with the potential to affect developments within the six-state region include those of the Cascade Range in Oregon and Washington and the Yellowstone volcanic field in Wyoming. Earthquake swarms and/or ground deformation (uplift or subsidence) have been reported for Mount Hood and South Sister (both located in Oregon) as recently as 2002 and 2004, respectively (Diefenbach et al. 2009). Mount St. Helens is the most frequently active volcano in the Cascade Range and has erupted as recently as 2008 (Diefenbach et al. 2009). Given its distance from the six-state study area, however, the only potential hazard from a large eruption from Mount St. Helens would result from tephra falls. Hazard zonation maps show that the probability of tephra accumulation of 4 in. (10 cm) or more would be less than 1% beyond a distance of about 400 mi (650 km) south and southeast of the volcano's center (Wolfe and Pierson 1995); all of the SEZs lie beyond this distance.

The volcanic-hydrothermal system of the Yellowstone region is very active and considered one of the largest in the world. It has produced at least three eruptions that deposited sheets of ash over most of the western and central parts of the United States, including all but northern California in the six-state study area (Christiansen et al. 2007). Earthquake swarms, ground deformation, and changes in hydrothermal activity have been ongoing at Yellowstone since 1980 (Diefenbach et al. 2009). No eruptions of lava or ash have occurred for thousands of years, but future eruptions are likely (though not predicted) (Lowenstern et al. 2005).

The types of hazards associated with volcanism relate to the composition of material erupted and the style of eruption; therefore, the classification of volcanoes is an important part of understanding the nature of future eruptions and their potential hazards. Large, silicic central-vent volcanoes like Mount Shasta and Lassen Peak are expected to erupt more frequently and explosively in the future because they are located above large, shallow chambers of viscous, gas-rich magma. Mafic magma arises from greater depths (i.e., not from large chambers in the crust). Vents within mafic volcanic fields therefore tend to erupt less frequently and are less likely to occur repeatedly from the same vent. Because mafic magma is less viscous, gas is able to escape nonexplosively (Miller 1989).

Volcanic hazards include flowage phenomena, such as directed blasts, pyroclastic flows and surges, lava flows and domes, landslides and debris flows (lahars), and floods; eruption of tephra, consisting of solidified lava, pumice, ash, and rock fragments ejected high into the air that fall back to earth on and downwind from the source vent; emissions of volcanic gases, consisting mainly of steam but also carbon dioxide, and compounds of sulfur and chlorine distributed by wind (Miller 1989; USGS 2010b).

4.7.2.3 Mass Wasting

4.7.2.3.1 Landslide-Prone Areas. Landslide-prone areas are generally closely related to high, steep, rugged terrain and a high level of precipitation. In the six-state study area, high landslide incidence and susceptibility are found primarily along the coast of California and in western Colorado and New Mexico (Figure 4.7-5). Moderate landslide susceptibility and incidence occur adjacent to the areas of high landslide susceptibility and incidence. It is important to note that many alluvial fans near mountain ranges also have high landslide susceptibility but are not shown on the map in Figure 4.7-5 because of the map's small scale. Fan deposits are common in the alluvial basins throughout the study area.

4.7.2.3.2 Debris Flows. A debris flow is a fast-moving mass of water with high sediment (from clay to boulder size) and debris (trees and brush) content capable of causing extensive damage to structures in its path with little or no warning. Debris flows are associated with younger (active) alluvial fans, which are cone- to fan-shaped landforms that commonly occur along the range fronts bordering alluvial basins. The behavior and path of a debris flow will depend on its sediment content and speed and on characteristics of the alluvial fan, such as soil and vegetation cover, slope, and fan type and degree of development. Debris flow hazards are greatest during heavy or sustained rainfall events and on steep fan slopes with available sediments and rocks (due to minimal vegetation cover). They also may be accompanied by flash floods (Larsen et al. 2001; National Research Council 1996; Meyer and Berger 1992; FEMA 1989).

Although rare, debris flows present significant hazards. These hazards include abrasion of objects and structures in the flow path, burial of objects and structures where debris is deposited, and erosion that occurs along the flow path—all with significant changes to the landscape (Katzer and Schroer 1986). The paths of future debris flows are not easy to predict since flows are subject to sudden relocation, even during a single event (FEMA 1989); however, geomorphological mapping of alluvial surfaces using the distribution patterns of soil development, desert pavement, and rock varnish to delineate active (and transient) parts of alluvial fans holds promise for flood-hazard assessment (Field 1997; Bedford and Miller 2010). Mitigation strategies to protect land from the hazards of debris flows involve building large structural controls (e.g., check dams) and avoiding construction on active alluvial fan surfaces (Larsen et al. 2001).

4.7.2.4 Land Subsidence

Land subsidence is a form of ground failure that occurs as the gradual settling or sudden collapse of the ground surface due to loss of subsurface support. Its cause is attributable to various human activities and natural processes, including withdrawal of underground fluids (groundwater, petroleum, and geothermal fluids), dewatering of organic soils, underground mining, wetting of dry, low-density sediments (hydrocompaction), natural compaction, dissolution of soluble sedimentary rocks (sinkholes), liquefaction, crustal deformation, and

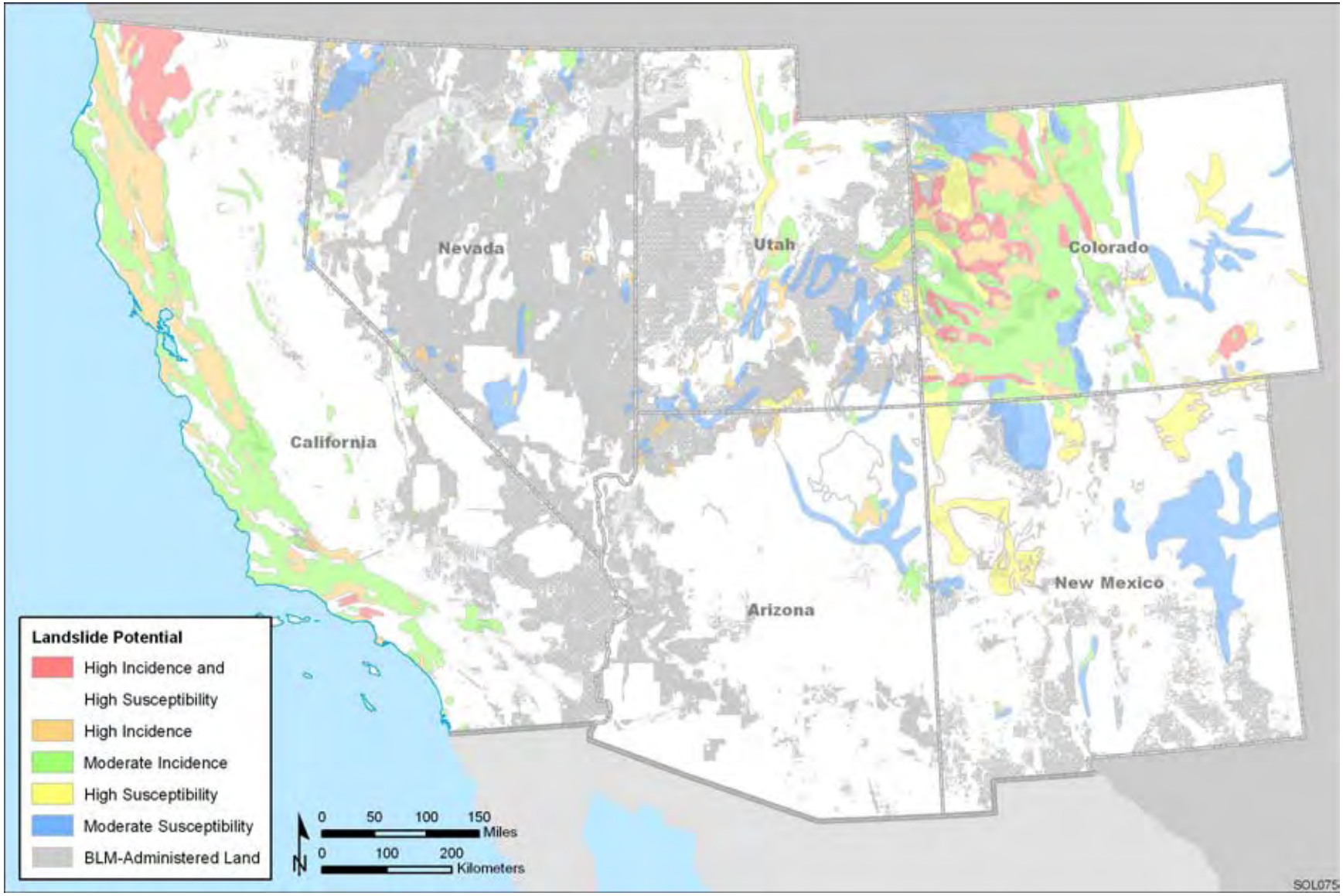

FIGURE 4.7-5 Landslide Hazard Potential Map of the Six-State Study Area (Source: National Atlas 2006)

thawing permafrost (Galloway et al. 1999; National Research Council 1991). In the six-state study area (especially in the alluvial basins where the SEZs are located), the most likely cause of subsidence is aquifer compaction as a result of groundwater withdrawal.

Alluvial basins are important sources of groundwater, especially for agricultural irrigation. When groundwater is over-pumped, water levels in the underlying aquifer decline, causing a decrease in the fluid pressures that normally support the weight of overburden. If the aquifer material is compressible, loss of pore volume (or compaction) occurs over a wide region, causing a permanent reduction in the total storage capacity of the aquifer system and land subsidence (National Research Council; Galloway et al. 1999). In the six-state study area, subsidence has been reported in numerous basins in California, Nevada, Arizona, and New Mexico (Table 4.7-3).

The types of hazards associated with land subsidence caused by groundwater withdrawal include flooding (due to reductions in ground elevation in flood-prone areas; e.g., Centennial Wash near Wendon, Arizona); earth fissures (Harquahala Plain, Arizona); differential vertical subsidence (due to variations in thickness of underlying compressible deposits; e.g., Las Vegas Valley); and horizontal displacement (Burbey 2002).

TABLE 4.7-3 Areas of Subsidence in California, Nevada, Arizona, and New Mexico due to Groundwater Withdrawal

California	
Antelope Valley	Salinas Valley
Coachella Valley	San Benito Valley
Elsinore Valley	San Bernardino area
La Verne area	San Gabriel Valley
Lucerne Valley	San Jacinto Valley
Mojave River Basin	San Luis Obispo area
Oxnard Plain	Santa Clara Valley
Pomona Basin	Temecula Valley
Sacramento Valley	Wolf Valley
Nevada	
Las Vegas Valley	
Arizona	
Avra Valley	San Simon Valley
East Salt River Valley	Stanfield Basin
Eloy Basin	Tucson Basin
Gila Bend area	West Salt River Valley
Harquahala Plain	Wilcox Basin
New Mexico	
Albuquerque Basin	
Mimbres Basin	

Source: Galloway et al. (1999).

4.7.3 Soil Resources

4.7.3.1 Soil Taxonomy

Soil formation results from the complex interactions between parent (geologic) material, climate, topography, vegetation, organisms, and time. The classification of soils is based on their degree of development into distinct layers or horizons and their dominant physical and chemical properties. For the purpose of this report, soils in the six-state study area are described according to their soil order, the highest category of soil taxonomy used by the Natural Resources Conservation Service (NRCS 1999). The eight soil orders within the study area, their distribution, and general characteristics are described in Table 4.7-4 in order of decreasing predominance. Most of the 24 SEZs are located in alluvial basins on soils that are predominantly Aridisols.

4.7.3.2 Biological Soil Crusts

Biological soil crusts, also known as cryptogamic, cryptobiotic, microbiotic, or microphytic soil crusts, are composed of complex communities of cyanobacteria, green algae, bryophytes, lichens, mosses, microfungi, and other bacteria. The filaments produced by these organisms weave through the top few millimeters of soil, forming a matrix that stabilizes and protects soil surfaces from wind and water erosion and retains soil moisture. They also contribute carbon to the underlying soils and increase the bioavailability of nutrients such as nitrogen and phosphorus (Belnap 2001; BLM 2007a; Rosentreter et al. 2007).

Biological soil crusts are commonly found in semiarid and arid environments, such as those throughout the six-state study area. They occur on all types of soils, especially in areas where vegetation is widely spaced. Their composition varies with soil pH and salinity; for example, green algae favor acidic soils with low salt content, while cyanobacteria favor alkaline soils with high salt content. The cover of lichens and mosses is greater in soils with high clay and silt content (except on clay soils with high shrink-swell potential) and in moist habitats (Rosentreter et al. 2007).

Biological soil crusts are highly susceptible to disturbance, especially in sandy soils. Disturbance can affect their composition (e.g., intense disturbance favors the growth of cyanobacteria but not lichens) and may reduce the number of crust organisms found on the surface. In areas where biological soil crusts are abundant, these changes may increase the rate of soil loss due to surface runoff or wind erosion (Belnap 2001; BLM 2007a). More information on biological soil crusts, including photographs and a complete reference list, is available on a USGS Web site: www.soilcrust.org.

TABLE 4.7-4 Soil Orders in the Six-State Study Area in Order of Decreasing Predominance

Soil Order	Geographic Extent	Characteristics
Aridisols	Arizona, southern California, Colorado, Nevada, New Mexico, and Utah	Light in color and low in organic material. Exhibit extreme water deficiency. Subsurface accumulations of soluble materials like calcium carbonate, silica, gypsum, soluble salts, and exchangeable sodium result in hardpans that impede water infiltration. Support desert rangeland; generally not productive without irrigation.
Mollisols	Arizona, California, Colorado, Nevada, New Mexico, and Utah	Commonly dark-colored, organic-rich, mineral soils. Base-rich throughout and highly fertile. Typically develop under grasslands, although some have formed under a forest ecosystem, in subhumid to subarid climates having a moderate to pronounced seasonal moisture deficit. Support cropland and pasture or rangeland.
Entisols	Arizona, California, Colorado, Nevada, New Mexico, and Utah	Common in lower elevation arid and semiarid environments. Young, weakly developed mineral soils showing little or no horizon development. Include recent alluvium, sands, soils on steep slopes, and shallow soils. Also formed in recently deposited sediments on floodplains, dunes, fans, and deltas along rivers and small streams. Support wildlife habitat and pasture or rangeland, but can support trees in areas of high precipitation.
Alfisols	Arizona, California, Colorado, New Mexico, and Utah	Occur in semiarid to moist areas. Characterized by subsurface clay accumulations leached from surface layer and nutrient-rich subsoils. Formed under forest or mixed vegetation cover. Can support cropland and commercial timberland.
Inceptisols	Arizona, northern California, Colorado, Nevada, New Mexico, and Utah	Occur in a wide range of climates, from semiarid to humid. Generally young mineral soils showing only moderate degrees of soil development and weathering (more than entisols). Develop where the native vegetation is grass, but some support trees. Can support pasture or cropland, rangeland, forest, or wildlife habitat.
Andisols	Limited areas in northern California	Common in cool areas with moderate to high precipitation. Formed from weathering processes that result in minerals with little orderly crystalline structure, including soils with a high percentage of volcanic glass. Highly productive soils.

TABLE 4.7-4 (Cont.)

Soil Order	Geographic Extent	Characteristics
Vertisols	Scattered in Arizona, California, and New Mexico	High content of expanding clay that swells when wet. Because of their swelling capacity, they transmit water very slowly and have undergone little leaching. Support natural vegetation that is predominantly forest, grass, or savannah. High in natural fertility. Used mainly as cropland, rangeland, or forest, although they present a drainage problem for croplands because of their low hydraulic conductivity when wet.
Ultisols	Scattered in northern California	Occur in humid environments. Strongly acid mineral soils, low in nutrients. Show intensive leaching of clay minerals and other constituents, resulting in a clay-enriched subsoil dominated by quartz, kaolinite, and iron oxides. Formed under forest vegetation.

Sources: BLM (2007a); NRCS (1999, 2010).

4.7.3.3 Desert Pavement

Desert pavement is a type of surface armor that forms on the ground in hot desert environments, such as those covering the southern portion of the six-state study area. Desert pavements consist of a thin layer of closely packed, angular to sub-rounded coarse rock fragments and are associated with alluvial fans and other unsorted alluvial deposits (Ritter 1986). They typically occur on surfaces with very little relief and lie above a gravel-free layer of well-developed soil; their exposed surface is often characterized by a dark and shiny coating or varnish of minerals (e.g., iron oxide) and organic carbon (McFadden et al. 1987). The abundance of coarse particles on desert pavements is thought to be the result of deflation, a process whereby fine sediments are eroded from alluvium by wind or water and/or the upward movement of larger clasts through the alluvial matrix (by cycles of shrinking and swelling and/or freezing and thawing) until they reach the surface (Ritter 1986). Other investigators have observed well-developed desert pavements in volcanic terrains where eolian silt and fine sand have filled the voids between clasts of basaltic colluvium (e.g., Cima volcanic field) and scoria (e.g., Amargosa Desert) (McFadden et al. 1987; Valentine and Harrington 2005).

Desert pavements are less susceptible to disturbance than biological soil crusts, but once they are disturbed, desert pavements lose their armoring function, increasing the likelihood of soil loss due to surface runoff or wind erosion.

4.7.3.4 Wind Erosion of Soils

The soils of desert environments within the six-state study area are highly vulnerable to erosion by wind. Airborne dust is generated when wind forces exceed the ability of stabilizing factors to hold the fine-grained components of soil in place. Factors that function to stabilize soils include vegetation cover, biological soil crust cover, rock cover, high salt or calcium carbonate content, high clay and silt content, physical crusts (e.g., gypsite or playa efflorescent crusts), and desert pavement. When these factors are compromised by the compressional and shear forces created by vehicles and the trampling effects of livestock and humans, the loss of soil fines reduces the soil's productivity. This reduction of productivity occurs because most plant-essential nutrients are bound to fine particles near the surface and because the loss of the fine particles also reduces the soil's often already low water-holding capacity. Once airborne (as fugitive dust), soil fines are a nonpoint source of air pollution with potentially significant health effects. Deposition of soil fines may also be problematic because it reduces the fertility of plants and biological crusts (by burial of photosynthetic components) and contributes to sedimentation in surface water bodies (Belnap 2001; Belnap et al. 2007).

Because soil formation by weathering of parent rock is a slow process, often taking thousands of years, and dust deposition is low in most regions (except in areas near large dust sources), the replacement of lost soil is also very slow (Belnap et al. 2007). Therefore, the best mitigation to reduce soil loss by wind erosion is to follow practices that avoid soil disturbance and control dust emissions to the maximum extent possible.

Table 4.7-5 provides a summary of soil textures and their vulnerability to wind erosion, as expressed by the U.S. Department of Agriculture's (USDA's) wind erodibility index. The wind erodibility index is a measure of soil (in tons) eroded by wind from an acre (4,000 m^2) of exposed land over a one-year period based on the amount of fines in the soil. The largest erodible aggregate (soil particle) size is about 84 mm (0.033 in.) in diameter. Soils with a small percentage of dry aggregates greater than 84 mm (0.033 in.) contain more fines and have a high erodibility index (high vulnerability to wind erosion) relative to soils with a large percentage of dry aggregates greater than 84 mm (0.033 in.) (Countess Environmental 2006; USDA 2010).

The soil texture class most vulnerable to wind erosion is sand (very fine sand, fine sand, sand, or coarse sand), a common constituent of exposed sediments in the alluvial basins throughout the study area. The soil sections in later chapters provide wind erodibility ratings and the wind erosion group designations for the soils within and adjacent to the individual SEZs.

4.8 MINERALS (FLUIDS, SOLIDS, AND GEOTHERMAL RESOURCES)

Energy and mineral resources have the highest economic values among commercial uses for surface lands and subsurface estates administered by the BLM in the six-state study area (Table 4.8-1). These economic values derive from the production of locatable, leasable, and salable mineral resources. Locatable minerals, defined in the General Mining Law of 1872, can be obtained by locating a mining claim; they include both metallic (e.g., gold, silver, lead) and nonmetallic (e.g., gemstones, fluorspar, mica) materials. Leasable minerals are subject to the

TABLE 4.7-5 Wind Erodibility of Soils by Soil Texture

Soil Texture	Dry Aggregates greater than 0.84 mm (wt.%)	Wind Erodibility Index (tons/ac/yr)	Wind Erodibility Group
Very fine sand, fine sand, sand or coarse sand	1 2 3 5 7	310 250 220 (average) 180 160	1 (High)[a]
Loamy very fine sand, loamy fine sand, loamy sand, and loamy course sand; very fine sandy loam and silt loam with ≤5% clay and ≤25% very fine sand; and sapric material	10	134	2 (High)
Very fine sandy loam, fine sandy loam, sandy loam, and coarse sandy loam; noncalcareous silt loam with ≥20% to <50% very fine sand and ≥5 to <12% clay	25	86	3 (Moderate)
Clay, silty clay, noncalcareous clay loam with >35% clay and noncalcareous silty clay loam with >35% clay	25	86	4 (Moderate)
Calcareous loam, calcareous silt loam, calcareous silt, calcareous sandy clay, calcareous sandy clay loam, calcareous clay loam, and calcareous silty clay loam	25	86	4L (Moderate)
Noncalcareous loam with <20% clay; noncalcareous silt loam with ≥5 to <20% clay; noncalcareous sandy clay loam; noncalcareous sandy clay; and hemic soil materials	40	56	5 (Moderate)
Noncalcareous loam and silt loam with ≥20% clay; noncalcareous clay loam and noncalcareous silty clay loam with ≤35% clay; silt loam with high iron oxide content	45	48	6 (Moderate)
Noncalcareous silt; noncalcareous silty clay, noncalcareous silty clay loam, and noncalcareous clay with high iron oxide content	50	38	7 (Low)
Soils not susceptible to wind erosion due to rock and pararock fragments at the surface and/or wetness	NA	0	8 (Low)

[a] Designations of high, moderate, or low are for purposes of this report only.

Sources: USDA (2010); Countess Environmental (2006).

TABLE 4.8-1 Subsurface Mineral Lands under BLM-Administered Surface Lands within the Six-State Study Area[a]

State	Subsurface Mineral Estates Underlying Federal Surface Lands[b] (millions of acres)
Arizona	33.0
California	47.0
Colorado	27.1
Nevada	56.1
New Mexico	36.0
Utah	33.9
Total	233.1

[a] Data from FY 2002 (BLM 2003a-f).

[b] To convert acres to km^2, multiply by 0.004047.

Mineral Leasing Act of 1920 and include energy (e.g., coal, oil, gas, geothermal) and nonenergy (e.g., sodium, phosphate) resources. Leases for these resources are obtained through a competitive bidding process.

Salable minerals include basic natural resources, such as sand, gravel, and building stone; the BLM sells them at fair market value. The BLM may also grant free-use leases to states, counties, or other government entities for public projects (BLM 2005b). Through the land use planning process, the BLM may identify specific terms and conditions applicable to developing mineral resources in specific areas or in some instances may recommend that the mineral estate not be available for development because of the presence of other important resource values.

4.9 WATER RESOURCES

4.9.1 Surface Water Resources

4.9.1.1 Hydrologic Regions

Nine major hydrologic regions have been identified in the six-state study area based on the USGS's classification system (Figure 4.9-1): (1) Pacific Northwest, (2) California, (3) Upper Colorado, (4) Lower Colorado, (5) Rio Grande, (6) Missouri, (7) Great Basin,

FIGURE 4.9-1 Hydrologic Regions in the Six-State Study Area (Source: USGS 2008a)

(8) Arkansas–White-Red, and (9) Texas–Gulf. Each hydrologic region encompasses either the drainage area of a major river or the combined drainage areas of a series of rivers (USGS 2008a). Table 4.9-1 lists the hydrologic regions in the six-state study area and their major river systems and provides a brief description of precipitation patterns and principal uses of surface water within each region.

Stream discharge in the six-state study area is affected by precipitation (which varies with season) and the regional topography. For example, moist air masses from the Pacific Ocean rise and cool as they approach the various mountain ranges in the western states. This condition causes increased precipitation with elevation on the western slopes of the ranges, thereby stripping moisture from the air masses as they move eastward and reducing the moisture available for precipitation on the eastern slopes of the ranges (creating a rainshadow effect). Seasonally, spring snowmelts cause high streamflows during the spring months. High streamflows also occur during summer thunderstorms. Many streams, especially those in basins, rely on groundwater discharge for their flow. Decrease of natural streamflow may occur due to consumptive use of surface water and/or groundwater in a basin, such as use for irrigation and public drinking water supply. Many rivers in the six-state study area are regulated by dams and other flow control structures, so stream discharge is also controlled by release schedules from reservoirs.

The quality of surface water varies by stream segment and is related to the volume of streamflow, the nature of local bedrock and soils, and human activities (e.g. mining, wastewater discharges, and agriculture). Generally, the quality of surface water in mountainous areas is considered good. However, as the water flows downstream to arid and semiarid valleys, the quality is reduced as tributaries pick up dissolved solids and sediments from bedrock and soils. Evaporation also increases the dissolved solids content of waters. During the spring, meltwater may dilute these constituents, but by summer the dilution effect disappears. The quality of groundwater discharge also contributes to the quality of surface water. The return base flows from agricultural irrigation commonly carry elevated levels of nutrients, salts, and metals leached from the soils. As base flows eventually return to surface water bodies, they could degrade the quality of surface water.

4.9.1.2 Wild and Scenic Rivers

Surface waters that are classified as Wild and Scenic Rivers (WSRs) are of particular concern with regard to impacts. The Wild and Scenic Rivers Act (Public Law [P.L.] 90–542 as amended; 16 USC 1271–1287), enacted in October 1968, provides a national policy and program to preserve and protect selected rivers, or segments of rivers, in their free-flowing condition. The Act states that certain selected rivers of the nation, along with their immediate environments, possessing outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, shall be preserved in free-flowing condition, and that they shall be protected for the benefit of present and future generations. The Act also states that each component of the National Wild and Scenic Rivers System (NWSRS) shall be administered in such a manner as to protect and enhance its values, without limiting other uses, water rights, or

TABLE 4.9-1 Hydrologic Regions and Surface Water Conditions in the Six-State Study Area

Hydrologic Region	Geographic Area	Major River Systems	Precipitation	General Surface Water Quality
Pacific Northwest	A small region in northern Nevada and northern Utah	Snake	Precipitation decreases east of the Cascades, and stream flow is driven primarily by snowmelt or groundwater discharge.	Agricultural areas degraded by nutrients (nitrates and phosphates) and pesticides from agricultural and grazing practices.
California	Most of California and a very small portion of western Nevada	Sacramento, San Joaquin	Precipitation occurs primarily in winter, with prolonged summer periods of little rainfall. Streamflow derived primarily from spring snowmelt.	Elevated TDS[a] levels from high salinity because of irrigation practices and arid climate. Agricultural practices in central California have resulted in elevated nutrients and pesticides.
Upper Colorado	Colorado Plateau in western Colorado, eastern Utah, northern Arizona, and New Mexico	Upper Colorado	Precipitation varies with elevation and includes winter snow storms and heavy fall rainstorms, with most streamflow dominated by snowmelt in the mountains.	Generally good water quality except in historic mining areas and in agricultural areas. Areas of sedimentary rock may have high levels of TDS, radon, uranium, and other metals.
Lower Colorado	Most of Arizona and portions of western New Mexico, southern Nevada, and southeastern California	Lower Colorado	This region is arid, with precipitation limited to winter months and periods of heavy storms. Streamflow is largely absent except in winter or after major storms. High erosion rates common in areas with grazing livestock.	Elevated TDS in areas with agriculture and grazing, and metals in mining areas.

TABLE 4.9-1 (Cont.)

Hydrologic Region	Geographic Area	Major River Systems	Precipitation	General Surface Water Quality
Rio Grande	Central New Mexico and south central Colorado	Rio Grande, Pecos	An arid region with precipitation limited to winter months and periods of heavy storms. Streamflow derived from spring snowmelt and summer thunderstorms.	Elevated TDS and nutrient and pesticide contamination in agriculture areas. Upper reaches of the Rio Grande have elevated levels of metals in mining areas attributed to the Creede mining district of southern Colorado.
Missouri	Northeastern Colorado	Platte	Precipitation generally sparse in summer and fall, with streamflow derived from snowmelt in mountainous areas, and in summer and fall from groundwater discharge.	Good water quality in high Rocky Mountains. Quality degrades as streams enter plains and valleys, where agricultural practices and urban runoff impact water quality. Mining and oil extraction cause locally increased TDS and metals concentrations, while grazing contributes sediments and nutrients.
Great Basin	Central and northern Nevada and western Utah, and a very small portion of northeastern California	Humbolt, Truckee	Arid region located in rain shadow of the Sierra Nevada Mountains. Surface water flow in basins derived from rain and snow falling in mountain areas.	Poor water quality in areas near urban centers; elevated metal concentrations in historic mining areas. Near-surface rocks naturally contribute arsenic, uranium, and radon to surface waters.
Arkansas–White-Red	Southeastern Colorado and northeastern New Mexico	Arkansas, Canadian, Red	Precipitation sparse in summer and fall. Streamflow derived from snowmelt in the mountainous areas.	Surface water quality is typically moderate in this region except poor in areas with extensive agricultural or livestock production.

TABLE 4.9-1 (Cont.)

Hydrologic Region	Geographic Area	Major River Systems	Precipitation	General Surface Water Quality
Texas-Gulf	A small region in eastern New Mexico	Running Water Draw, Black Water Draw, Yellow House Draw, Lost Draw, Sulphur Springs Draw, Mustang Draw, Monument-Seminole Draw[b]	An arid region with precipitation limited to winter months and periods of heavy storms. Streamflow derived from spring snowmelt and summer thunderstorms.	Not known.[c]

[a] TDS = total dissolved solids; a measurement of water quality.

[b] Source: New Mexico State University (2008).

[c] Data for the Texas-Gulf hydrologic region are incomplete (Jantzen 2005).

development projects that do not substantially interfere with public use and enjoyment of these values.

4.9.1.2.1 Designated Rivers. The NWSRS consists of selected rivers or segments of rivers that Congress authorizes for inclusion (designation by Congress) or that are designated as wild, scenic, or recreational rivers by the legislatures of the states through which they flow and are approved by the Secretary of the Interior (Section 2(a)(ii) of the Act). The former are assigned for administration either to the Secretary of the Interior or the Secretary of Agriculture through their agencies (e.g., BLM), while the latter are administered by the state. If a river or a segment of river is included in the system, it must be classified, designated, and administered as a wild, scenic, or a recreational river area. Additionally, a comprehensive management plan must be created and implemented for each WSR to protect its outstanding remarkable values.

Figure 4.9-2 is a map of WSR segments within the six-state study area. These rivers and segments are listed in Table 4.9-2, which identifies the specific classification (wild, scenic, or recreational) and administrative authority for each designated segment.

4.9.1.2.2 Congressionally Authorized Wild and Scenic Study Rivers. In addition to the directly designated rivers, the Secretary of the Interior, the Secretary of Agriculture, or the two Secretaries jointly could submit to the President names of additional rivers suitable for inclusion in the NWSRS. The President must make recommendations and proposals to Congress for potential additional rivers. Among the potential additions, those authorized by Congress for studies would be provided statutory protection. Congressionally authorized study rivers are afforded statutory protection under Section 7(b) of the Wild and Scenic Rivers Act for a 3-year period after the report is submitted to Congress (NWSRS 1999). Analogous to designated rivers, this provision protects the congressionally authorized study rivers from the harmful effects of water resources projects (for any part of a project proposed for construction within a study river bed or its banks).

4.9.1.2.3 Federal Agency Protected Rivers. Section 5(d)(1) of the Wild and Scenic Rivers Act directs each federal agency to identify potential additions to the NWSRS through agency planning processes. However, such rivers are not provided statutory protection. Each federal agency provides protection to the study river's free-flowing condition, outstandingly remarkable values, and classification through guidance in its respective policy and through other authorities. For example, BLM policy for identifying and managing wild and scenic rivers can be found in BLM WSR Manual 8351 (BLM 1993). The NPS maintains a list of river segments that potentially qualify as WSR areas in the Nationwide Rivers Inventory (NRI). A presidential directive requires that each federal agency avoid or mitigate adverse impacts on rivers listed in the NRI (NPS 2010).

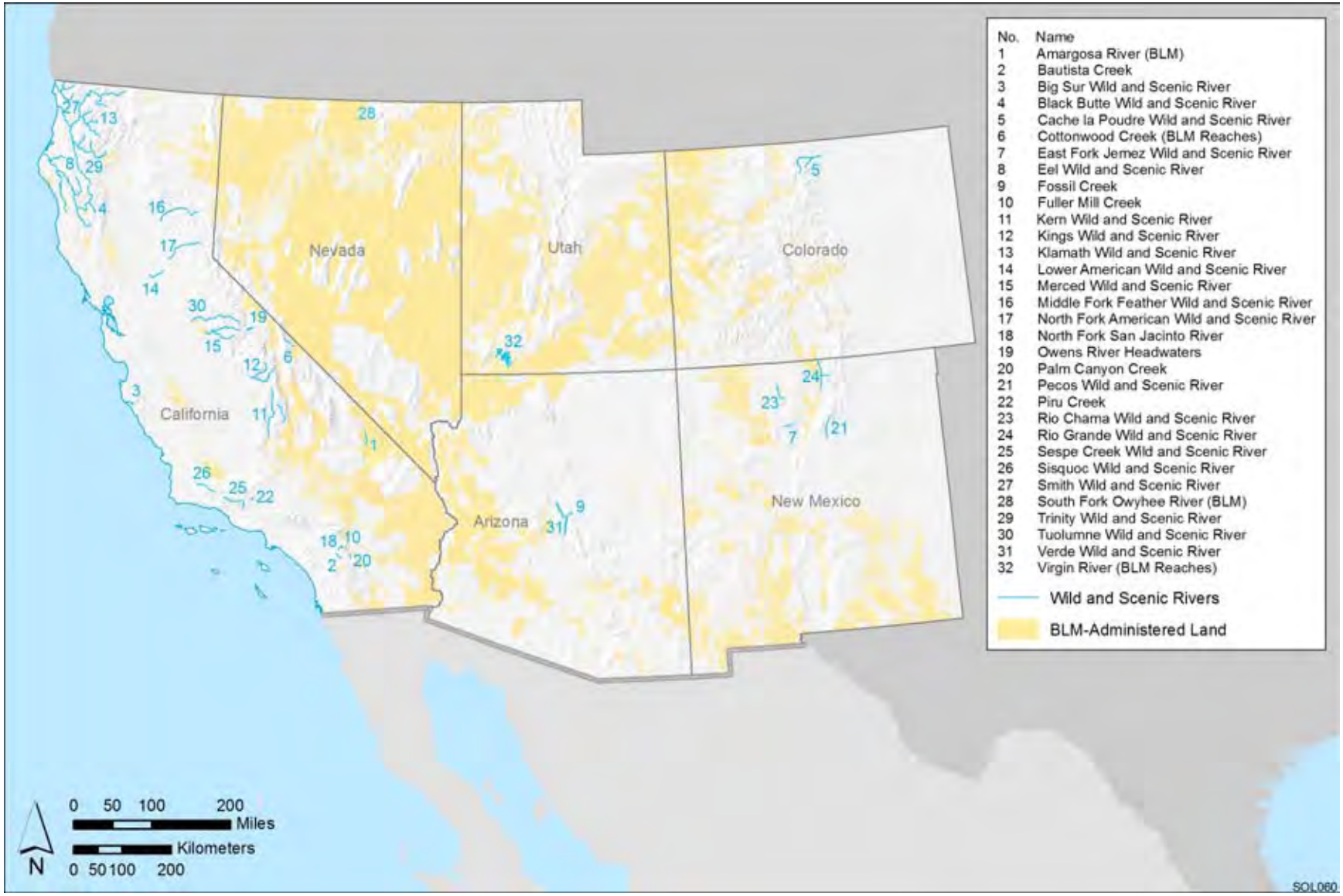

FIGURE 4.9-2 Wild and Scenic River Segments within the Six-State Study Area

TABLE 4.9-2 Designation Classification and Administrative Authority for Wild and Scenic Rivers in the Six-State Study Area

State	Wild and Scenic River	Administrative Authority[a]	Designation Classification and Length (mi)[b] Wild	Scenic	Recreational	Total Designated Miles[b]	Designated Location and Length[b]
Arizona	Verde	USFS	22.2	18.3	– [c]	40.5	The northern boundary of the Scenic River Area from the section line between Sections 26 and 27, the Gila-Salt River meridian, to the southern boundary, the Mazatzal Wilderness. The northern boundary of the Wild River Area from the boundary of the Mazatzal Wilderness to the southern boundary at the confluence of Red Creek with the Verde River.
California	American (Lower)	State of California	–	–	23.0	23.0	From the confluence with the Sacramento River to the Nimbus Dam.
	American (North Fork)	USFS BLM	26.3 12.0	– –	– –	26.3 12.0	From a point 0.3 mi above Health Springs downstream to a point 1,000 ft upstream of Colfax-Iona Hill Bridge.
	Big Sur	USFS	19.5	–	–	19.5	From the confluence of the South and North Forks downstream to the boundary of the Ventana Wilderness. The South Fork and the North Fork from their headwaters to their confluence.
	Eel	State of California USFS BLM Round Valley Reservation	36.0 35.0 21.0 5.0	22.5 – 4.5 1.0	250.5 – 6.5 16.0	309.0 35.0 32.0 22.0	From the mouth of the river to 100 yd below Van Ardsdale Dam. The Middle Fork from its confluence with the main stem to the southern boundary of the Yolla Bolly Wilderness Area. The South Fork from its confluence with the main stem to the Section Four Creek confluence. The North Fork from its confluence with the main stem to Old Gilman Ranch. The Van Duzen River from its confluence with the Eel River to Dinsmure Bridge.
	Feather	USFS	32.9	9.7	35.0	77.6	The entire Middle Fork downstream from the confluence of its tributary streams 1 km south of Beckwourth, California.
	Kern	USFS NPS	96.1 27.0	20.9 –	7.0 –	124.0 27.0	The North Fork from the Tulare-Kern County line to its headwaters in Sequoia National Park. The South Fork from its headwaters in the Inyo National Forest to the southern boundary of the Domelands Wilderness in the Sequoia National Forest.

TABLE 4.9-2 (Cont.)

State	Wild and Scenic River	Administrative Authority[a]	Designation Classification and Length (mi)[b] Wild	Scenic	Recreational	Total Designated Miles[b]	Designated Location and Length[b]
California *(Cont.)*	Kings	USFS	16.5	–	9.0	25.5	From the confluence of the Middle Fork and the South Fork to the point at elevation 1,595 ft above mean sea level. The Middle Fork from its headwaters at Lake Helen to its confluence with the main stem. The South Fork from its headwaters at Lake 11599 to its confluence with the main stem.
		NPS	49.0	–	6.5	55.5	
	Klamath	State of California	–	3.0	41.0	44.0	From the mouth to 3,600 ft below Iron Gate Dam. The Salmon River from its confluence with the Klamath to the confluence of the North and South Forks of the Salmon River. The North Fork of the Salmon River from the Salmon River confluence to the southern boundary of the Marble Mountain Wilderness Area. The South Fork of the Salmon River from the Salmon River confluence to the Cecilville Bridge. The Scott River from its confluence with the Klamath to its confluence with Schackleford Creek. All of Wooley Creek.
		USFS	12.0	21.0	177.5	210.5	
		BLM	–	–	1.5	1.5	
		Hoopa Valley Reservation	–	–	29.0	29.0	
		NPS	–	–	1.0	1.0	
	Merced	USFS	15.0	2.0	12.5	29.5	From its source (including Red Peak Fork, Merced Peak Fork, Triple Peak Fork, and Lyle Fork) in Yosemite National Park to a point 300 ft upstream of the confluence with Bear Creek. The South Fork from its source in Yosemite National Park to the confluence with the main stem.
		NPS	53.0	14.0	14.0	81.0	
		BLM	3.0	–	9.0	12.0	
	Sespe Creek	USFS	27.5	4.0	–	31.5	The main stem from its confluence with Rock Creek and Howard Creek downstream to where it leaves Section 26, T5N, R20W.
	Sisquoc	USFS	33.0	–	–	33.0	From its origin downstream to the Los Padres National Forest boundary.

TABLE 4.9-2 (Cont.)

State	Wild and Scenic River	Administrative Authority[a]	Designation Classification and Length (mi)[b] Wild	Scenic	Recreational	Total Designated Miles[b]	Designated Location and Length[b]
California *(Cont.)*	Smith	State of California	–	0.5	28.5	29.0	The segment from the confluence of the Middle Fork Smith River and the North Fork Smith River to its mouth at the Pacific Ocean. The Middle Fork from its headwaters to its confluence with the North Fork Smith River, including Myrtle Creek, Shelly Creek, Kelly Creek, Packsaddle Creek, the East Fork of Patrick Creek, the West Fork of Patrick Creek, Little Jones Creek, Griffin Creek, Knopki Creek, Monkey Creek, Patrick Creek, and Hardscrabble Creek. The Siskiyou from its headwaters to its confluence with the Middle Fork, including the South Siskyou Fork of the Smith River. The South Fork from its headwaters to its confluence with the main stem, including Williams Creek, Eightmile Creek, Harrington Creek, Prescott Fork, Quartz Creek, Jones Creek, Hurdygurdy Creek, Gordon Creek, Coon Creek, Craigs Creek, Goose Creek, the East Fork of Goose Creek, Buch Creek, Muzzleloader Creek, Canthook Creek, Rock Creek, and Blackhawk Creek. The North Fork from the California-Oregon border to its confluence with the Middle Fork of the Smith River, including Diamond Creek, Bear Creek, Still Creek, the North Fork of Diamond Creek, High Plateau Creek, Stony Creek, and Peridotite Creek.
		USFS	78.0	30.5	187.9	296.4	
	Trinity	State of California	2.0	11.0	24.0	37.0	From the confluence with the Klamath River to 100 yd below Lewiston Dam. The North Fork from the Trinity River confluence to the southern boundary of the Salmon-Trinity Primitive Area. The South Fork from the Trinity River confluence to the California State Highway 36 bridge crossing. The New River from the Trinity River confluence to the Salmon-Trinity Primitive Area.
		USFS	42.0	22.0	71.0	135.0	
		BLM	–	–	17.0	17.0	
		Hoopa Valley Reservation	–	6.0	8.0	14.0	
	Tuolomne	USFS	7.0	6.0	13.0	26.0	The main stem from its source to the Don Pedro Reservoir.
		NPS	37.0	17.0	–	54.0	
		BLM	3.0	–	–	3.0	

TABLE 4.9-2 (Cont.)

State	Wild and Scenic River	Administrative Authority[a]	Designation Classification and Length (mi)[b] Wild	Scenic	Recreational	Total Designated Miles[b]	Designated Location and Length[b]
Colorado	Cache La Poudre	USFS	18.0	–	46.0	64.0	From Poudre Lake downstream to where the river intersects the easterly north-south line of the west half of the southwest quarter of Section 1, T8N, R71W of the sixth principal meridian. The South Fork from its source to Section 1, T7N, R73W of the sixth principal meridian, from its intersection with the easterly section line of Section 30 of the sixth principal meridian to the confluence with the main stem.
		NPS	12.0	–	–	12.0	
Nevada	No WSR						
New Mexico	Jemez (East Fork)	USFS	4.0	5.0	2.0	11.0	From the Santa Fe National Forest boundary to its confluence with the Rio San Antonio.
	Pecos	USFS	13.5	–	7.0	20.5	From its headwaters to the town of Terrerro.
	Rio Chama	USFS and BLM	19.8	4.9	–	24.7	From El Vado Ranch launch site (immediately south of El Vado Dam) downstream for 24.7 mi.
	Rio Grande	USFS and BLM	53.2	–	2.5	55.7	The segment extending from the Colorado state line downstream approximately 68 mi to the west section line of Section 15, T23N, R10E. The lower 4 mi of the Red River.
Utah	No WSR						

[a] BLM = Bureau of Land Management; USFS = U.S. Forest Service; NPS = National Park Service.

[b] To convert mi to km, multiply by 1.609; to convert ft to m, multiply by 0.3048; to convert yd to m, multiply by 0.9144.

[c] A dash indicates zero mileage.

Sources: NPS (2006); USFWS (2008a).

4.9.1.3 Floodplains, Ephemeral Streams, and Wetlands

Surface water resources of the affected environment include lakes and rivers, as well as numerous floodplains, ephemeral streams (i.e., streams that carry water only briefly in direct response to precipitation), and wetlands. The Clean Water Act (33 USC §1251–1387) is the primary law protecting water quality in surface waters by means of regulatory and nonregulatory methods to limit pollution discharges by point and non-point sources. Additional protections to floodplains, ephemeral streams, and wetlands are provided by Executive Orders 11988 and 11990 ("Floodplain Management" [*Federal Register*, Volume 42, page 26951, May 24, 1977] and "Protection of Wetlands" [*Federal Register*, Volume 42, page 26961, May 24, 1977]). Appendix H provides further information on laws and regulations governing surface waters at the state and local levels for the six-state study region.

Floodplain maps are usually prepared for populated areas that could experience flooding. These maps are generally prepared by the Federal Emergency Management Agency (FEMA) for floods that statistically have a 1% chance of occurring each year (i.e., 100-year flood events). Such maps are used for property insurance purposes (FEMA 2008). Because the six-state study area has large areas that have not been evaluated for 100-year flood potential, affected environments and future project-specific impacts would need to be addressed during site-specific project planning.

Stream channels for ephemeral and intermittent streams are often incorporated in the National Hydrography Dataset from the USGS, but drainages and washes often are not. Again, for site-specific project work, planners would need to identify these drainages during assessment of affected environments and future project-specific impacts (e.g., using aerial photographs, field surveys). The six-state study region contains many mountain valley regions with low-relief alluvial fans. Surface water flows over alluvial fans and drainages can be significant during large storm events, resulting in localized flooding and severe erosion.

Wetlands in the six-state study area are often associated with perennial water sources such as springs, streams, lakes, or ponds. Given the arid climate of the Southwest, wetlands in this region are often inundated from seasonal to intermittent portions of the year. However, even when wetlands are not inundated, shallow groundwater depths are typical, which often supports vegetation important to ecological habitats (see Section 4.10.1 for further discussion of wetlands).

4.9.1.4 Water Management: Interstate Compacts and International Treaties

Several international compacts pertain to the governing of water rights in the southwestern United States for both surface waters and groundwater. The International Boundary and Water Commission (IBWC) was established in 1889 to implement water treaties between the United States and Mexico (IBWC 2010a). The commission has sections representing each country that consist of an engineer-commissioner, a team of engineers, and legal staff. The main goals of the IBWC relate to boundary preservation, water conveyance, water quality, and resource management of water bodies shared along the United States–Mexico border (IBWC

2010b). Two major river systems cross several western states and Mexico—the Colorado River and the Rio Grande River—along with several smaller water bodies. There are also groundwater aquifers that underlie the border between the United States and Mexico. In 2006, the United States and Mexico signed the Transboundary Assessment Aquifer Act (P.L. 109-448), which promotes sustainability of the aquifer systems that are shared across the United States–Mexico border. The Transboundary Aquifer Assessment Act allocates funds to study aquifers that underlie the United States–Mexican border with the states of Arizona, New Mexico, and Texas. The program aims to better understand the properties of groundwater aquifers along the border and has identified several priority aquifers that will be studied through 2016. The Act does not impact water rights, laws, or international treaties.

4.9.1.4.1 Colorado River. The Colorado River Basin covers an area of 156 million acres (632,000 km^2) across seven states: Colorado, Wyoming, Utah, New Mexico, Nevada, Arizona, and California). The Colorado River headwaters are located in the Colorado Rocky Mountains, and the river historically flowed 1,440 mi (2,300 km) to Mexico's Gulf of California, but currently its waters are consumed before reaching the Gulf. The Colorado River is managed by an assemblage of compacts, federal laws, court decrees, and contracts that form the "Law of the River." In the Consolidated Decree (2006) the Supreme Court directed the Secretary of the Interior to determine and manage flow of the Colorado River, acting as a water master. The major components of the Law of the River are described in Table 4.9-3.

Most of the components of the Law of the River pertain to allocation of Colorado River water, but the Colorado River Basin Salinity Control Act of 1974 addresses water quality. Salinity has long been recognized as one of the major problems of the Colorado River (CRBSCF 2005). The river carries an average salt load of about 4.4 million tons (4.0 million metric tons) annually past Lees Ferry, Arizona. It is estimated that the BLM-administered lands in the Upper Colorado River Basin contribute about 700,000 tons (635,000 metric tons) of salt per year from surface runoff. The remaining 3.7 million tons (3.4 million metric tons) are contributed primarily by groundwater inflow and saline springs, as well as runoff from other federal, Tribal, state, and private lands (DOI 2005). The sources of salinity in the Colorado River Basin 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 of the Bureau of Reclamation (BOR), USDA, and the BLM prevented a total of 1,072,000 tons (972,300 metric tons) of salts from entering the river. A goal has been set to prevent an additional 728,000 tons/yr (660,000 metric tons/yr) from entering the river basinwide by 2025 (DOI 2005).

4.9.1.4.2 Rio Grande. The Rio Grande originates in the San Juan Mountains in southern Colorado and flows 1,865 mi (3,000 km) south through New Mexico before forming the border between Texas and Mexico in route to the Gulf of Mexico. Debates over Rio Grande water resources have led to three major water compacts—the 1905 Rio Grande Project (RGP) compact between Texas and New Mexico; the 1906 United States–Mexico treaty; and the 1938 Rio Grande Compact between Colorado, Texas, and New Mexico (Littlefield 1999). These treaties

TABLE 4.9-3 Summary of Components to the Law of the River

Year	Agreement	Components
1922	Colorado River Compact	Defined Upper Colorado River Basin and Lower Colorado River Basin and allotted to each 7.5 million ac-ft/yr (9.3 billion m^3/yr) of water for beneficial use.
1928	Boulder Canyon Project Act	Ratified the 1922 compact. Authorized the construction of Hoover Dam and related facilities. Apportioned the Lower Colorado River Basin's 7.5 million ac-ft/yr (9.3 billion m^3/yr) to Arizona (2.8 million ac-ft/yr [3.5 billion m^3/yr]), California (4.4 million ac-ft/yr [5.4 billion m^3/yr]), and Nevada (0.3 million ac-ft/yr [370 million m^3/yr]). Authorized the Secretary of the Interior to manage all water uses in Lower Colorado River Basin.
1931	California Seven Party Agreement	Prioritized California's allotment among local water management entities– Palo Verde Irrigation District, Yuma Project, Imperial Irrigation District, Coachella Valley Irrigation District, Metropolitan Water District, and the City and County of San Diego.
1944	Mexican Water Treaty	Committed 1.5 million ac-ft/yr (1.9 billion m^3/yr) of Colorado River water to Mexico
1948	Upper Colorado River Basin Compact	The Upper Colorado River Commission was created and apportioned the Upper Colorado River Basin's 7.5 million ac-ft/yr (9.3 billion m^3/yr) to Colorado (51.75%), New Mexico (11.25%), Utah (23%), and Wyoming (14%). The northern portion of Arizona located within the Upper Colorado River Basin was granted 50,000 ac-ft/yr (62 million m^3/yr).
1956	Colorado River Storage Project Act	Provided comprehensive water resources development plan for the Upper Colorado River Basin and authorized the construction of the Glen Canyon, Flaming Gorge, Navajo, and Curecanti Dams, as well as several irrigation projects.
1964	Arizona v. California U.S. Supreme Court Decision	Settled dispute between Arizona and California regarding each state's allotment of Colorado River water. Directed the Secretary of the Interior to account for consumptive use of Colorado River water.
	Supplemental Decree (1979)	Addressed the current status of perfected water rights outlined in the Colorado River Compact and the Boulder Canyon Project Act.
	Consolidated Decree (2006)	Provided a single reference to the 1964 U.S. Supreme Court Decision and provisions. Also incorporated provisions for Tribal water rights for the Fort Yuma Indian Reservation.

TABLE 4.9-3 (Cont.)

Year	Agreement	Components
1968	Colorado River Basin Project Act	Authorized the construction of several water development projects, including the Central Arizona Project. Directed the Secretary of the Interior to develop long-range operating criteria for the Colorado River reservoir system.
1970	Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs	Provided the coordination of Colorado River reservoirs between the upper and lower basins and set conditions for water releases from Lake Powell and Lake Mead.
1973	Minute 242 of the U.S.-Mexico International Boundary and Water Commission	Required the United States to take action in reducing salinity in Colorado River water released from Morelos Dam into Mexico.
1974	Colorado River Basin Salinity Control Act	Authorized desalinization projects, including the Yuma desalting plant, to improve water quality.

Source: BOR (2010b).

are overseen and enforced cooperatively by the New Mexico Office of the State Engineer (NMOSE), New Mexico's Elephant Butte Irrigation District, Texas' El Paso County Water Improvement District No. 1, and the BOR. The Rio Grande Compact establishes appropriations of Rio Grande water between Colorado, New Mexico, and Texas by setting downstream delivery schedules for each state based on the natural supply. The Mexican Water Treaty of 1944 allocated water to Mexico, including 1.5 million ac-ft/yr (1.9 billion m^3/yr) of Colorado River water (Table 4.9-3) and two-thirds of the flows that originate from tributaries originating in Mexico, which averages to 350,000 ac-ft/yr (432 million m^3/yr) over a 5-year period (CRS 2005).

4.9.2 Groundwater Resources

Fourteen major aquifer systems occur in the six-state study area (Figure 4.9-3). Groundwater occurs primarily in basin-filled sediments, volcanic rocks, and carbonate bedrock. The most widely distributed systems are the basin-fill aquifers of the Basin and Range Region in Nevada, southeastern California, and western Utah, and the aquifers within the Colorado Plateau that occupy western Colorado, eastern Utah, northeastern Arizona, and northwestern New Mexico. Other major aquifer systems include the Central Valley aquifer system in California, the Rio Grande aquifer system in New Mexico, and the High Plains aquifer system east of the Rocky Mountains (Planert and Williams 1995; Robson and Banta 1995).

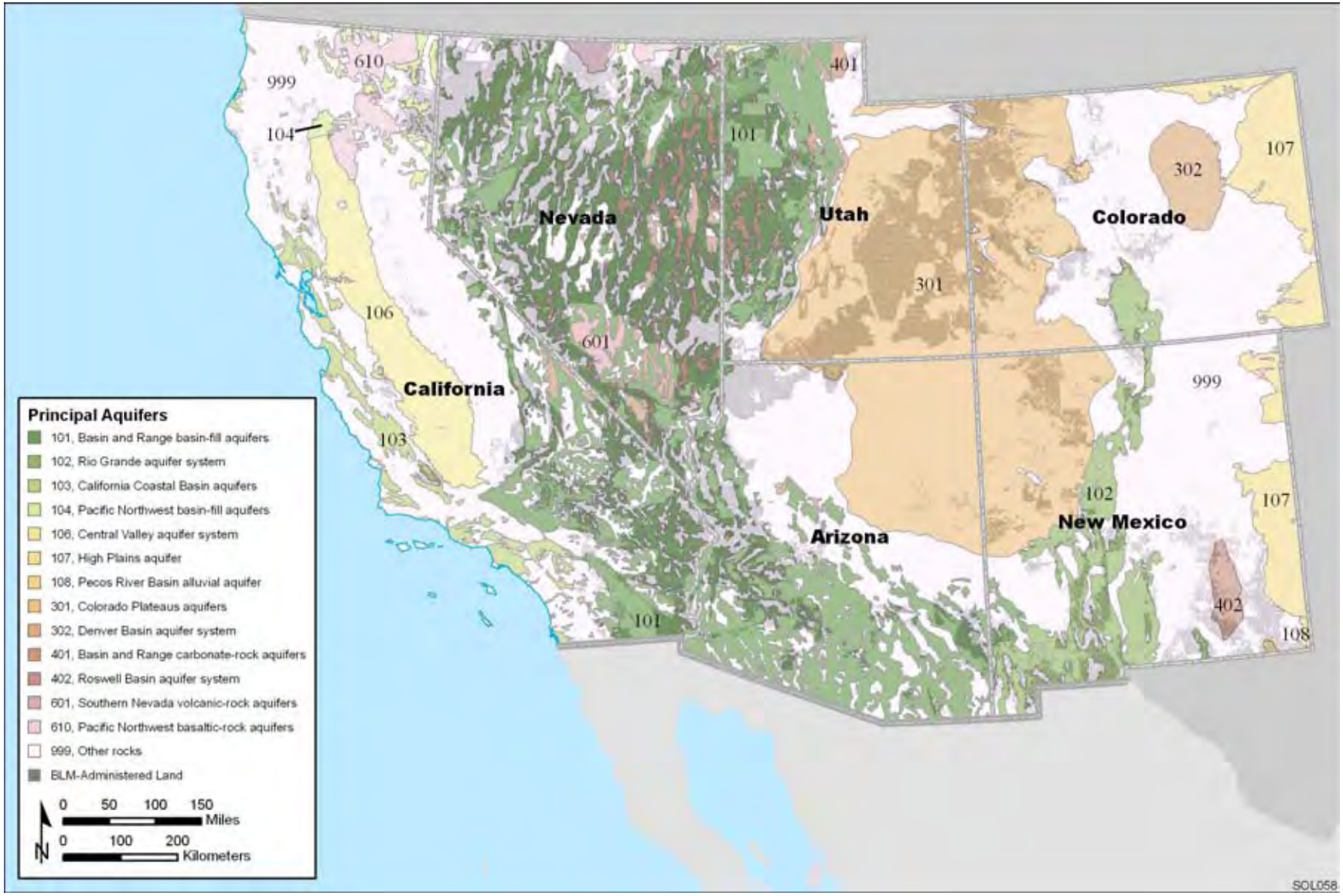

FIGURE 4.9-3 Major Aquifer Systems in the Six-State Study Area (USGS 2003)

Shallow groundwater is typically found near the surface in the vicinity of large surface water bodies (i.e., lakes and streams) and near the areas with lowest elevation in a basin. Deeper groundwater may occur at great depths in bedrock aquifers. Recharge of these aquifer systems occurs mainly through precipitation, especially in mountainous areas where snow precipitation is significant and evaporation is relatively low. Groundwater discharges to local streams and rivers and to springs in valleys of low-lying areas and in alluvial fans. During the summer, groundwater discharges contribute significantly to streamflows in low-lying arid and semiarid regions. Groundwater quality is significantly affected by the host bedrock. Recharge of aquifers can be of critical importance to the appropriate management of groundwater resources. Overdraft conditions occur when more water is discharged from an aquifer than is recharged to the aquifer. Overdraft conditions can lead to permanent damage to the storage capacity of an aquifer. Subsidence and surface fissures may occur due to severe overdraft. Determining the water budget of a specific local basin is an important tool for proper management of groundwater use. Table 4.9-4 lists the potentially affected aquifer systems within the nine hydrologic regions covered by the six-state study area and summarizes their principal uses and general water quality.

A few aquifers provide the major water supply for local communities and are federally designated as sole source aquifers (Table 4.9-5). The U.S. Environmental Protection Agency (EPA) defines a sole source (or principal source) aquifer as one that supplies at least 50% of the drinking water consumed in the area overlying the aquifer. The EPA's criteria for sole source aquifer designation also require that the area have no alternative drinking water sources that could physically, legally, and economically supply all those who depend upon the aquifer for drinking water (EPA 2008a).

The EPA's Sole Source Aquifer Protection Program is authorized by Section 1424(e) of the U.S. Safe Drinking Water Act (SDWA). Proposed federally funded projects that have the potential to contaminate a designated sole source aquifer are subject to EPA review. In many cases, Memoranda of Understanding (MOUs) have been developed by the EPA with federal funding agencies (e.g., the Federal Highway Administration and the Department of Housing and Urban Development) to establish a review of responsibilities under the Sole Source Aquifer Protection Program and to list categories of projects that should or should not be referred to the EPA for review. MOUs help ensure that projects that pose serious threats to groundwater quality are referred to the EPA (EPA 2008a).

Most projects referred to the EPA for review meet all federal, state, and local groundwater protection standards and are approved without imposing additional conditions. Occasionally, site- or project-specific concerns for groundwater quality protection lead to specific recommendations or additional pollution prevention requirements as a condition of funding. In rare cases, federal funding has been denied when the applicant either has been unwilling or unable to modify the project (EPA 2008a).

TABLE 4.9-4 Characteristics of Major Aquifer Systems in the Six-State Study Area

Hydrologic Region	Geographic Area	Major Aquifer Systems	Aquifer Types	Principal Water Uses	General Groundwater Quality
Pacific Northwest	A small region in northern Nevada	Pacific Northwest basaltic-rock aquifers	Bedrock	Irrigation	Generally good water quality.
California	Most of California and a very small portion of western Nevada	Pacific Northwest basin-fill aquifers, Pacific Northwest basaltic-rock aquifers, Basin and Range carbonate-rock aquifers, Basin and Range basin-fill aquifers, California Coastal Basin aquifers, and Central Valley aquifer system	Sedimentary rocks (including carbonate rock) and basin sediments	Main source of water for public supply, domestic consumption, and agricultural irrigation	Elevated TDS levels from evaporative beds in southern California. Agricultural practices in central California combined with a high evaporation rate have resulted in elevated nitrates and pesticides in shallow groundwater systems and substantial declines in shallow groundwater tables.
Upper Colorado	Colorado Plateau in western Colorado, eastern Utah, northern Arizona, and New Mexico	Colorado Plateau aquifers	Sedimentary rocks	Major source of water for municipal and domestic uses	Groundwater quality is influenced by the nature of the bedrock. Elevated levels of TDS in areas of sedimentary rock. Mining may cause metal contamination in local groundwater.
Lower Colorado	Most of Arizona and portions of western New Mexico, southern Nevada, and southeastern California	Southern Nevada volcanic-rock aquifers, Rio Grande aquifer system, Basin and Range basin-fill aquifers, and the Colorado Plateau aquifers	Basin sediments and bedrock	Main source of water for domestic consumption and agricultural irrigation	Groundwater quality is influenced by the nature of the bedrock. Elevated TDS and salinity in alluvium or in areas with Late Tertiary sedimentary bedrock. Elevated metals in groundwater in mining areas. Good water quality in deep, carbonate aquifers. Irrigation and mine dewatering lowered the water levels in shallow groundwater in Arizona.

TABLE 4.9-4 (Cont.)

Hydrologic Region	Geographic Area	Major Aquifer Systems	Aquifer Types	Principal Water Uses	General Groundwater Quality
Rio Grande	Central New Mexico and south central Colorado	Rio Grande aquifer system, Colorado Plateau aquifers, Roswell Basin aquifer system, and the High Plains aquifer	Basin sediments	Irrigation, livestock watering, and domestic uses	Elevated nitrate in agricultural areas such as the San Luis and Rincon Valleys. Pesticides detected in agricultural and urban areas.
Missouri	Northeastern Colorado	Denver Basin aquifer system and the High Plains aquifer	Basin sediments	Primarily for irrigation. Other uses include municipal and domestic water supplies	Generally good water quality. Elevated levels of sulfate and metals in local groundwater near mining areas. Elevated concentrations of nutrients and pesticides in shallow alluvial groundwater near agricultural areas.
Great Basin	Central and northern Nevada and western Utah	Basin and Range basin-fill and carbonate-rock aquifers and the southern Nevada volcanic-rock aquifers	Basin sediments and bedrock	Domestic consumption, public water supply, irrigation, and power plant cooling	Groundwater quality is influenced by the nature of the bedrock. Good water quality in carbonate rock and sandstone aquifers. Elevated levels of salts and TDS in the central parts of basins, elevated metal concentrations in historic mining areas, and elevated nitrate and pesticide concentrations in shallow groundwater in agricultural areas.
Arkansas-White-Red	Southeastern Colorado and northeastern New Mexico	High Plains	Basin sediments	Irrigation	Generally good quality. Dissolved solid concentrations less than 250 mg/L are found in northeastern Colorado and are the result of relatively large recharge rates in areas of sandy soil that contains few soluble minerals.

TABLE 4.9-4 (Cont.)

Hydrologic Region	Geographic Area	Major Aquifer Systems	Aquifer Types	Principal Water Uses	General Groundwater Quality
Texas-Gulf	A small region in eastern New Mexico	High Plains	Basin sediments	Irrigation	Not known.[a]

[a] Data for the Texas-Gulf hydrologic region is incomplete (Jantzen 2005).

Sources: BLM (2007a); Hutson et al. (2004).

TABLE 4.9-5 Sole Source Aquifers in the Six-State Study Area

Sole Source Aquifer	Location
Upper Santa Cruz and Avra Basin Aquifer	Arizona
Bisbee-Naco Aquifer	Arizona
Fresno County Aquifer	California
Santa Margarita Aquifer, Scotts Valley	California
Campo/Cottonwood Creek	California
Ocotillo-Coyote Wells Aquifer	California
Española Basin Aquifer System	New Mexico
Glen Canyon Aquifer	Utah
Castle Valley Aquifer	Utah
Western Unita Arch Paleozoic Aquifer System	Utah

Sources: EPA (2008b-d).

Special agency stipulations may apply to lands that have been designated with sole source aquifers. For example, no surface-disturbing activities would be allowed within sole source aquifer designated areas on BLM lands, unless an exception was granted for activities for which it can be demonstrated that the proposed action would not result in a negative impact on the aquifer.

4.9.3 Water Rights, Supply, and Use

The arid climate and scarcity of water resources of the Southwest make water rights and management of extreme importance in achieving beneficial uses of water resources while maintaining healthy aquatic ecosystems. Water rights and management activity varies by state, and in addition, surface water and groundwater can be managed together or separately. Beneficial uses of water resources vary by state, but typically include irrigation, domestic, recreational, and industrial uses. Balancing beneficial uses with scarce water resources, in combination with complex water rights and management practices, can make obtaining water supplies for solar energy development difficult. A significant component to any solar energy development plan will be an analysis to determine the ability to meet the necessary water requirements. Regulation of water resources can be imposed by state and local agencies, legislation, Native American water rights, court decisions, and international compacts. The myriad of applicable laws and agencies regulating water resources in any one location is complex and often needs to be assessed on a case-by-case basis. There are varying water management doctrines and approaches among the states, and sometimes surface water resources are managed differently than groundwater resources. Variation of management among the states stems from quantity and types of available resources, the climate and terrain of a state, and historical development. Water management strategies must accommodate many water needs and uses (human and ecological), while maintaining the sustainability of those resources. The following sections provide descriptions of general water management concepts and of the

various agencies involved in water management and water rights issues, and a summary of state-by-state water management.

For the rest of this section, the general supply and uses of water resources in the six-state study area are described. The description uses the long-term water supply as a baseline. Several constraints in using this baseline should be recognized. Drought conditions, which have occurred in the six states since early 2000, may reduce the water supply substantially from time to time, thus affecting the pattern of water use. Water use may also be legally restricted because of water right issues and various interstate compacts. As water rights can be transferred or traded, the use of water among various sectors could also change with time. Such transfer of water rights is affected by national and local economies. Regional population growth and weather patterns related to climate change may also contribute to the variation of water supply and use. Finally, conservation measures implemented in different states change water use behaviors. All in all, water supply and use are dynamic and interdependent in nature. The information on water supply and use described below provides a general picture of existing conditions by state. Whether the supply is able to meet the demand varies among different hydrologic basins and water management areas, districts, or hydrologic regions within each state. Therefore, local hydrologic conditions and water rights and management must be considered when impacts are evaluated at the project level.

Water Rights Doctrines. Two main water rights doctrines are used as the basis of water laws in the United States: the riparian doctrine and the doctrine of prior appropriation. The right to use water that is present or passes through a piece of property is termed a riparian water right. The riparian doctrine of water rights is based on the principle of "reasonable use." A property owner is allowed to divert or consume water that physically touches their property, but it must not be unreasonably detained or diverted. The definition of reasonable use of riparian water is variable among states, and the definition is subject to change. Riparian water rights are tied to the land adjacent to the water body and are generally not transferrable to non-riparian areas. Most of the eastern United States follows the riparian doctrine. Within the six-state study area analyzed for this PEIS, California is the only state that uses aspects of the riparian doctrine for land that borders a surface water body. California also uses aspects of the doctrine of prior appropriation, but the riparian rights are considered the most senior rights in a system.

The doctrine of prior appropriation says that the first person (or entity) to divert water from a source has a priority to that water right, and so on. Owners of water rights do not need to be adjacent to the water body, as in the riparian doctrine, but can divert water for use where it is needed. Most of the western states use the prior appropriation doctrine to manage water resources. Under the system of prior appropriation, water rights that are junior are not allowed to prevent senior water rights holders from obtaining their allocation of water. Thus, in times of drought, a junior water rights holder may not be entitled to their share of the resource. However, even senior water rights holders are not allowed to change the time of use, place of use, purpose of use, or point of diversion of the right if it would injure other water rights holders within a basin. Some areas allow transfer of water rights away from the land the water is tied to, but other areas forbid such transfers. Additionally, some states specify that if a water right is not used for a certain period of time, that water right is forfeited. In Arizona, if a water right is not used for five

consecutive years, the water right is considered forfeited and the water becomes available for appropriation again (BLM 2001).

Beneficial Use of Water Resources. In some states, the priority of a water right can be based solely upon the first date of use, and in others the priority can also depend on the specific use of the water. Priority "beneficial uses" of water can be specified, including for example: municipal, irrigation, industrial, or habitat uses. Each state has its own system for defining priorities regarding beneficial uses of water, from different sources and in different basins. For example, water rights in Utah are based on the concept of beneficial use, and any water right granted in the state has a specified beneficial use associated with it (BLM 2001).

Water that supports wildlife within a stream system can be defined as a beneficial use and is sometimes termed "instream flow." Some states, or basins within states, define instream flow, and accompanying support of wildlife, a beneficial use of that water. This use can be given a priority in times of drought to support wildlife by maintaining a minimum amount of water that has been demonstrated to support wildlife. In Utah, instream flows were defined as a beneficial use in 1986 through passage of legislation. The instream flow water rights in Utah can only be held by the Utah Division of Wildlife Resources or the Division of Parks and Recreation and can only be obtained through legislative approval. New Mexico has no state laws governing instream flows, and they are not recognized as a beneficial use in the state. However, ongoing litigation in New Mexico is working toward defining instream flows as a beneficial use (BLM 2001).

Federal, Native American, and Pueblo Water Rights. While most water rights are determined by the states, the United States has implied reserved water rights, termed federal reserved water rights, for Indian reservations and for most federal lands. The federal reserved water rights are only to include water needed to maintain the "primary purpose" for which the land was established. Determining the amount needed to satisfy the "primary purpose" of the land is subject to court ruling by the states (BLM 2001). In addition, there are federal water rights that apply to Indian Tribes and their reservations. The U.S. Supreme Court has typically sided with tribal governments over the management of federal Indian water rights (Williams 1997). Pueblo water rights apply to lands that were recognized by Spanish law as Spanish or Mexican pueblos (cities) and have been designated in California and New Mexico. A pueblo water right specifies that water flowing through or contained within the original pueblo can be used for municipal purposes within the modern city limits.

Federal, State, and Local Legislation and Adjudications. Water use is primarily governed through state and/or local regulations, but there are a few federal laws that play an important role in water use in the Southwest. As discussed above, the United States has federal reserved water rights that apply to most federal lands and to Indian reservations, and for the most part, these rights are independent of state laws. Wilderness designations can secure a minimum amount of water for wildlife that is dependent upon such water, as set forth in the Wilderness Act of 1964. Also, designation of a Wild and Scenic River under the Wild and Scenic Rivers Act of 1968 is accompanied by a minimum flow requirement to maintain the character of the river as

defined in the designation. Additionally, no diversions are allowed on the reach of the river that has been designated as Wild and Scenic (NPS 1998).

Some aquifers provide the major water supply for local communities and are federally designated as sole source aquifers. The EPA defines a sole source (or principal source) aquifer as one that supplies at least 50% of the drinking water consumed in the area overlying the aquifer. The EPA's criteria for sole source aquifer designation also require that the area have no alternative drinking water source(s) that could physically, legally, and economically supply all those who depend upon the aquifer for drinking water (EPA 2008a). Proposed federally funded projects that have the potential to contaminate a designated sole source aquifer are subject to EPA review.

All of the states in the six-state study area have passed legislation concerning the use and supply of water. For example, California has a suite of water laws that fall under the *California Code of Regulations*, Title 23. Colorado also has enacted statewide water laws in the *Colorado Revised Statutes.* Additionally, Colorado has a system of water courts that handle all water rights applications. Many of the states also provide specific regulations on standards for the reuse or recharge of municipal wastewater. The state water laws establish the rules and agencies/parties responsible for enforcing those rules. Additionally, some counties in the southwestern United States have additional laws or ordinances that govern the water supplies within that county. For example, 27 county-level ordinances have been established in California to manage groundwater resources. Local and municipal ordinances relating to water use or regulations within an irrigation district may also apply to certain areas in the Southwest.

Court determinations, termed adjudications, can also be used to determine the priority of, and settle disputes over, water rights in a basin. Adjudications have been necessary in many states to resolve complex water rights claims, including those claimed under the federal reserved rights doctrine (including tribal rights) that had previously not been included in a state's accounting of water rights for a basin (Gerlak and Thorson 2006). The McCarran Amendment of 1952 assigned the state court systems responsibility for determining the federal and tribal water rights for a basin (Hobbs 2006). The adjudications involve all water users in a basin, so the process can be long and complex. In New Mexico, the adjudication of the Pecos River basin began in 1956 and is still ongoing (NMOSE 2010b). Each state handles water rights adjudications in different ways. In New Mexico, Nevada, and Utah, the State Engineer initiates the adjudications. In California, the State Water Board has only initiated 2 out of 20 adjudications, the rest are conducted by the state or federal court system or by the court system with the State Water Board as a referee (CADWR 2010a). The results of adjudications are often a complex set of new rules and regulations for a basin that are enforced by state or regional water officials (Gerlak and Thorson 2006; Hobbs 2006). The water rights decisions can sometimes include a settlement of both money and water (Gerlak and Thorson 2006).

Federal, State, and Local Agencies and Water Resources Managed. A myriad of agencies are involved with water management. At the federal level, the EPA and the U.S. Army Corps of Engineers (USACE) enforce many programs to protect water bodies from, for example, contamination or physical alteration. The EPA also has set standards and regulations for the

reuse of wastewater treatment plant effluent. The National Park Service (NPS), the U.S. Fish and Wildlife Service (USFWS), the BLM, and other federal agencies are responsible for securing federal reserved water rights that accompany the land holdings of these agencies. Often, these agencies are interested in preserving instream flows or maintaining groundwater-fed springs to protect wildlife habitat. The BOR and the USACE are responsible for managing hydropower and other types of dams; however, the flows from these dams are often regulated by state laws or international treaties. The U.S. Section of the IBWC is the agency responsible for managing the water at the United States–Mexico border.

Water management at the state level is typically performed by a division of water resources or an office of the state engineer, and a combination of agencies is responsible for water management in some cases. In Utah, there are two agencies: the Division of Water Resources, responsible for planning within the surface water basins, and the Division of Water Rights, responsible for appropriating available water resources within basins. In California, the State Water Resources Control Board holds the primary responsibility for issuing and regulating surface water rights, while groundwater resources are typically managed at a local level. The California Department of Water Resources is responsible for planning for the future of California's water resources and is a repository of information on those resources. For example, all wells drilled in the state must be registered with the Department of Water Resources, and water levels for 35,000 wells are available from their Web site (CADWR 2010b). Additionally, each state has a department of environmental quality or equivalent agency that regulates the quality of water and maintains drinking water standards within the state.

At a regional, county, or local level, there is often another layer of management. In New Mexico, the Office of the State Engineer has identified priority regions within the state, each of which has an appointed "water master" to help track water use and enforce water law within that region. New Mexico also has a system of acequias, or community ditches, that have been in existence since the Spanish colonized the area starting in the seventeenth century (NMOSE 2010c). Acequia associations are in charge of distributing surface water in certain areas of New Mexico. In California, water masters are often appointed to enforce an adjudication of a basin. Colorado water rights are established through seven regional water court systems throughout the state and enforced by regional water commissioners. Before a water right is approved, it must be approved by both the water court system and the local Division Engineer Office (CDWR 2008). Additionally, in many regions of the southwestern United States, water conservation agencies and irrigation districts are responsible for the local management of water resources, and can also act as the water master for adjudicated basins (e.g. Imperial Irrigation District, Mojave Water Agency, Palo Verde Irrigation District, and Metropolitan Water Agency, operating in California).

There are many different approaches to managing water resources. In some states surface water and groundwater are managed differently, and in others all water resources are managed conjunctively. Also, in some regions, the beneficial uses of water within a basin are stipulated by water management agencies. For example, in Nevada the groundwater in some basins is designated as having preferred beneficial uses, and all other uses are not allowed within the basin. As is the case with many basins in Nevada, agricultural irrigation is not allowed as a groundwater use in the Las Vegas Valley basin. Other uses are specified as preferred within the

basin. Various beneficial uses are recognized in the six southwestern states. Arizona recognizes the following beneficial uses: domestic, municipal, irrigation, stock watering, power, mining, recreation, wildlife and fish, and groundwater recharge. California recognizes several more beneficial uses, including aquaculture, fire protection, frost protection, heat control, industrial use, and water quality control (BLM 2001).

To obtain water rights in most states, users must submit to the appropriate state (or local) agency an application that, in most cases, must identify the source of the water, the location of the proposed diversion (or well), the proposed place of use, the beneficial use, and the proposed quantity of use. Surface water is almost universally acquired using a process similar to that described here, but the process of obtaining groundwater varies from state to state. Permits to withdraw groundwater are not required to be obtained through a state agency in California, but may be required through a county or local agency. In Arizona, permits to withdraw groundwater are only required in certain areas. In Nevada, the exact same process must be followed for obtaining rights to surface water or groundwater.

Many groundwater basins in the six southwestern states have been over-appropriated and are experiencing groundwater overdraft. The basins in overdraft have been experiencing groundwater level declines because the outputs from the basins (including withdrawals from wells) have far exceeded the inputs to the basins. The declining water levels have the potential to cause land subsidence. Many of the over-appropriated basins are closed to new applications for groundwater use, and any future groundwater use within the basins must be transferred from other uses. Each state handles these groundwater overdrafts differently. Many states (including Arizona, California, and Nevada) have started artificially recharging some overdrawn aquifers by either diverting surface waters to infiltration basins and allowing water to percolate from the surface into an aquifer or by pumping the water down wells to replenish an aquifer. In most cases, excess surface water during wet periods is diverted for these artificial recharge activities. Usually, the water is considered available for use later, during times of water shortage. Special permits may be required to use artificially recharged water.

Another strategy for optimizing water use has been the rise of the reuse of wastewater treatment plant effluent for irrigation, energy production, artificial recharge, industrial purposes, or other uses. Most western states are encouraging the reuse of treated water to optimize water use, especially within heavily populated areas. In Arizona, 80,000 ac-ft/yr (99 million m^3/yr) of effluent from the Phoenix metro area is allocated to the Palo Verde Nuclear Generating Station for cooling, allowing the existence of the only nuclear power plant not located on a major body of water (Azcentral 2010).

Many states have a process for designating basins or regions as special management areas to impose additional regulation of water resources. The Nevada Department of Water Resources (NDWR) designates groundwater basins when they are deemed to be in a state of overdraft. As of 2005, the New Mexico Office of the State Engineer (NMOSE) had “declared” every basin within the state as being in need of management (NMOSE 2010e). Prior to that time, basins that had not been declared were not subject to regulation by the NMOSE. Additionally, New Mexico has instituted a program called Active Water Resource Management that is currently being employed in the seven “priority” basins within New Mexico (NMOSE 2004). This initiative is

developing tools to perform detailed accounting of water use, implementing new or existing regulations, creating water districts for management, and assigning water masters to those districts (NMOSE 2004).

Most states allow interbasin transfers of water if water is available in one place but needed in another. States handle these interbasin transfers in different ways. In Nevada, there is a formal process by which the NDWR approves interbasin transfers, but in Utah, for example, interbasin transfers are allowed, but there is no formal process for evaluating and approving them in the state. In Colorado, interbasin transfers are necessary to support the half of the population that lives on the eastern side of the state that only receives 20% of the precipitation (CLCS 2009). Twenty-five of the 39 interbasin transfers in Colorado originate from the Colorado River Basin (CLCS 2009).

In addition to managing surface water and groundwater resources, water managers also need to consider the health of springs and seeps, the quality of water, and instream flow needs for wildlife. Water supports life, and clean, flowing water is needed in many areas to support wildlife, some of which is threatened or endangered. The need to support wildlife can often lead to court cases to establish the amount of water deemed sustainable to withdrawal from a stream or aquifer in order to maintain ecosystems in a basin.

4.9.3.1 Arizona

Arizona water law is based on the doctrine of prior appropriation. However, water laws in Arizona are based on a bifurcated system in which surface water and groundwater rights are administered and assessed separately. Arizona has four main sources of water: (1) Colorado River water, (2) surface water separate from the Colorado River, (3) groundwater, and (4) treated effluent. Rights for these four sources are assessed and administered separately. Colorado River water is regulated under the Law of the River; surface water is based on prior appropriation; and groundwater rights are handled on a region by region basis (BLM 2001). Effluent is not available for use until it takes on the characteristics of surface water through treatment (ADWR 2010f). The Arizona Department of Water Resources (ADWR) is the agency responsible for the conservation and distribution of water in the state. It is also responsible for the administering and assessment of novel and transfer of existing water rights and applications. The agency's broad goal is the security of long-term dependable water supplies for the state, which is the main factor in the assessment of water right applications (ADWR 2010a).

Upon completion of an application for water rights, the ADWR assesses it with three main criteria: (1) whether the proposed water right will conflict with more senior water rights, (2) whether the proposed right is a threat to public safety, and (4) whether the proposed right will be detrimental to the interests and welfare of the general public (BLM 2001). Generally, surface water rights are assessed solely upon these four criteria, but they may also be subject to certain management plans in specific areas put into effect by the ADWR. Unlike the majority of groundwater rights that are bound to the land they occupy, users of surface water rights have the option to change location of the water right but not the beneficial use (a change of beneficial use application would need to be submitted). In order to change a surface water right's location, a

"sever and transfer" permit needs to be approved by the ADWR and the governing body of the irrigation district or water users council of the proposed new location of the surface water right. Evaluations of "sever and transfer" permits follow the same general evaluation guidelines as new surface water rights, and the proposed new location of the right after the transfer is treated as a new surface water right. The new surface water right must not exceed the old one in annual water use (ADWR 2010f).

Because of historic groundwater overdraft, where groundwater recharge is exceeded by discharge (in some places groundwater overdraft is in excess of 700,000 ac-ft/yr [863 million m^3/yr]), the Ground Water Management Code (the Code) was put into effect in 1980 (ADWR 1999, 2010d). The Code describes three main goals for the state regarding the management of groundwater: (1) controlling severe overdraft, (2) allocation of the limited water resources of the state, and (3) enhancement of the state's groundwater resources using water supply development (BLM 2001). Arizona's groundwater management laws are separated using a three tier system based on the Code. In that system, proposed applications are evaluated with an increasing level of scrutiny. The lowest level of management includes provisions that apply statewide, Irrigation Non-Expansion Areas (INAs) have an intermediate level of management, and Active Management Areas (AMAs) have the highest level of management with the most restrictions and provisions. There are currently five AMAs and three INAs in the state, each of which has its own specific rules and regulations regarding the appropriation of groundwater (ADWR 2010b).

Recently, the ADWR has created guidelines regarding the appropriation of water for solar generating facilities, specifically detailing what information needs to be submitted for permit evaluation (ADWR 2010e). The information required includes the proposed method of power generation, the proposed amount of water to be consumed, the point of diversion, and to what or whom the power is to be distributed (ADWR 2010f). To secure water rights for a solar facility to be located within an AMA, the applicant must demonstrate that there is an "assured water supply" for the life of the project (ADWR 2010e). The ADWR then makes a decision based on whether the proposed water right will be detrimental to public welfare and general conservation of water (ADWR 2010f).

Arizona has rights to 2.8 million ac-ft (3.5 billion m^3) of Colorado River water annually, which is further sub-divided into allocations for both general Colorado River water users and Central Arizona Project (CAP) users (ADWR 2010c). CAP is a system of water delivery canals, aqueducts, and pumping stations that deliver 1.5 million ac-ft/yr (1.9 billion m^3/yr) of Colorado River water from Lake Havasu to Pima, Pinal, and Maricopa Counties annually (CAP 2010). The flows of the Colorado River are variable, and thus the water resource actually available varies from year to year.

In addition to the Colorado River, the Salt, Verde, and Gila Rivers provide essential supplies for water users in central Arizona. In other parts of Arizona, local surface water supplies, such as Little Colorado River, San Pedro River, Verde River, and other rivers and streams, as well as captured runoff in reservoirs and springs, are used by municipal, industrial, and agricultural users.

The Arizona State Legislature created the Underground Water Storage and Recovery Program in 1986 and enacted the Underground Water Storage, Savings, and Replenishment Act in 1994 to make use of excess water that may otherwise be lost in times of surplus water supply (AWBA 2010). The Underground Water Storage, Savings, and Replenishment Act created the Arizona Water Banking Authority, which has two programs: (1) Underground Storage Facilities, which use excess CAP water, other surface water, or effluent to artificially recharge a groundwater aquifer, and (2) Groundwater Savings Facilities, which provide water supplies (CAP water, other surface water or effluent) in lieu of using groundwater, allowing the groundwater to stay in storage and become "savings" (ADWR 2010e; AWBA 2010). The ADWR is in charge of the distribution of the program's waters as well as the evaluation of permits to store and recover their waters (ADWR 2010e). To put this water to use, the ADWR must first award a recovery well permit (ADWR 2010e). If a recovery well permit is submitted for use inside an AMA, a "hydrologic impact analysis" report may also need to be submitted (ADWR 2010f).

Table 4.9-6 lists the water withdrawal in Arizona in 2003. The table shows that the state relies on both groundwater and surface water for its water use. Among the various water uses, agricultural and municipal uses are the biggest consumers, accounting for 5.4 million and 1.6 million ac-ft (6.7 billion and 1.9 billion m^3), respectively. With population growth, the effluent water from sewage treatment plants increases. This effluent and the effluent from the Palo Verde nuclear power plant also provide 190,000 ac-ft (230 million m^3) of water, primarily for irrigation and recharges. The total amount of water used in 2003 was about 7.8 million ac-ft (9.6 billion m^3).

4.9.3.2 California

California uses a "plural" system to manage water resources that consists of a mixture of riparian and prior appropriation doctrines for surface waters, a separate doctrine for groundwater, and pueblo rights (BLM 2001). Several agencies are involved with the management of California's water resources, including federal, state, local, and water/irrigation districts. For example, water rights and water quality are managed by the State Water Control Board, while the Department of Water Resources manages water conveyance, infrastructure, and flood management (CADWR 2010c). Surface water appropriations for nonriparian rights begin with a permit application to the State Water Control Board and a review process that examines the application's beneficial use, pollution potential, and water quantity availability. The permitting, review, and licensing procedure should not take more than 6 months to complete unless the application is protested (BLM 2001).

The California Department of Water Resources divides the state into 10 hydrologic regions for managing its water resources: (1) North Coast, (2) San Francisco Bay, (3) Central Coast, (4) South Coast, (5) Sacramento River, (6) San Joaquin River, (7) Tulare Lake, (8) North Lahontan, (9) South Lahontan, and (10) Colorado River. In addition to these 10 regions, 2 special districts (the Mountain Counties and the Sacramento-San Joaquin Delta area) are delineated. The special districts overlay parts of the other hydrologic regions.

TABLE 4.9-6 Water Withdrawal (thousand ac-ft[a]) in Arizona by Sector, 2003

Use Sector	Surface Water	Groundwater	CAP[b]	Effluent	Others	Subtotal
Municipal	418	633	422	94.0		1,567
Agricultural	2,298	2,484	585	69.4		5,436
Industrial	6.7	312	1.8	21.2	600	403
Tribal	130	145	140	5.2		421
Subtotal	2,913	3,575	1,149	189.8	600	7,827
Total						7,827

[a] To convert ac-ft to m^3, multiply by 1,234.

[b] CAP = Central Arizona Project; includes direct use and recharge credit recovery in the CAP, in which water from the Colorado River is transferred to central Arizona.

Source: ADWR (2006).

Groundwater management in California is primarily implemented at the local level of government through local agencies or ordinances and can also be subject to court adjudications. State statute provides authority and revenue mechanisms to several types of local agencies to provide water for beneficial uses, as well as to manage withdrawals in order to prevent overdraft of the aquifers. Local ordinances (typically at the county level) can also be used to manage groundwater resources and have been adopted in 27 California counties. Many of these local groundwater ordinances are focused on controlling water exports out of the basin through permitting processes. Court adjudications are the strongest form of groundwater management used in California and often result in the creation of a court-appointed water master agency to manage withdrawals for all users to ensure that the court-determined safe yield is achieved (CADWR 2003).

Reuse of effluent in California is governed under Title 22 of the *California Code of Regulations.* California has long been a leader in recycled water use and technology (Davis 2000). Artificial recharge is also widely practiced throughout the state for various purposes, but there is no state law that governs this practice. California is divided into regions, and each regional water quality control board has different regulations that must be complied with in that region that determine the management strategy of the artificial recharge activities (Mills et al. 2009).

The water supplies of California are based on precipitation in the state as well as imports from neighboring states, such as Arizona (the Colorado River) and Oregon, and from Mexico. For water management purposes, the surface water supplies are provided in different storage and delivery systems and are divided as follows: Local Deliveries, Local Imported Deliveries, Colorado River Deliveries, Central Valley Project (CVP) Base and Project Deliveries, Other

Federal Deliveries, State Water Project (SWP) Deliveries, and Required Environmental Instream Flow. Groundwater is also used extensively in California.

The water supply in California varies from year to year. Table 4.9-7 summarizes the water supply for 1998, 2000, and 2001. These three years represent a wet year, a normal year, and a slightly dry year, respectively. As indicated in the table, yearly water usage is dictated by the precipitation of that year. During a wet year (such as 1998), surface water is the primary source. However, that source is substituted by groundwater during a dry year (such as 2001). The reuse/recycle water is also reduced in a dry year.

California receives water from the Colorado River. Under the Colorado River Compact of 1922, California is apportioned with 4.4 million ac-ft/yr (5.4 billion m^3/yr) of the river water. In 2001, inflow from the Colorado River was 5.2 million ac-ft (6.4 billion m^3) (CDWR 2005). The state is going to reduce the inflow in the future to meet the Compact's requirement, thus reducing its supply from the Colorado River.

Table 4.9-8 gives the water consumption of different water users. Water use fluctuates among different sectors with hydrologic conditions, such as a wet (1998), normal (2000), or dry year (2001), especially for environmental use, which ranges from 14.5million to 44.7 million ac-ft (17.9 billion to 55.1 billion m^3) in depletion from 1998 to 2001. Agricultural use of water is more than three times the urban use, regardless of the hydrologic conditions. The agricultural depletion ranges from 20.4 million ac-ft (25.2 billion m^3) (1998 wet year) to 26 million ac-ft (32 billion m^3) (2001 dry year) and was not affected much by hydrologic conditions. Urban use ranged from 6.3 million to 7.2 million ac-ft (7.8 billion to 8.9 billion m^3) in the same period.

TABLE 4.9-7 Water Supplies (thousand ac-ft[a]) for Applied Water[b] in California, 1998, 2000, and 2001

Year	Surface Water	Groundwater	Deep Percolation of Surface water and Groundwater	Reuse/Recycle	Subtotal
1998	68,900	4,400	5,600	15,400	94,500
2000	55,700	7,800	7,000	11,800	82,500
2001	38,200	11,000	6,700	8,800	64,800

[a] To convert ac-ft to m^3, multiply by 1,234.

[b] Applied water refers to the total amount of water that is diverted from any source to meet the demands of water users, without adjusting for water that is used up, returned to the developed supply, or irrecoverable.

Source: CDWR (2005).

TABLE 4.9-8 Water Use in California (thousand ac-ft[a]) by Sector, 1998, 2000, and 2001

	1998		2000		2001	
Sector	Applied Water Use[b]	Depletion[c]	Applied Water Use[b]	Depletion[c]	Applied Water Use[b]	Depletion[c]
Urban[d]	7,800	6,300	8,900	7,200	8,600	7,000
Agricultural[e]	27,300	20,400	34,200	25,600	33,700	26,000
Environmental[f]	59,400	44,700	39,400	28,500	22,500	14,500

[a] To convert ac-ft to m^3, multiply by 1,234.

[b] Applied water refers to the total amount of water that is diverted from any source to meet the demands of water users, without adjusting for water that is used up, returned to the developed supply, or irrecoverable.

[c] Depletion is the water consumed in the system, irrecoverable water, and outflow minus water that can be later recovered, such as deep percolation and return flow to developed supply.

[d] Urban water use includes large landscape, commercial, industrial, energy production, residential, evapotranspiration of applied water, deep percolation to salt sink, outflow, any conveyance water, groundwater recharge applied water, groundwater recharge evaporation, and evapotranspiration.

[e] Agricultural water use includes on-farm applied water, evapotranspiration of applied water, deep percolation to salt sink, outflow, any conveyance water, groundwater recharge applied water, groundwater recharge evaporation, and evapotranspiration.

[f] Environmental water use includes instream flow, WSR, required delta outflow, and managed wetlands flows.

Source: CDWR (2005).

4.9.3.3 Colorado

Colorado administers its water rights using the doctrine of prior appropriation as its cornerstone, with water rights being granted by a water court system and administered by the Colorado Division of Water Resources (CDWR) (BLM 2001). Surface waters in much of Colorado were over-appropriated before the turn of the twentieth century, groundwater was not actively managed until mid 1960, and the Water Rights Determination and Administration Act of 1969 (C.R.S. §§37-92-101 through §§37-92-602) required that surface waters and groundwater be managed together (CDWR 2010a).

The state has seven regional division engineer offices, corresponding with the state's seven major river basins. These division offices are authorized by the CDWR to review and administer water rights within the basin boundaries. The process of obtaining both surface and groundwater rights in Colorado differs from those of other western states. In Colorado, water rights are established through regional water court systems throughout the state and enforced by regional water commissioners. Before a water right is granted, it must be approved by both the water court system and the local division engineer office. Proposed water rights are assessed based on whether the proposed right will have available, unappropriated water and if it will

impair existing water rights (CDWR 2008). A water right's date of establishment is determined by when the water was first put to beneficial use, and this date determines the priority of the water right in the basin. Water rights are considered real property in Colorado and can be bought and sold as such, but transfer of rights requires approval of a change application by the CDWR (BLM 2001).

Groundwater in Colorado is governed by the Groundwater Management Act of 1965. Under this act, all Colorado groundwater is governed under the doctrine of prior appropriation and is typically considered part of a surface water body. If a potential groundwater user can prove that the proposed groundwater right will not deplete a surface water body by a tenth of one percent of the proposed amount of groundwater withdrawn for 100 years, the groundwater will be deemed as "non-tributary" groundwater, and thus deemed not connected to a surface water body (BLM 2001).

If the primary source of water within a basin has been groundwater for a period of 15 years, the basin may be deemed "designated" by the State Engineer (CDWR 2008). Within designated basins, water courts have no water right authority. Authority to distribute, administer and review novel and transfer of existing water rights within designated basins is held solely by the Colorado Ground Water Commission (the Commission) (CDWR 2010b). The Commission's overall goals are working toward water conservation and protecting existing senior water rights. To fulfill those goals, pumping levels and rates of discharge are established and assessed on a basin-by-basin basis (BLM 2001; CDWR 2008). Within designated basins of the state, groundwater management districts (GWMD) may be formed; however, GWMDs do not have any permit approval authority. Once a proposed application is approved by the Commission, GWMDs have authority to administer groundwater and adopt new regulations to help conservation goals within their basin (CDWR 2008). Colorado's 8 designated basins and 13 GWMDs are all located in the eastern portion of the state.

In 2002, Colorado experienced one of the worst droughts of the century, which sparked development of improved water resource planning and reuse facilities that capture effluent water to be recycled. Prior to the 2002 drought, the primary use of recycled water was irrigation and golf course watering (CDM 2007). There are now 18 water reuse facilities statewide that distribute treated effluent to a wide variety of water users, including municipal and industrial users (CDM 2007). Along with water recycling programs, Colorado also has an extensive artificial recharge program. Artificially recharged water is designed to be used in times of shortage and to reduce falling groundwater levels in areas where natural recharge may not offset discharge of the aquifer (CWCB 2007).

In response to increasing water demands in the state, the Colorado Legislature enacted the *Colorado Water for the 21st Century Act* in 2005, which created the Interbasin Compact Committee (IBCC) along with nine basin roundtables (CLCS 2009; Houston 2007). The nine roundtables are composed of water rights owners, water suppliers, and representatives of all water interests of the basin (agricultural, industrial, municipal, recreational, etc). These roundtables meet periodically to discuss statewide and basin-specific water management issues and possible solutions (CWCB 2010a; CWCB 2010d).The IBCC consists of 27 members—some appointed by the governor or legislature and others appointed by the basin roundtables. The

IBCC is responsible for facilitating negotiations between the basin roundtables and assessing and approving any project, compact proposal, or proposed interbasin transfer between each of the basins involved (CWCB 2010c; Houston 2007). Each roundtable is also responsible for developing a basin-specific report that focuses on current and projected unmet demands and future plans of conservation to meet demands (CWCB 2010b).

Colorado's water supply comes from precipitation in the form of rain or snow. No major rivers flow into Colorado. Instead, several major river basins originate in the Colorado Rockies and flow out of the state, thus providing water to neighboring states (McKee et al. 2000). On average, some 16.0 million ac-ft (19.7 billion m^3) of precipitation finds its way into Colorado's creeks and rivers annually. As a headwater state, under various interstate compacts Colorado is legally obligated to provide two-thirds of the surface water it receives from precipitation to downstream users (Fey 2007). Each year, a total of about 10.2 million ac-ft (12.6 billion $m^{3)}$ of water flows to Utah, Nevada, California, New Mexico, Arizona, Nebraska, Kansas, Wyoming, and Mexico. This leaves about 6.0 million ac-ft (7.4 billion m^3) of water for the state in the form of surface water and groundwater (Fey 2007). The precipitation as well as the water supply for Colorado fluctuates with time. In all parts of Colorado, no consistent long-term trends in annual precipitation have been detected in the last 100 years (Ray et al. 2008). Annual precipitation ranges from roughly half to double the long-term average.

Water withdrawals in Colorado in 2000 by water use category are shown in Table 4.9-9. The statewide water use for municipal and self-supplied industries was estimated to be 1.1 million ac-ft (1.4 billion m^3) in 2000. Agricultural irrigation used about 12.8 million ac-ft (15.8 billion m^3), accounting for about 90% of water withdrawals in 2000. Historically, 80 to 85% of the water in Colorado was used for agricultural irrigation (CAWA 2008).

Groundwater use is widespread and constitutes almost 20% of total water use in Colorado. In 2000, groundwater withdrawals for irrigation accounted for 93% of the groundwater used (and about 17% of the total water withdrawals). Other major uses of groundwater were for the public water supply (2.3% of groundwater use) and self-supplied domestic use (2.9% of groundwater use). The remainder of the groundwater withdrawals (about 1.7%) were for industrial and thermoelectric uses.

The Northern and Southern High Plains Designated Basins are two important groundwater resources. The recoverable groundwater was estimated to be 12 million ac-ft (14.8 billion m^3) in the Southern High Plains and 48 million ac-ft (59.2 billion m^3) in the Northern High Plains. The current withdrawal rate in the Southern High Plains Basin is about 220,000 ac-ft/yr (270 million m^3/yr). Groundwater levels have been declining at an average rate of about 5.4 ft/yr (1.6 m/yr) over the past 10 years. The pumping rate in the Northern High Plains Basin was unclear. However, pumping from large wells for irrigation results in drawdown in water levels of more than 10 ft/yr (3 m/yr) in large areas of several counties.

The recoverable groundwater in the Denver Basin bedrock aquifers was estimated to be 206 million to 295 million ac-ft (254 billion to 364 billion m^3), depending on the assumed values of the aquifer storage coefficient. Pumping of the Denver Basin bedrock aquifers results in significant large drawdown in water levels, as much as 30 ft/yr (9.1 m/yr) in some locations

TABLE 4.9-9 Water Withdrawals (thousand ac-ft[a,b]) in Colorado by Water Use Category, 2000

Use Category	Surface Water	Groundwater	Total	Percentage of Total Withdrawal
Public water supply	948	60.2	1,008	7.1
Self-supplied domestic	0	74.9	74.9	0.53
Irrigation	10,400	2,420	12,820	90
Livestock	NC[c]	NC[c]	NC[c]	0
Aquaculture	NC[c]	NC[c]	NC[c]	0
Industrial self-supplied[a]	108	26.4	134.4	0.95
Mining[a]	NC[c]	NC[c]	NC[c]	0
Thermoelectric power[a]	137	18.0	155	1.1
Subtotal	11,593	2,600	14,193	

[a] Values converted from million gallons/day.

[b] To convert from ac-ft to m^3, multiply by 1,234.

[c] NC = data not collected.

Source: Hutson et al. (2004).

(CWCB 2004). The sustainable yield of the aquifer is much less than that of recoverable groundwater.

4.9.3.4 Nevada

All waters in Nevada are the property of the public in the state and are subject to the laws described in *Nevada Revised Statutes*, Chapters 532 through 538 (available at http://leg.state.nv.us/nrs/). The Nevada Division of Water Resources (NDWR), lead by the State Engineer, is the agency responsible for managing both the surface water and groundwater resources. This responsibility includes overseeing water right applications, appropriations, and interbasin transfers (NDWR 2010a). The two principal ideas behind water rights in Nevada are the prior appropriations doctrine and the concept of beneficial use. A water right establishes an appropriation amount and date such that more senior water rights have priority over newer water rights. Additionally, water rights are treated as both real and personal property, such that water rights can be transferred without affecting the land ownership (NDWR 2010a). Water rights applications (new or transfer of existing) are approved if the water is available to be appropriated, if existing water rights will not be affected, and if the proposed use is not deemed to be harmful to the public interest. If these conditions are satisfied according to the State Engineer, a proof of beneficial use of the approved water must be provided within a certain time period, and following that a certificate of appropriation is issued (BLM 2001).

Surface water use makes up 70% of all water uses in the state, and all surface water resources are considered fully appropriated; however, transfer of rights is possible (NDWR 1999). Averaging only 9 in. of annual precipitation, Nevada is the most arid state in the nation. This makes surface water resources highly variable, causing higher rates of groundwater use during periods of growth and shortage (NDWR 1999).

Nevada has 14 hydrographic regions, which are further divided into 232 sub-basins. Groundwater use in the state makes up 30% of total water use during periods of average surface water flow and 40% during periods of surface water shortage (NDWR 1999). Considering the fact that surface water rights in the state are fully appropriated, the potential for development in the state relies almost solely upon the use of groundwater (NDWR 1999). In 1999, it was estimated that 60% of Nevada's basins might have room for additional appropriations; however, some basins were already over-appropriated by over four times above the estimated perennial basin yield, often causing groundwater overdraft (NDWR 1999). Following the realization of a basin's being in a state of overdraft, the NDWR may deem the basin "designated" (NDWR 2010b). Of Nevada's 232 sub-basins, 116 are deemed "designated" (NDWR 2010b). In these basins, unlike surface water rights, the doctrine of prior appropriation may not be the only basis on which groundwater rights are managed. The NDWR, in the interest of the public welfare, has the authority to prioritize preferred uses of groundwater (e.g., municipal or industrial), as well as groundwater extraction quantities (NDWR 2010b).

Artificial recharge in Nevada is mostly through geothermal energy production plants, but it is also associated with mining operations and groundwater replenishment in the Las Vegas Valley (SNWA 2010; Lopes and Evetts 2004).

The estimated average annual yield from Nevada's surface water bodies is about 3.2 million ac-ft (3.9 billion m^3). The annual surface runoff from watersheds within the state is about 1.9 million ac-ft (2.3 billion m^3), while the annual inflow from other states is 1.3 million ac-ft (1.6 billion m^3). Nevada is one of the lower basin states of the Colorado River Basin. It is entitled to 300,000 ac-ft/yr (370 million m^3/yr) of water under the Colorado River Compact of 1922. The perennial yield of the groundwater, defined as the amount of usable water that can be economically withdrawn from a groundwater aquifer and consumed each year without depleting the source, is estimated to be 2.1 million ac-ft/yr (2.6 billion m^3/yr) (NDWP 1999a).

Surface water provides 60% to 70% of the total water supply used in Nevada and has been fully appropriated and used for many years (NDWP 1999a). The rest of the water supply is from groundwater. In some areas, groundwater provides the entire supply.

The total water withdrawal in Nevada was 4.0 million ac-ft (5.0 billion m^3) in 1995 (Table 4.9-10). Agricultural withdrawals accounted for 3.1 million ac-ft (3.8 billion m^3), or 77% of the total water withdrawals in 1995. Public water supply was the second biggest water withdrawal, about 525,000 ac-ft (648 million m^3) (about 13% of the total withdrawal). The mining and self-supplied uses were 274,000 ac-ft (338 million m^3) (6% to 7%) and 122,000 ac-ft (150 million m^3) (3% to 4%), respectively (NDWP 1999b).

TABLE 4.9-10 Water Withdrawals (ac-ft[a]) in Nevada by Sector, 1995

Sector	Surface Water	Groundwater	Total	Percentage of Total Withdrawal
Irrigation	1,975,401	1,138,184	3,113,585	77
Public supply	392,903	131,958	524,861	13
Self-supplied domestic	321	17,783	18,104	0.45
Self-supplied commercial	15,559	7,919	23,478	0.58
Self-supplied industrial	8,446	8,322	16,768	0.41
Thermoelectric	23,176	40,650	63,826	1.6
Livestock	5,210	1,119	6,329	0.16
Mining	3,909	270,524	274,433	6.8
Subtotal	2,424,925	1,616,459	4,041,384	

[a] To convert ac-ft to m^3, multiply by 1,234.

Source: NDWP (1999b).

4.9.3.5 New Mexico

Water law in New Mexico is governed under the doctrine of prior appropriation. All waters (both groundwater and surface water) are public and subject to appropriation by a legal entity with plans of beneficial use (BLM 2001). A water right in New Mexico is a legal entity's right to appropriate water for a specific beneficial use and is defined by seven major elements: owner, point of diversion, place of use, purpose of use, priority date, amount of water, and periods of use. Water rights in New Mexico are administered through the Water Resources Allocation Program (WRAP) under the New Mexico Office of the State Engineer (NMOSE 2010d).

Under the WRAP, the NMOSE is responsible for both surface and groundwater appropriations (both novel and transfer of existing water rights). The extent of the NMOSE's authority to regulate groundwater applies only to those groundwater basins that are "declared" as underground water basins. As of 2005, all groundwater basins within the state have been declared. An application for appropriation must be filed with declared basins. When assessing water right applications, the WRAP considers the following factors: the existence of unappropriated waters within the basin, the possibility of impairing existing water rights, whether granting the application would be contrary to the conservation of water within the state, and if the application will be detrimental to public welfare (BLM 2001).

In most regions of the state, groundwater and surface water appropriation application procedures are handled the same; however, the criteria for which they are evaluated and administered may vary by region or case (NMOSE 2005, 2006). Within select basins, in addition to the routine evaluations described above, groundwater and surface water rights applications may be subject to water management plans to ensure that the proposed junior water rights will

not be detrimental to more senior water rights or impair efforts of water conservation in the specific region (NMOSE 2004). The WRAP has created the Active Water Resource Management (AWRM) initiative, which is responsible for administering the water management plans in specific basins/regions (NMOSE 2010a). The AWRM is also responsible for the prioritization of basins that are in need of conservation and water management plans. In basins deemed "priority," policies are set in place that mandate junior water rights be temporarily curtailed in favor of more senior water rights in times of drought or shortage. These priority basins are generally more restrictive in terms of rewarding novel and transfer of existing water rights (NMOSE 2004). Specific tools that are to be used in the AWRM initiative are (1) detailed accounting for water use, (2) implementing new or existing regulations, (3) creating water districts for management purposes, and (4) assigning water masters to those districts (NMOSE 2004). The water masters are tasked with prioritizing water rights, which is necessary to accurately establish which rights will be curtailed and which will not in a time of water shortage.

The New Mexico Interstate Stream Commission was created in 1935 by the New Mexico State Legislature to "investigate, protect, conserve and develop New Mexico's waters including both interstate and intrastate stream systems" (BOR 2010a). The responsibilities of the commission include evaluating of the conditions of the eight interstate river basins and ensuring compliance with interstate compacts for those basins. In 1987, the New Mexico Legislature created a regional water planning program for the state, which is overseen by the Interstate Stream Commission (NMOSE 2010f). The Interstate Stream Commission has divided the state into 16 regions and has funded the creation of unique regional water plans corresponding to each of the regions (NMOSE 2010f). The regional water plans examine water resource availability issues at smaller scales and highlight the diverse availability of water resources throughout the state. The plans present data on water supply, water demand, and projected demands for each region. Using these datasets, conclusions are drawn as to where water shortage areas are and where they may soon appear based on historical water consumption records, historical population data, and projected population increases. This information enables the regions to construct plans for times of shortage to ensure senior water rights are protected (NMOSE 2010f).

The water supply in New Mexico is difficult to quantify (OSE/ISC 2003) because of high natural variability in the surface water supply; data limitations of groundwater; variation in yearly obligations of in-state and interstate delivery; the interrelationship between groundwater and streamflows; and the complication caused by groundwater quality, economic constraints, local land use regulations, and land ownership. Nevertheless, the Office of the State Engineer and Interstate Stream Commission of New Mexico in the 2003 State Water Plan concluded that the water supply barely accommodates and has sometimes fallen short of existing demand, even during the unusually wet years of the 1980s and 1990s. During times of average water supply, the demand for water exceeds the supply.

The Office of the State Engineer's Water Use and Conservation Bureau of New Mexico conducts statewide water use inventories every 5 years. The latest report was published in 2008 for water use in 2005 (Longworth et al. 2008). The water uses were listed by river basins as well as by counties and could be used to estimate the water resource demand in the state. In general, groundwater withdrawals (or uses) in 2005 accounted for 46.5% (or 1.8 million ac-ft

[2.3 billion m^3]) of the total withdrawals (3.9 million ac-ft [4.8 billion m^3]), while surface water withdrawals accounted for the remainder (2.1 million ac-ft [2.6 billion m^3]). Total withdrawals from streams and aquifers in 2000 were more than 4.2 million ac-ft (5.2 billion m^3).

Table 4.9-11 gives water use in New Mexico in 2005. Water for agricultural irrigation accounted for the largest water usage, at about 78% of the total water withdrawal that year. Public water supply and reservoir evaporation were the second and third largest use categories, with about 8% and 7% of the total water withdrawal, respectively. More than 90% of New Mexico's population depends on groundwater for drinking, and it is the only source of potable water in many areas of the state (OSE/ISC 2003). Groundwater contributed about 87% of the public water supply in 2005.

4.9.3.6 Utah

Utah water law is governed under the doctrine of prior appropriation (BLM 2001). The agency responsible for the regulation, appropriation, and distribution of the state's water is the Utah Division of Water Rights, headed by the State Engineer (Utah Division of Water Rights 2010a). Water rights are assessed regionally in one of the seven regional offices of the Utah Division of Water Rights (Reid et al. 2008). The Utah Division of Water Rights assesses proposed water right applications based on whether the proposed right will have available unappropriated water, whether the right will impair existing rights, and whether granting the proposed right will be detrimental to the public welfare (BLM 2001). The means to acquire both

TABLE 4.9-11 Water Withdrawals (thousand ac-ft[a]) in New Mexico by Water Use Category, 2005

Use Category	Surface Water	Groundwater	Total	Percentage of Total Withdrawal
Public water supply	42	278	320	8.1
Self-supplied domestic	0	35.8	35.8	0.91
Irrigated agriculture	1,731	1,344	3,075	78
Self-supplied livestock	3.3	53.7	57.0	1.4
Self-supplied commercial	1.5	39.1	40.6	1.0
Industrial	2.0	16.3	18.3	0.46
Mining	1.4	58.8	60.2	1.5
Power	51.6	12.0	63.6	1.6
Reservoir evaporation	279		279	7.1
Subtotal	2,112	1,838	3,950	

[a] To convert ac-ft to m^3, multiply by 1,234.

Source: Longworth et al. (2008).

surface and groundwater rights (novel and transfer of existing rights) are identical; however, the policy on which they are assessed varies. Surface water applications are assessed solely upon the criteria previously stated, while groundwater rights applications are assessed on a regional basis (BLM 2001). About one third of the state's groundwater basins are closed to new appropriations, so the only means of appropriating water within those basins would be the transfer of existing rights (Utah Department of Water Resources 2005). Interbasin transfers of water are considered legal in Utah; however, unlike other states that allow them (e.g., Colorado and Nevada), Utah has no formal process for dealing with interbasin transfers (Houston 2007). Water rights in Utah are considered property and may be bought, sold, and transferred as such, but a change application must be approved by the Utah Division of Water Rights (BLM 2001).

There are 11 primary river basins in Utah, each with variable supplies of water on a yearly basis. A basin plan has been written by the Utah Division of Water Resources for each of the 11 basins describing the basin's current and projected water use and detailing methods of meeting future projected water demands (Utah Department of Water Resources 2010). Transfer of existing surface rights is possible but must be approved by the Utah Division of Water Rights (BLM 2001).

About one third of the groundwater basins in Utah are closed to new appropriations of water rights and another third are "restricted," implying that the assessment of proposed water rights by Utah Division of Water Rights is conditional on a number of factors. The remaining third of the state is open to new water right appropriation applications, which are assessed on a regional basis. Of the 36 defined groundwater basins, 12 have experienced water level drops of up to 110 ft (33.5 m) since 1950. All 12 of these areas are closed to new appropriations and have basin-specific water plans that outline conservation guidelines and goals for the future. Some of these plans include strict guidelines involving water right transfers (Utah Department of Water Resources 2005). It has been suggested that additional groundwater may be available outside of the 36 primary basins,; however, issues concerning depth to water table, water quality, and overdraft may prove detrimental to the approval of new water rights (Utah Department of Water Resources 2001).

In Utah, there are six effluent reuse programs throughout the state, with five more planned for future use. The effluent is used primarily for irrigation or watering of residential and golf course grass. The appropriation and use of effluent requires a water right that must be granted by the Utah Division of Water Rights, and the main criterion of assessment is whether the proposed right will be reduce the water quantity for use by downstream users who may depend on the effluent to satisfy their water rights (Utah Department of Water Resources 2001).

The Utah Division of Water Rights manages and oversees the state's aquifer storage and recovery (ASR) facilities, where artificial recharge of aquifers occurs (Utah Division of Water Rights 2010b). To date, there are six ASR facilities statewide, and recovery of ASR facility water requires the approval of a recovery permit by the Utah Division of Water Rights (2010d-f). Recovery permits give the water user the right to use the recovered water "in the manner in which the water was permitted to be used or exchanged before the water was artificially recharged, unless a change or exchange application is filed and approved" (Utah Division of Water Rights 2010g). The main factor in assessing potential recovery permits is whether the

proposed application will be detrimental to current water rights, so permit approval varies by region (Utah Division of Water Rights 2010c).

Between 1961 and 1990, the long-term water supply in Utah was estimated to be 7.3 million ac-ft (9.0 billion m^3) annually (UDNR 2001). The estimate was derived from total precipitation in the state and interstate inflows minus the amount of evapotranspiration and the export due to interstate compacts, and accounts for both the surface water and groundwater resources.

The groundwater resources in Utah are well delineated. Thirty-six areas have significant groundwater development, most of them in central Utah (UDNR 2001). The average annual yields of these areas range from less than 3,000 to 133,000 ac-ft (3.7 million to 164 million m^3), based on data collected from 1989 to 1998. The total amount of groundwater developed was 851,000 ac-ft/yr (1.0 billion m^3/yr) during that period.

Water withdrawals in Utah (in 2000) by water use category are shown in Table 4.9-12. Agricultural irrigation was the largest water use category, accounting for 4.3 million ac-ft/yr (5.3 billion m^3/yr), about 78% of Utah's water withdrawals in 2000. Municipal and industrial usage was about 769,000 ac-ft/yr (949 million m^3/yr) (about 14% of the water withdrawal in 2000). Great Salt Lake evaporation, wetland and riparian evaporation and evapotranspiration, and reservoir evaporation combined to deplete another 4.0 million ac-ft/yr (4.9 billion m^3/yr) (UDNR 2001).

TABLE 4.9-12 Water Withdrawals (thousand ac-ft)[a,b] in Utah by Water Use Category, 2000

Use Category	Surface Water	Groundwater	Total	Percentage of Total Withdrawal
Public water supply	307	408	715	13
Self-supplied domestic	0	18.0	18.0	0.32
Irrigation	3,800	526	4,326	78
Livestock	NC[c]	NC[c]	NC[c]	0
Aquaculture	0	130	130	2.3
Industrial self-supplied[a]	9.39	44.1	53.5	0.96
Mining[a]	217	33.7	251	4.5
Thermoelectric power[a]	55.1	14.7	69.8	1.3
Subtotal	4,388	1,175	5,563	

[a] Values converted from million gallons/day.

[b] To convert ac-ft to m^3, multiply by 1,234.

[c] NC = data not collected.

Source: Hutson et al. (2004).

4.10 ECOLOGICAL RESOURCES

4.10.1 Vegetation

Plant communities occurring within the six-state study area span a great variety of ecosystems, from arid deserts to coastal coniferous forests. Each plant community is unique in species composition, richness, diversity, and structure. Several environmental factors, including climate, elevation, aspect (i.e., compass direction of slope), precipitation, and soil type, influence the presence and development of various types of plant communities throughout the study region.

Because of the great variety and complexity of the plant communities occurring within the six states, the area is best represented by description at the "ecoregion" level. The concept of ecoregions is intended to provide a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components (EPA 2007a). An ecoregion is an area having a general similarity in ecosystems and is characterized by the spatial patterning and composition of biotic and abiotic features, including vegetation, wildlife, geology, physiography (patterns of terrain or land forms), climate, soils, land use, and hydrology, such that within an ecoregion, there is a similarity in the type, quality, and quantity of environmental resources present (EPA 2007b). Ecoregions of North America have been mapped in a hierarchy of four levels, with Level I being the broadest classification. Each level consists of subdivisions of the previous (next highest) level. Level IV ecoregions have not been developed for all of the six states of the study area. Therefore, the ecoregion discussions presented in this PEIS follow the Level III ecoregion classification, with 22 ecoregions covering the six-state area (see Figure I.1, Appendix I). These ecoregions are based on Omernik (1987) and refined through collaborations among EPA regional offices, state resource management agencies, and other federal agencies (EPA 2007b). Ecoregion descriptions and maps that overlay solar energy resources with the ecoregions in each state are presented in Appendix I.

The 22 ecoregions in the six states include a wide variety of upland plant community types, such as coniferous forest, coniferous and deciduous woodland, shrub communities, shrub steppe, and grassland. Mountain ranges often support coniferous forest and woodlands, such as the ponderosa pine (*Pinus ponderosa*) habitats and pinyon-juniper (*Pinus* sp.-*Juniperus* sp.) woodlands found in many of the ecoregions, or mixed habitats such as the oak-juniper (*Quercus* sp.-*Juniperus* sp.) woodlands of the Chihuahuan Deserts and Madrean Archipelago ecoregions. Numerous basins occur in the study area and often support shrublands, such as Great Basin sagebrush (*Artemisia* sp.), saltbush-greasewood (*Atriplex* sp.-*Sarcobatus vermiculatus*), creosotebush (*Larrea tridentata*), or palo verde (*Cercidium* sp.) -cactus shrublands. Basins in the region are typically arid and include the Chihuahuan, Mojave, and Sonoran Deserts. Habitats on plateaus may include woodland, shrubland, or grassland. The Arizona/New Mexico Plateau ecoregion, for example, supports shrublands of big sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus* sp.), winterfat (*Ceratoides lanata*), shadscale saltbush (*Atriplex confertifolia*), and greasewood, and grasslands of blue grama (*Bouteloua gracilis*), western wheatgrass (*Agropyron smithii*), green needlegrass (*Stipa viridula*), and needle-and-thread grass (*Stipa comata*). Shrublands and pinyon-juniper woodlands are

common in the Colorado Plateaus ecoregion. The basins and plateaus of the study area include the predominance of those areas where solar energy development is most likely to occur.

Wetlands occurring within these ecoregions are extremely varied and include such wetland types as marshes, bogs, vernal pools, and forested wetlands. 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. Streambeds, mudflats, gravel beaches, and rocky shores are wetland areas that may not be vegetated (Cowardin et al. 1979). While surface flows provide the water source for some wetlands, others, such as springs and seeps, are supported by groundwater discharge. Wetlands are often associated with perennial water sources, such as springs, perennial segments of streams, or lakes and ponds. However, some wetlands, such as vernal pools, have seasonal or intermittent sources of water. The total wetland areas present within each of the six states, based on estimates from the 1980s, range from about 236,350 acres (956 km^2) in Nevada to 1,000,000 acres (4,047 km^2) in Colorado (Table 4.10-1). These estimates represent 1.5% or less of the total surface area of each of the six states and less than 1% of the total state surface area for four of the states. Annual wetland losses have since decreased nationally compared with pre-1980s levels (Dahl 2006). While freshwater wetlands showed a slight overall gain in total area in recent years, vegetated freshwater wetlands continued to show losses (Dahl 2006).

TABLE 4.10-1 Wetland Areas in the Six-State Study Area, 1980s Estimates

State	Wetland Area (acres[a])	Percentage of Surface Area of State
Arizona	600,000	0.8
California	454,000	0.4
Colorado	1,000,000	1.5
Nevada	236,350	0.3
New Mexico	481,900	0.6
Utah	558,000	1.0

[a] To convert from acres to km^2, multiply by 0.004047.

Source: Dahl (1990).

Riparian vegetation communities occur along rivers, perennial and intermittent streams, lakes, and reservoirs, and at springs. These communities generally form a vegetation zone along the margin that is distinct from the adjacent upland area in species composition and density and may be emergent marsh, scrub-shrub, or forest communities. Riparian communities are dependent on streamflows or reservoir levels and are strongly influenced by the hydrologic regime, which affects the frequency, depth, and duration of flooding or soil saturation. Riparian communities may include wetlands; however, the upper margins of riparian zones may be only infrequently inundated. Riparian areas and wetlands are valued because of the important services they provide within the landscape, such as providing fish and wildlife habitats and maintaining water quality and flood control.

4.10.2 Wildlife

The various ecoregions encompassed by the six-state study area (Section 4.10.1) include a wide range of habitats that support a high diversity of terrestrial wildlife species Table 4.10-2 lists the number of wildlife species that occur within the six-state study area. Many of these

TABLE 4.10-2 Number of Wildlife Species in the Six-State Study Area[a]

State	Amphibians	Reptiles	Birds	Mammals
Arizona	29	113	544	162
California	68	90	640	180
Colorado	18	56	490	129
Nevada	15	54	483	128
New Mexico	25	96	523	154
Utah	17	57	432	134

[a] Excludes marine mammal species, native species that have been extirpated and not subsequently reintroduced into the wild, and feral domestic species.

Sources: AZGFD (2008); American Society of Mammalogists (1999); CDFG (2006); CDOW (2008); Colorado Herpetological Society (2006); Hole (2007); Lepage (2008); NNHP (2002); UDWR (2008).

species may be expected to occur within or near a solar energy facility or associated ancillary facilities (e.g., transmission lines and access roads), depending upon the plant communities and habitats present within the project area.

The BLM and other federal agencies that administer public lands have active wildlife management programs. These programs are aimed largely at habitat protection and improvement. The general objectives of wildlife management are to (1) maintain, improve, or enhance wildlife species diversity while ensuring healthy ecosystems; (2) restore disturbed or altered habitat with the objective of obtaining desired native plant communities while providing for wildlife needs and soil stability; and (3) protect and maintain wildlife and associated wildlife habitat by addressing and mitigating impacts from authorized and unauthorized uses of BLM-administered lands. Federal agencies such as the BLM are primarily responsible for managing habitats, while state agencies (e.g., Colorado Department of Natural Resources and Utah Department of Wildlife Resources) are responsible for managing the big game, small game, and nongame wildlife species in cooperation with the BLM. The USFWS has responsibility for oversight of migratory bird species and most federal threatened, endangered, proposed, or candidate species. Management of threatened and endangered species is discussed in Section 4.10.4.

The following discussions present general descriptions of the wildlife species that may occur on BLM and other federally administered lands where solar energy development could occur.

4.10.2.1 Amphibians and Reptiles

The six-state study area supports a variety of amphibians and reptiles, many of which may occur at or in the vicinity of an individual solar facility. The number of amphibian species reported from these states ranges from 15 species in Nevada to 68 species in California. The number of reptile species reported from these states ranges from 54 species in Nevada to 113 species in Arizona (Table 4.10-2). The amphibians include frogs, toads, and salamanders that occupy a variety of habitats that include forested headwater streams in mountain regions, marshes, and wetlands, and xeric habitats in the desert areas of the Southwest. The reptile species include a variety of turtles, snakes, and lizards.

4.10.2.2 Birds

Several hundred species of birds have been reported from the six-state study area (Table 4.10-2), ranging from 432 in Utah to 640 in California. The bird species in coastal areas of California include oceanic species such as boobies, gannets, frigatebirds, fulmars, and albatrosses that would not be expected in areas where solar energy development may occur.

A number of Important Bird Areas (IBAs) have been identified by the National Audubon Society within the six-state study area. IBAs are locations that provide essential habitats for breeding, wintering, or migrating birds. While these sites can vary in size, they are discrete areas that stand out from the surrounding landscapes. IBAs must support one or more of the following:

- Species of conservation concern (e.g., threatened or endangered species);
- Species with restricted ranges;
- Species that are vulnerable because their populations are concentrated into one general habitat type or ecosystem; or
- Species or groups of similar species (e.g., waterfowl or shorebirds) that are vulnerable because they congregate in high densities.

The IBA program has become a key component of many bird conservation efforts (National Audubon Society 2008). Information on the IBA program and a list of IBAs for each state can be found at http://www.audubon.org/bird/iba.

4.10.2.2.1 Migratory Routes. Many of the bird species occurring in the six-state study area are seasonal residents within individual states and exhibit seasonal migrations. These birds include waterfowl, shorebirds, raptors, and neotropical songbirds. The six-state study area falls within two of the four major North American migration flyways (Lincoln et al. 1998)—the Central Flyway and the Pacific Flyway (Figure 4.10-1). These pathways are used in spring by birds migrating north from wintering areas to breeding areas and in fall by birds migrating south to wintering areas.

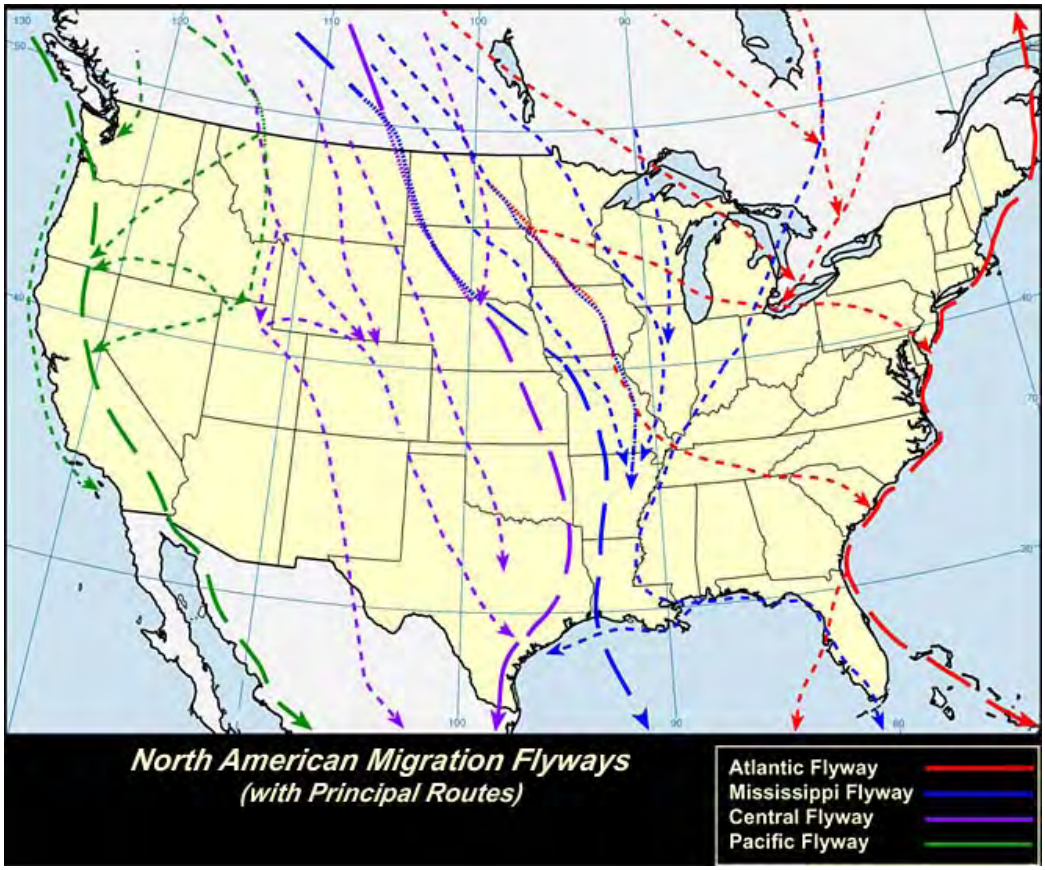

FIGURE 4.10-1 North American Migration Flyways (Source: Birdnature.com 2006, used with permission)

The Central Flyway includes the Great Plains–Rocky Mountain routes (Lincoln et al. 1998). These routes extend from the northwest arctic coast south between the Mississippi River and the Rocky Mountains. Within the six-state study area, this flyway encompasses all or most of Colorado, a large portion of New Mexico, and a portion of Utah. This flyway is relatively simple, with the majority of birds making relatively direct north and south migrations.

The Pacific Flyway includes the Pacific Coast Route, which occurs between the Rocky Mountains and the Pacific coast of the United States. In the six-state study area, this flyway encompasses the states of California and Nevada. Birds migrating from the Alaskan Peninsula follow the coastline to near the mouth of the Columbia River, then travel inland to the Willamette River Valley before continuing south through interior California (Lincoln et al. 1998). Birds migrating south from Canada pass through portions of Montana and Idaho and then migrate either east to enter the Central Flyway, or turn southwest along the Snake and Columbia River Valleys and then continue south across central Oregon and the interior valleys of California (Birdnature.com 2006). This route is not as heavily used as some of the other migratory routes in North America (Lincoln et al. 1998).

4.10.2.2.2 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 in the six-state 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). While many of these species nest in Canada and Alaska, a number, such as the American avocet (*Recurvirostra americana*), willet (*Catoptrophorus semipalmatus*), spotted sandpiper (*Actitis macularia*), gadwall (*Anas strepera*), and blue-winged teal (*A. discors*), also nest in suitable habitats in many of the western states (National Geographic Society 1999). Most are ground-level nesters, and many sometimes forage in relatively large flocks on the ground or water. Within the region, migration routes for these birds are often associated with riparian corridors and wetland or lake stopover areas.

Major waterfowl species hunted in the six-state study area include the mallard (*Anas platyrhynchos*) and Canada goose (*Branta canadensis*). Other species commonly hunted include gadwall, American widgeon (*A. americana*), teal (*A.* spp.), northern pintail (*A. acuta*), northern shoveler (*A. clypeata*), and snow goose (*Chen caerulescens*) (USFWS 2005). Hunting for sandhill cranes (*Grus canadensis*) also occurs in Arizona, Colorado, New Mexico, and Utah (Sharp et al. 2005). Various conservation and management plans exist for waterfowl, shorebirds, and waterbirds.

4.10.2.2.3 Neotropical Migrants. Songbirds of the order Passeriformes represent the most diverse category of birds, with the warblers and sparrows representing the two most diverse groups of passerines. The passerines exhibit a wide range of seasonal movements, with some species remaining as year-round residents in some areas and migratory in others, and still other species undergoing migrations of hundreds of miles or more (Lincoln et al. 1998). Nesting occurs in vegetation from near ground level to the upper canopy of trees. Some species, such as the thrushes and chickadees, are relatively solitary throughout the year, while others, such as swallows and blackbirds, may occur in small to large flocks at various times of year. Foraging may occur in flight (e.g., swallows and swifts) or on vegetation or the ground (e.g., warblers, finches, and thrushes). Various conservation and management plans exist for neotropical migrants (and other landbirds), including the Partners in Flight North American Landbird Conservation Plan (Rich et al. 2004) and numerous physiographic area and state plans. These plans can be accessed from the Partners in Flight Web site (http://www.partnersinflight.org).

The regulatory framework organized to protect the neotropical migrants includes:

- *Migratory Bird Treaty Act.* The Migratory Bird Treaty Act implements a variety of treaties and conventions among the United States, Canada, Mexico, Japan, and Russia. This treaty makes it unlawful to take, kill, or possess migratory birds, as well as their eggs or nests. Most of the bird species reported from the six-state study area are classified as migratory under this act.

- *Executive Order 13186:* "Responsibilities of Federal Agencies to Protect Migratory Birds" (*Federal Register,* Volume 66, page 3853, January 17,

2001). Under this Executive Order, each federal agency that is taking an action that could have, or is likely to have, negative impacts on migratory bird populations must work with the USFWS to develop a memorandum of understanding (MOU) to conserve those birds. The MOUs developed by this consultation are intended to guide future agency regulatory actions and policy decisions.

In addition to the federal regulatory framework, the individual states have regulations that apply to the general protection of avian species. While the BLM is not bound by those state regulations, they are an important consideration in that they apply to private projects or actions that take place on BLM-administered lands.

4.10.2.2.4 Birds of Prey. The birds of prey include the raptors (hawks, falcons, eagles, kites, and osprey), owls, and vultures. These species represent the top avian predators in many ecosystems. Common raptor and owl species include the red-tailed hawk (*Buteo jamaicensis*), sharp-shinned hawk (*Accipiter striatus*), northern harrier (*Circus cyaneus*), Swainson's hawk (*B. swainsoni*), American kestrel (*Falco sparverius*), golden eagle (*Aquila chrysaetos*), great horned owl (*Bubo virginianus*), short-eared owl (*Asio flammeus*), and burrowing owl (*Athene cunicularia*). The raptors and owls vary considerably among species with regard to their seasonal migrations, with some species being nonmigratory (year-round residents), others being migratory in the northern portions of their ranges and nonmigratory in the southern portions of their ranges, and still other species being migratory throughout their ranges.

Raptors forage on a variety of prey, including small mammals, reptiles, other birds, fish, invertebrates, and, at times, carrion. They typically perch on trees, utility support structures, highway signs, and other high structures that provide a broad view of the surrounding topography, and they may soar for extended periods at relatively high altitudes. The raptors forage from either a perch or on the wing (depending on the species), and all forage during the day. The owls also perch on elevated structures and forage on a variety of prey, including mammals, birds, and insects. Forest-dwelling species typically forage by diving on a prey item from a perch, while open-country species hunt on the wing while flying low over the ground. While generally nocturnal, some owl species are also active during the day.

The vultures are represented by three species: the turkey vulture (*Cathartes aura*), which occurs in each of the six western states; the black vulture (*Coragyps atratus*), which is reported from Arizona, California, and New Mexico; and the endangered California condor (*Gymnogyps californianus*), reported from Arizona and California. These birds are large, soaring scavengers that feed on carrion.

The bald eagle (*Haliaeetus leucocephalus*) and golden eagle are protected under the Bald and Golden Eagle Protection Act (16 USC 668–668d, 54 Statute 250, as amended), which prohibits the taking or possession of, or commerce in, bald and golden eagles, with limited exceptions for permitted scientific research and Native American religious purposes. The Secretary of the Interior can authorize the taking of eagle nests that interfere with resource development or recovery operations (USFWS 2008b). The BLM field offices also have specific

management guidelines for raptors, including eagles. States also have regulations regarding the protection of raptors that would be applicable to private projects or actions conducted on BLM-administered lands.

4.10.2.2.5 Upland Game Birds. Upland game birds that are native to the six-state study area include dusky grouse (*Dendragapus obscurus*), ruffed grouse (*Bonasa umbellus*), greater sage-grouse (*Centrocercus urophasianus*), Gunnison sage-grouse (*C. minimus*), lesser prairie chicken (*Tympanuchus pallidicinctus*), Gambel's quail (*Callipepla gambelii*), California quail (*C. californica*), scaled quail (*C. squamata*), mountain quail (*Oreortyx pictus*), mourning dove (*Zenaida macroura*), and white-winged dove (*Z. asiatica*). Introduced species include ring-necked pheasant (*Phasianus colchicus*), chukar (*Alectoris chukar*), and gray partridge (*Perdix perdix*). The wild turkey (*Meleagris gallopavo*) is native to Arizona, Colorado, and New Mexico and has been introduced to the three other states. All of the upland game bird species are year-round residents.

Most concerns about upland game birds in the six-state study area have focused on the potential impacts on the greater sage-grouse and the Gunnison sage-grouse because of the reduction, fragmentation, and modification of grassland and shrubland habitats. Within the six-state study area, the Gunnison sage-grouse is restricted to southwestern Colorado and southeastern Utah, while the greater sage-grouse occurs in all of the states except Arizona and New Mexico, where they are extirpated (Bird and Schenk 2005; NatureServe 2010). The life history and habitat requirements of both species are similar (Bird and Schenk 2005); therefore, the following discussion emphasizes the more widely distributed greater sage-grouse.

The decline in greater sage-grouse populations over the past half century is believed to be the result of many factors, including oil and gas wells and their associated infrastructure, traffic, power lines, urbanization, recreation, predators, and a decline in the quality and quantity of sagebrush habitat (due to alteration of historical fire regimes, water developments, drought, use of herbicides and pesticides, livestock and wild horse grazing, and establishment of invasive species) (see Connelly et al. 2000; Lyon and Anderson 2003; Crawford et al. 2004; Holloran 2005; Holloran et al. 2005; Rowland 2004; Schroeder et al. 2004; Bird and Schenk 2005; Braun 2006; Aldridge and Boyce 2007; Walker et al. 2007; Colorado Greater Sage-grouse Steering Committee 2008; Doherty et al. 2008 and references cited therein). West Nile virus is also a significant stressor of greater sage-grouse (Naugle et al. 2004).

The BLM manages more habitats for greater sage-grouse than does any other entity; therefore, it has developed a National Sage-Grouse Habitat Conservation Strategy for BLM-administered public lands that is intended to maintain, enhance, and restore greater sage-grouse habitat while providing for multiple uses of BLM-administered public lands (BLM 2004). In addition, the Western Association of Fish and Wildlife Agencies has produced two documents that together constitute a conservation assessment for greater sage-grouse (Connelly et al. 2004; Stiver et al. 2006). A rangewide conservation plan has been prepared for the Gunnison sage-grouse (Gunnison Sage-grouse Rangewide Steering Committee 2005). Also, state and/or regional recovery, management, or conservation plans have been prepared for grouse species that occur

throughout the western states. The recommendations in these documents would be considered for solar energy developments.

4.10.2.3 Mammals

The number of mammal species reported from the six-state study area ranges from 128 species in Nevada to 180 species in California (Table 4.10-2). The following discussion emphasizes big game and small mammal species that (1) have key habitats within or near the areas in which solar energy development may occur, (2) are important to humans (e.g., big and small game and furbearer species), and/or (3) are representative of other species that share important habitats.

The primary big game species within the six-state study area include elk (*Cervis canadensis*), mule deer (*Odocoileus hemionus*), white-tailed deer (*O. virginianus*), pronghorn (*Antilocapra americana*), bighorn sheep (*Ovis canadensis*), American black bear (*Ursus americanus*), and cougar (*Puma concolor*). Several other big game species occur within a few states. These include the moose (*Alces americanus*) in Colorado and Utah; American bison (*Bos bison*) in Arizona, California, New Mexico, and Utah; African oryx (*Oryx gazella*), ibex (*Capra ibex*), and Barbary sheep (*Ammotragus lervia*) in New Mexico; javelina (*Pecari tajacu*) in Arizona and New Mexico; and the wild pig (*Sus scrofa*) in California. The African oryx, ibex, and Barbary sheep are non-native species that were introduced for hunting.

A number of the big game species make migrations when seasonal changes reduce food availability, when movement within an area becomes difficult (e.g., due to snow pack), or when local conditions are not suitable for calving or fawning. Established migration corridors for these species provide an important transition habitat between seasonal ranges and provide food for the animals during migration (Feeney et al. 2004). Maintaining genetic interchange through landscape linkages among subpopulations is also essential for long-term survival of species. Maintaining migration corridors and landscape linkages, especially when seasonal ranges or subpopulations are far removed from each other, can be difficult because of the various land ownership mixes that often need to be traversed (Sawyer et al. 2005).

The following paragraphs present a generalized overview of the primary big game species. Table 4.10-3 presents the conservation status for the primary big game species within the six-state study area.

4.10.2.3.1 Elk. Elk are generally migratory between their summer and winter ranges, although some herds remain within the same area year-round (UDWR 2005). Their summer range occurs at higher elevations. Aspen and conifer woodlands provide security and thermal cover, while upland meadows, sagebrush/mixed grass, and mountain shrub habitats are used for forage. Their winter range occurs at mid to lower elevations, where they forage in sagebrush/mixed grass, big sagebrush/rabbitbrush, and mountain shrub habitats. They are highly mobile within both summer and winter ranges in order to find the best forage conditions. In winter, they congregate into large herds of 50 to more than 200 individuals. The crucial winter range

TABLE 4.10-3 State Conservation Status Ranks for Big Game Species in the Six-State Study Area

Species	State Conservation Status Rank[a]					
	AZ	CA	CO	NM	NV	UT
Elk (*Cervis canadensis*)	U	AS	S	V	S	AS
Mule deer (*Odocoileus hemionus*)	S	S	S	S	S	S
White-tailed deer (*Odocoileus virginianus*)	S	–	S	AS	–	CI
Pronghorn (*Antilocapra americana*)	S	AS	AS	S	S	AS
Bighorn sheep (*Ovis canadensis*)[b]	AS	V	AS	CI	V	V
American black bear (*Ursus americanus*)	S	S	S	AS	AS	V
Cougar (*Puma concolor*)	AS	S	AS	V	S	AS

[a] – = the state is not within the species' range; AS = apparently secure (uncommon but not rare, some cause for long-term concern due to declines or other factors); CI = critically imperiled (critically imperiled because of extreme rarity [often 5 or fewer occurrences] or because some factors such as very steep declines make it especially vulnerable to extirpation); S = secure (common, widespread, and abundant); U = unranked (conservation status not yet assessed); V = vulnerable (vulnerable due to a restricted range, relatively few populations [often 80 or fewer], recent or widespread declines, or other factors making it vulnerable to extirpation).

[b] The peninsular bighorn sheep (*Ovis Canadensis nelsoni*) and the Sierra Nevada bighorn sheep (*Ovis Canadensis sierrae*) in California are federally endangered.

Source: NatureServe (2010).

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. Elk calving generally occurs in aspen-sagebrush parkland vegetation and habitat zones during late spring and early summer. Calving areas are mostly located where cover, forage, and water are nearby. They may migrate up to 60 mi (97 km) annually (NatureServe 2010). Elk are susceptible to chronic wasting disease.

4.10.2.3.2 Mule Deer. Mule deer occur within most ecosystems in the six-state study area but attain their highest densities in shrublands characterized by rough, broken terrain with abundant browse and cover. The size of home ranges can vary from 74 to 593 acres (0.3 to 2.4 km^2) or more, depending on the availability of food, water, and cover (NatureServe 2008). Some populations of mule deer are resident (particularly those that inhabit plains), but those in mountainous areas are generally migratory between their summer and winter ranges (NatureServe 2010). In arid regions, they may migrate in response to rainfall patterns (NatureServe 2010). In mountainous regions, they may migrate more than 62 mi (100 km) between high summer and lower winter ranges (NatureServe 2010). Their summer range occurs at higher elevations that contain aspen and conifers and mountain browse vegetation. Fawning

occurs during the spring while the mule deer are migrating to their summer range. This normally occurs in aspen-mountain browse intermixed vegetation.

Mule deer have a high fidelity to specific winter ranges where they congregate within a small area at a high density. Their winter range occurs at lower elevations within sagebrush and pinyon-juniper vegetation. Winter forage is primarily sagebrush, but Colorado birchleaf mountain-mahogany (*Cercocarpus montanus*), fourwing saltbush (*Atriplex canescens*), and antelope bitterbrush (*Purshia tridentata*) are also important. Pinyon-juniper provides emergency forage during severe winters. 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); mule deer do best in habitats that are in the early stage of succession (UDWR 2003). 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 of mule deer in the 1980s and early 1990s. In arid regions, they are seldom found more than 1.0 to 1.5 mi (1.6 to 2.4 km) from water. Mule deer are also susceptible to chronic wasting disease. When the disease is present, up to 3% of a herd's population can be affected. Some deer herds in Colorado have experienced significant outbreaks of chronic wasting disease.

4.10.2.3.3 White-Tailed Deer. White-tailed deer inhabit a variety of habitats but are often associated with woodlands and agricultural lands (CDOW 2008). Within arid areas, they are mostly associated with riparian zones and montane woodlands that have more mesic conditions. They can also occur within suburban areas. Urban areas and very rugged mountain terrain are unsuitable habitats (NatureServe 2010).

White-tailed deer occur in two social groups: (1) adult females and young and (2) adult and occasionally yearling males, although adult males are generally solitary during the breeding season except when with females (NatureServe 2010). The annual home range of sedentary populations can average as much as 1,285 acres (5 km^2), while some populations can undergo annual migrations of up to 31 mi (50 km). In some areas, the density of white-tailed deer may exceed 129/mi^2 (50/km^2) (NatureServe 2010). Snow accumulation can have a major controlling effect on populations (NatureServe 2010). White-tailed deer feed mostly on agricultural crops, browse, grasses, and forbs but also consume mushrooms, acorns, fruits, and nuts (CDOW 2008; UDWR 2008). They often cause damage when browsing on ornamental plants around homes (NatureServe 2010).

4.10.2.3.4 Pronghorn. Pronghorn inhabit nonforested areas such as desert, grassland, and sagebrush habitats. Herd size can commonly exceed 100 individuals, especially during winter. Pronghorn consume a variety of forbs, shrubs, and grasses, with shrubs being most important in winter. 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. Other pronghorn are migratory. Most herds range within an area 5 mi (8 km) or more in diameter, although the separation between summer and winter ranges has been reported

to be as much as 99 mi (159 km) or more (NatureServe 2010). Pronghorn populations have been adversely affected in some areas by historic range degradation and habitat loss and by periodic drought conditions.

4.10.2.3.5 Bighorn Sheep. The bighorn sheep is considered to be a year-long resident; it does not make seasonal migrations as do elk and mule deer. However, it does make vertical migrations in response to an increasing abundance of vegetative growth at higher elevations in the spring and summer and when snow accumulation occurs in high-elevation summer ranges (NatureServe 2010). Also, ewes move to reliable watercourses or water sources during the lambing season, with lambing occurring on steep talus slopes within 1 to 2 mi (1.6 to 3.2 km) of water. Bighorn sheep prefer open vegetation such as low shrub, grassland, and other treeless areas with steep talus and rubble slopes. Unsuitable habitats include open water, wetlands, dense forests, and other areas without grass understory (NatureServe 2010).

The diet of the bighorn sheep consists of shrubs, forbs, and grasses. In the early 1900s, bighorn sheep experienced significant declines due to disease, habitat degradation, and hunting. Threats to bighorn sheep include habitat changes resulting from fire suppression, interactions with feral and domestic animals, and human encroachment (NatureServe 2010). 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. In appropriate locations, reintroduction efforts, coupled with water and vegetation improvements, have been conducted to restore bighorn sheep to their native habitat.

4.10.2.3.6 American Black Bear. American black bears are found mostly within forested or brushy mountain environments and woody riparian corridors (UDWR 2008). They are omnivorous. Depending upon seasonal availability, they will feed on forbs and grasses, fruits and acorns, insects, small vertebrates, and carrion (CDOW 2008). Breeding occurs in June or July, with young born in January or February (UDWR 2008). American black bears are generally nocturnal and have a period of winter dormancy (UDWR 2008). They are locally threatened by habitat loss and disturbance by humans (NatureServe 2010). The home range size of American black bears varies depending on area and gender and has been reported to be from about 1,250 to nearly 32,200 acres (5 to 53 km^2) (NatureServe 2010).

4.10.2.3.7 Cougar. Cougars (also known as mountain lions or puma) inhabit most ecosystems in the six-state 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 (CDOW 2008). They mostly occur in remote and inaccessible areas (NatureServe 2010). Their annual home range can be more than 560 mi^2 (1,450 km^2), while densities are usually not more than 10 adults/100 mi^2 (10 adults/259 km^2) (NatureServe 2010). The cougar is generally found where its prey species (especially mule deer) are located. In addition to preying on deer, cougars prey upon most other mammals (which sometimes include domestic livestock) and some insects, birds, fishes, and berries (CDOW 2008). They are active

year-round. Their peak periods of activity are within 2 hours of sunset and sunrise, although their activity peaks after sunset when they are near humans (NatureServe 2010; UDWR 2008). In some states, they are hunted on a limited and closely monitored basis (NatureServe 2010).

4.10.2.3.8 Small Mammals. Small mammals include small game, furbearers, and nongame species. Small game species that occur within the six-state study area include black-tailed jackrabbit (*Lepus californicus*), white-tailed jackrabbit (*L. townsendii*), desert cottontail (*Sylvilagus audubonii*), mountain cottontail (*S. nuttallii*), squirrels (*Sciurus* spp.), snowshoe hare (*L. americanus*), and yellow-bellied marmot (*Marmota flaviventris*). Common furbearers include American badger (*Taxidea taxus*), American marten (*Martes americana*), American beaver (*Castor canadensis*), bobcat (*Lynx rufus*), common muskrat (*Ondatra zibethicus*), coyote (*Canis latrans*), red fox (*Vulpes vulpes*), gray fox (*Urocyon cinereoargenteus*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and long-tailed weasel (*Mustela frenata*). Nongame species include bats, shrews, mice, voles, chipmunks, and many other rodent species. Bats may be of particular importance because of their function in vector control and the fact that bat populations have declined in many parts of North America.

4.10.3 Aquatic Biota

Within the six-state study area, the BLM administers lands containing a variety of freshwater aquatic habitats, which in turn support a wide diversity of aquatic biota. The area considered contains a variety of freshwater aquatic habitats, which in turn support a wide diversity of aquatic biota. Aquatic habitats on these lands range from isolated desert springs in the southwestern portion that support unique and endemic fish species such as pupfish (family Cyprinodontidae); cold- and coolwater portions of the Colorado, Green, and Snake Rivers that support trout fisheries; and coastal rivers of northern California that support anadromous salmon. Sport fish throughout the six-state study area include trout and salmon (family Salmonidae), catfish (family Ictaluridae), sunfish and black basses (family Centrarchidae), suckers (family Catostomidae), perch and walleye (family Percidae), and pike (family Esocidae). Nonsport fish include numerous species of minnows and other species. In addition to fish, aquatic habitats also support a large variety of aquatic invertebrates, including mollusks, crustaceans, and insects.

The following sections provide a general description of freshwater aquatic organisms and habitats grouped according to the major USGS water resource regions that coincide with the six-state study area.

4.10.3.1 Pacific Northwest Hydrologic Region

Only a small portion (in northern Nevada and northern Utah) of the Pacific Northwest hydrologic region falls within the six-state study area; the remainder of this hydrologic region encompasses the states of Washington, Oregon, Idaho, and portions of Montana (Figure 4.9-1). It is considered unlikely that utility-scale solar energy projects would be considered on most lands within this region, but the region is discussed here for completeness. In terms of ecological,

cultural, and commercial importance, fishes in the family Salmonidae make up the most important group of native fishes found in this hydrologic region (ODFW 2005a,b). This group, which includes salmon, trout, grayling, and whitefish, requires relatively clear and cold freshwater habitats during part or all of their life cycles, and as such, depend greatly on the conditions of surrounding forests and rangelands to ensure their survival.

Some species of salmonids within this hydrologic region are anadromous (i.e., they spawn in freshwater but spend part of their life cycle at sea). These species require large stream and river systems with direct ocean access. In the Pacific Northwest, streams that support important stocks of anadromous salmon within public lands include those within the Columbia and Snake River Basins. Because of the need for these salmon to migrate between ocean and freshwater environments in order to reproduce and to become adults, one of the major factors that has affected the distribution and survival of salmon stocks in recent decades is the construction of obstacles to migration (e.g., dams) in streams and rivers used by these species (ODFW 2005a,b).

Various fish species have been introduced into aquatic systems throughout the Pacific Northwest. Most of these non-native species have been introduced to promote sportfishing opportunities. Introduced salmonids (such as brook, brown, lake, and rainbow trout), sunfishes, basses, and walleye now support much, if not most, of the non-native sport fishing opportunities within the region (Moyle and Marchetti 2006; Moyle and Davis 2001).

A variety of aquatic invertebrates occur in aquatic habitats of the Pacific Northwest. The diversity of aquatic insects is generally lower in glacier-fed streams; whereas streams flowing through conifer forests typically support a more diverse aquatic invertebrate fauna, including many types of mayflies, stoneflies, and caddisflies. Freshwater mollusks, including mussels (Nedeau et al. undated) and snails, are also important components of the invertebrate fauna in some aquatic ecosystems.

4.10.3.2 Lower Colorado, Rio Grande, and Great Basin Hydrologic Regions

As described in Section 4.9.1 (Surface Water Resources), the Lower Colorado, Rio Grande, and Great Basin hydrologic regions include arid areas in Arizona, Nevada, New Mexico, southwestern Utah, and south-central Colorado (Figure 4.9-1). The natural hydrology of southwestern desert rivers and streams in these hydrologic regions is highly variable and episodic, with hydrologic inputs typically occurring in pulses of short duration. Springs and seeps also occur throughout the desert ecosystem within these hydrologic regions, ranging from quiet pools or trickles to small headwater streams. Many of the larger springs discharge warm water, with temperatures that are greater than the mean annual air temperature. Water conditions in springs can range from freshwater to highly mineralized, and some of these springs contain very low dissolved oxygen levels.

Although relatively few fish and invertebrate species may occur within some desert streams, springs, and pools, the native species that do occur are often specially adapted to the conditions in these systems, and 82% of desert fish are endemic (i.e., native to only a single

locality) (Rinne and Minckley 1991; USGS 2005; Mueller and Marsh 2002; Desert Fish Habitat Partnership Workgroup 2008). Natural flow regimes play an important role in sustaining the existing native fish populations and maintaining the ecological integrity of the aquatic ecosystems in these arid regions (e.g., Poff et al. 1997; Propst et al. 2008; Eby et al. 2003; Lytle and Poff 2004). Numerous fish species have been introduced, either intentionally or accidentally, into some watersheds within these hydrologic regions. Overall, non-native fish species in these hydrologic regions now outnumber natives in terms of numbers of species, population densities, and, often, biomass at many localities (Mueller and Marsh 2002; Olden and Poff 2005; Rinne and Minckley 1991). Common non-native fishes include sunfishes and black basses, trout, several species of catfishes (family Ictaluridae), and temperate basses (family Percithyidae) (Mueller and Marsh 2002).

The native fish community within the lower Colorado River hydrologic region is dominated by fishes within the minnow and sucker families. The Lower Colorado River itself was historically a warm, turbid, and swift river (Schmidt 1993). Construction of dams within the region, such as the Glen Canyon and Hoover Dams on the main-stem Colorado River, has now altered habitat conditions and changed flow regimes in some of the major river systems by creating a series of cold, clear impoundments. These changes, along with the introduction of non-native fishes and a variety of other anthropogenic influences, have resulted in declines in native fish populations throughout much of the lower Colorado River Basin (Mueller and Marsh 2002; Olden and Poff 2005; Propst et al. 2008). A variety of protected native fish species occur within the basin, including the endangered Gila trout, spikedace, headwater chub, and razorback sucker (Section 4.10.4).

The Rio Grande originates in the Rocky Mountains of southwestern Colorado and meanders about 1,900 mi (3,058 km) across Colorado, New Mexico, and Texas before terminating at the Gulf of Mexico. Public lands within the Rio Grande region are primarily limited to the upper and middle reaches of this drainage. Most precipitation in the basin falls as snow near its headwaters or as rain near its mouth, while little water is contributed to the system along the middle reaches of this river (Langman and Nolan 2005). Prior to the construction of dams such as the Cochiti Dam, the Rio Grande had characteristics similar to the Colorado River, with warm water and a high sediment load. Dams, and the resulting reservoirs, have resulted in slower, clearer, and colder water. The Rio Grande contains more than 16 families of fishes in the non-tidal portions of the river, including a diverse minnow assemblage. Benthic invertebrate sampling in portions of the Rio Grande in New Mexico revealed caddisflies, mayflies, black flies, and chironomids were dominant (Dahm et al 2005). Pupfish can be found in desert springs. Modification of stream habitat within the Rio Grande Basin due to impoundments, water diversion for agriculture, stream channelization, and the introduction of non-native fishes has affected the abundance and distribution of the Rio Grande silvery minnow, a species that was once widely distributed in the Pecos River and Rio Grande, but that is now federally listed as endangered. Currently, 157 mi (253 km) of the Rio Grande has been designated as critical habitat for this species (Section 4.10.4) (USFWS 2007).

The Great Basin hydrologic region covers an arid expanse of approximately 190,000 mi^2 (492,000 km^2) and is the area of internal drainage between the Wasatch Mountains of Utah and the Sierra Nevada Range in California and Nevada (Figure 4.9-1). Streams in this area never

reach the ocean, but instead drain toward the interior of the basin, resulting in terminal lakes such as Mono Lake and the Great Salt Lake, marshes, or similar hydrologic sinks that are warm and saline (Sigler and Sigler 1987). Some fish species that inhabit the Great Basin hydrologic region are adapted to extreme conditions (Sigler and Sigler 1987). Trout are found in lakes and streams at higher elevations within the basin. Bonneville cutthroat trout have persisted in the isolated, cool mountain streams of the eastern portion of the Great Basin hydrologic region, while Lahontan cutthroat trout populations occupy small, isolated habitats throughout the basin. These trout species are unusually tolerant of both high temperatures (greater than 80°F [27°C]) and large daily fluctuations in temperature (up to 35F° [19C°]). They are also quite tolerant of the higher alkalinity present in some of the aquatic habitats within this hydrologic region (USFWS 1995). Water diversions, subsistence harvest, and stocking of non-native fish have caused the extirpation of the Bonneville cutthroat trout from most of its range within the Great Basin hydrologic region. Lahontan cutthroat trout, which were once common in desert lakes and in large rivers, such as the Humboldt, Truckee, and Walker Rivers, have declined in numbers overall and have disappeared in many areas (USFWS 1995).

Various native and non-native minnows are common throughout streams and lakes of the Great Basin hydrologic region (Sigler and Sigler 1987). Native pupfish species, which are tolerant of high temperature ranges compared with many other fish species, occur in some of the thermal artesian springs and in some streams in portions of Nevada (Sigler and Sigler 1987). Because the isolation of these pupfish populations makes them more prone to extinction, most of them, such as the Devils Hole pupfish, are currently listed as endangered or threatened under the Endangered Species Act (ESA) or are considered species of special concern by the states where they occur (Section 4.10.4). Several species of springsnails (*Pyrgulopsis* spp. and *Tryonia* spp) are also protected or proposed for protection under the ESA.

4.10.3.3 California Hydrologic Region

Primarily composed of areas within the state of California, the California hydrologic region (Figure 4.9-1) can be broadly divided into northern and southern freshwater fish habitat regions (although finer-scale zoogeographic regions can also be delineated [Moyle and Marchetti 2006]). The northern region extends from the Oregon border south to Sacramento (the southernmost extent of anadromous salmon distribution in North America). This region includes rain-fed coastal streams, snow-fed streams of the western Sierra Nevada, and the Central and San Joaquin Valleys. Habitat characteristics and the associated fish assemblages are relatively similar to those in the western portion of the Pacific Northwest hydrologic region (as described previously).

Freshwater fish habitats within the southern portion of the California hydrologic region are located predominantly within the arid southeastern portion of the state. As described above for the Lower Colorado and Great Basin regions, native fish communities containing taxa such as pupfish and minnows occur in the lower elevations, and cutthroat trout populations occur in the mountainous regions.

Approximately 125 species of freshwater, anadromous, and euryhaline (saline-tolerant) fish occur in the inland waters of California (Moyle and Davis 2001). About 67 of these are native resident or anadromous species, 53 are non-native species, and 5 are marine species that occur in freshwater habitats (Moyle and Davis 2001). Most of the native fish species are endemic to California, a situation typical of fish faunas in regions with arid climates (Moyle and Marchetti 2006). New non-native fish species have become established in the state at the rate of about 1 species every 3 years since 1981 (Moyle and Davis 2001).

4.10.3.4 Upper Colorado River Hydrologic Region

The Colorado River Basin falls within two hydrologic regions: the Upper and Lower Colorado River hydrologic regions, with a dividing line near Lee's Ferry, Arizona. The Upper Colorado River hydrologic basin is predominantly within a subarid to arid region that includes portions of Wyoming, Colorado, Utah, Arizona, and New Mexico (Figure 4.9-1). Falling primarily between the Wasatch Mountains in Utah and the Rocky Mountains in Colorado, this hydrologic region is composed of three major subbasins: the Green River subbasin, the upper Colorado River subbasin, and the San Juan-Colorado River subbasin.

Coldwater assemblages in the Upper Colorado River hydrologic region typically include salmonids, such as mountain whitefish and 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 where water temperatures are cooler. Because deepwater releases from dams at some large, deep reservoirs can introduce cold, clear waters into rivers, coldwater fish assemblages have also become established in historically warmwater sections of some rivers, such as the portions of the Green River immediately downstream (i.e., tailwaters) of Fontenelle and Flaming Gorge Dams. Warmwater assemblages typically occur at lower elevations, where waters tend to be warmer and more turbid. Warmwater fish communities within the Upper Colorado River Basin include species of minnows (including chubs), suckers, sunfishes, black basses, and catfishes.

Historically, only 12 species of fish were native to the Upper Colorado River Basin, including 5 minnow species, 4 sucker species, 2 salmonids, and the mottled sculpin (family Cottidae). 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 4.10.4). In addition to native fish species, more than 25 non-native fish species are now present in the basin, often as a result of intentional introductions (e.g., for establishment of sport fisheries) (Muth et al. 2000; McAda 2003). While most of the trout species found within the Upper Colorado River Basin are introduced non-natives (e.g., rainbow, brown, and some strains of cutthroat trout), mountain whitefish and Colorado River cutthroat trout are native to the basin. Although it was once common within the upper Green River and upper Colorado River watersheds, the Colorado River cutthroat trout is now found only in isolated subdrainages in Colorado, Utah, and Wyoming and is a species of concern in those states (Hirsch et al. 2006).

4.10.3.5 Missouri River Basin Hydrologic Region

Portions of Colorado east of the Continental Divide fall within the Missouri River hydrologic region (Figure 4.9-1). Historically, the Missouri River carried a heavy silt load, which was collected from tributaries in the northern part of its drainage. Its wide and diverging channel created shifting sandy islands, spits, and pools, resulting in fish species suited to its turbid and dynamic conditions. Many of the fish communities within the upper reaches of the Missouri River are considered benthic fishes and include sturgeon (family Acipenseridae) and minnows. Streams flowing through the arid, desert plains of Colorado are characterized by low gradients, meandering or braided channels, and sand and gravel substrates. Riparian vegetation in this area is dominated by cottonwoods, willows, shrubs, and grasses. Native and non-native minnows and suckers dominate fish communities in these areas. Within the six-state area, the South Platte River in Colorado is the primary river draining into the Missouri River Basin. Fish within the upper reaches of the Platte River include native shiners, minnows (including chubs), and channel catfish. Examples of introduced species in the Missouri River drainage include smallmouth bass, walleye, and white crappie.

4.10.4 Special Status Species

Table 4.10-4 shows the species listed under the ESA that occur in the six-state study area. Species that are proposed for listing or candidates for listing under the ESA are also included in the table. The large area being considered under the proposed action and the large number of species that could be present in the vicinity of solar energy project areas preclude detailed species-specific evaluations. Project-specific assessments, which may include consultations with the USFWS or National Marine Fisheries Service (NMFS), would be conducted to comply with Section 7 of the ESA prior to approval of project development and subsequent ground-disturbing activities.

The following definitions are applicable to the species listing categories 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 for listing*: species that have been formally proposed for listing by the USFWS or NMFS by notice in the *Federal Register*.[6]

[6] Within 1 year of a listing proposal, the USFWS or NMFS must take one of three possible courses of action: (1) finalize the listing rule (as proposed or revised); (2) withdraw the proposal if the biological information on hand does not support the listing; or (3) extend the proposal for up to an additional 6 months because, at the end of 1 year, there is substantial disagreement within the scientific community concerning the biological appropriateness of the listing. After the extension, the USFWS or NMFS must make a decision on whether to list the species on the basis of the best scientific information available.

TABLE 4.10-4 Species That Occur in the Six-State Study Area That Are Listed, Proposed for Listing, or Candidates for Listing under the ESA

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Plants					
Abronia alpina	Ramshaw Meadows sand verbena	C	CA	N	N
Acanthomintha ilicifolia	San Diego thornmint	T	CA	Y	N
Acanthomintha obovata duttonii	San Mateo thornmint	E	CA	N	Y
Allium munzii	Munz's onion	E	CA	Y	N
Alopecurus aequalis var. *sonomensis*	Sonoma alopecurus	E	CA	N	N
Ambrosia pumila	San Diego ambrosia	E	CA	N	N
Amsinckia grandiflora	Large-flowered fiddleneck	E	CA	Y	Y
Amsonia kearneyana	Kearney's blue-star	E	AZ	N	Y
Arabis mcdonaldiana	McDonald's rock-cress	E	CA	N	Y
Arctomecon humilis	Dwarf bear-poppy	E	UT	N	Y
Arctostaphylos glandulosa crassifolia	Del Mar manzanita	E	CA	N	N
Arctostaphylos hookeri var. *ravenii*	Presidio manzanita	E	CA	N	Y
Arctostaphylos morroensis	Morro manzanita	T	CA	N	Y
Arctostaphylos myrtifolia	Ione manzanita	T	CA	N	N
Arctostaphylos pallida	Pallid manzanita	T	CA	N	Y
Arenaria paludicola	Marsh sandwort	E	CA	N	Y
Arenaria ursina	Bear Valley sandwort	T	CA	Y	N
Argemone pleiacantha pinnatisecta	Sacramento prickly poppy	E	NM	N	Y
Asclepias welshii	Welsh's milkweed	T	AZ, UT	Y	Y
Astragalus albens	Cushenbury milk-vetch	E	CA	Y	Y
Astragalus ampullarioides	Shivwits milk-vetch	E	UT	Y	Y
Astragalus brauntonii	Braunton's milk-vetch	E	CA	Y	Y
Astragalus clarianus	Clara Hunt's milk-vetch	E	CA	N	N
Astragalus cremnophylax var. *cremnophylax*	Sentry milk-vetch	E	AZ	N	Y
Astragalus desereticus	Deseret milk-vetch	T	UT	N	N
Astragalus holmgreniorum	Holmgren milk-vetch	E	AZ, UT	Y	Y
Astragalus humillimus	Mancos milk-vetch	E	CO, NM	N	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Plants (Cont.)					
Astragalus jaegerianus	Lane Mountain milk-vetch	E	CA	Y	N
Astragalus lentiginosus var. *coachellae*	Coachella valley milk-vetch	E	CA	Y	N
Astragalus lentiginosus var. *piscinensis*	Fish Slough milk-vetch	T	CA	Y	Y
Astragalus magdalenae var. *peirsonii*	Peirson's milk-vetch	T	CA	Y	N
Astragalus osterhoutii	Osterhout milk-vetch	E	CO	N	Y
Astragalus montii	Heliotrope milk-vetch	T	UT	Y	Y
Astragalus phoenix	Ash Meadows milk-vetch	T	NV	Y	Y
Astragalus pycnostachyus var. *lanosissimus*	Ventura Marsh milk-vetch	E	CA	Y	N
Astragalus tener var. *titi*	Coastal dunes milk-vetch	E	CA	N	Y
Astragalus tortipes	Sleeping Ute milk-vetch	C	CO	N	N
Astragalus tricarinatus	Triple-ribbed milk-vetch	E	CA	N	N
Atriplex coronata var. *notatior*	San Jacinto Valley crownscale	E	CA	N	N
Baccharis vanessae	Encinitas baccharis	T	CA	N	N
Berberis nevinii	Nevin's barberry	E	CA	Y	N
Blennosperma bakeri	Sonoma sunshine	E	CA	N	N
Brodiaea filifolia	Thread-leaved brodiaea	T	CA	Y	Y
Brodiaea pallida	Chinese Camp brodiaea	T	CA	N	N
Calochortus persistens	Siskiyou mariposa lily	C	CA	N	N
Calochortus tiburonensis	Tiburon mariposa lily	T	CA	N	Y
Calyptridium pulchellum	Mariposa pussypaws	T	CA	N	N
Calystegia stebbinsii	Stebbins' morning-glory	E	CA	N	Y
Camissonia benitensis	San Benito evening-primrose	T	CA	N	Y
Carex albida	White sedge	E	CA	N	N
Carex specuicola	Navajo sedge	T	AZ, UT	Y	Y
Castilleja affinis neglecta	Tiburon paintbrush	E	CA	N	Y
Castilleja campestris succulenta	Fleshy owl's-clover	T	CA	Y	Y
Castilleja cinerea	Ash-grey paintbrush	T	CA	Y	N
Castilleja mollis	Soft-leaved paintbrush	E	CA	N	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Plants (Cont.)					
Caulanthus californicus	California jewelflower	E	CA	N	Y
Ceanothus ferrisae	Coyote ceanothus	E	CA	N	Y
Ceanothus ophiochilus	Vail Lake ceanothus	T	CA	Y	N
Ceanothus roderickii	Pine Hill ceanothus	E	CA	N	Y
Centaurium namophilum	Spring-loving centaury	T	CA, NV	Y	Y
Chamaesyce hooveri	Hoover's spurge	T	CA	Y	Y
Chlorogalum purpureum	Purple amole	T	CA	Y	N
Chorizanthe howellii	Howell's spineflower	E	CA	N	Y
Chorizanthe orcuttiana	Orcutt's spineflower	E	CA	N	N
Chorizanthe parryi var. *fernandina*	San Fernando Valley spineflower	C	CA	N	N
Chorizanthe pungens var. *hartwegiana*	Ben Lomond spineflower	E	CA	N	Y
Chorizanthe pungens var. *pungens*	Monterey spineflower	T	CA	Y	Y
Chorizanthe robusta	Robust spineflower	E	CA	Y	Y
Chorizanthe valida	Sonoma spineflower	E	CA	N	Y
Cirsium fontinale var. *fontinale*	Fountain thistle	E	CA	N	Y
Cirsium fontinale var. *obispoense*	Chorro Creek bog thistle	E	CA	N	Y
Cirsium hydrophilum var. *hydrophilum*	Suisun thistle	E	CA	Y	N
Cirsium loncholepis	La Graciosa thistle	E	CA	Y	N
Cirsium vinaceum	Sacramento Mountains thistle	T	NM	N	Y
Clarkia franciscana	Presidio clarkia	E	CA	N	Y
Clarkia imbricata	Vine Hill clarkia	E	CA	N	N
Clarkia speciosa immaculata	Pismo clarkia	E	CA	N	Y
Clarkia springvillensis	Springville clarkia	T	CA	N	N
Cordylanthus maritimus maritimus	Salt marsh bird's-beak	E	CA	N	Y
Cordylanthus mollis mollis	Soft bird's-beak	E	CA	Y	Y
Cordylanthus palmatus	Palmate-bracted bird's beak	E	CA	N	Y
Cordylanthus tenuis capillaris	Pennell's bird's-beak	E	CA	N	Y
Coryphantha robbinsorum	Cochise pincushion cactus	T	AZ	N	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Plants (Cont.)					
Coryphantha scheeri var. *robustispina*	Pima pineapple cactus	E	AZ	N	N
Coryphantha sneedii var. *leei*	Lee pincushion cactus	T	NM	N	Y
Coryphantha sneedii var. *sneedii*	Sneed pincushion cactus	E	NM	N	Y
Cupressus abramsiana	Santa Cruz cypress	E	CA	N	Y
Cupressus goveniana goveniana	Gowen cypress	T	CA	N	Y
Cycladenia jonesii	Jones cycladenia	T	AZ, UT	N	Y
Deinandra conjugens	Otay tarplant	T	CA	Y	Y
Deinandra increscens villosa	Gaviota tarplant	E	CA	Y	N
Delphinium bakeri	Baker's larkspur	E	CA	Y	N
Delphinium luteum	Yellow larkspur	E	CA	Y	N
Dodecahema leptoceras	Slender-horned spineflower	E	CA	N	N
Dudleya abramsii parva	Conejo dudleya	T	CA	N	Y
Dudleya cymosa marcescens	Marcescent dudleya	T	CA	N	Y
Dudleya cymosa ovatifolia	Santa Monica Mountains dudleya	T	CA	N	Y
Dudleya setchellii	Santa Clara Valley dudleya	E	CA	N	Y
Dudleya stolonifera	Laguna Beach liveforever	T	CA	N	N
Dudleya verityi	Verity's dudleya	T	CA	N	Y
Echinocactus horizonthalonius var. *nicholii*	Nichol's Turk's head cactus	E	AZ	N	Y
Echinocereus fendleri var. *kuenzleri*	Kuenzler hedgehog cactus	E	NM	N	Y
Echinocereus triglochidiatus var. *arizonicus*	Arizona hedgehog cactus	E	AZ	N	Y
Echinomastus erectocentrus var. *acunensis*	Acuna cactus	C	AZ	N	N
Enceliopsis nudicaulis var. *corrugata*	Ash Meadows sunray	T	NV	Y	Y
Eremalche kernensis	Kern mallow	E	CA	N	Y
Eriastrum densifolium sanctorum	Santa Ana river woolly-star	E	CA	N	N
Erigeron lemmonii	Lemmon fleabane	C	AZ	N	N
Erigeron maguirei	Maguire daisy	T, PDL	UT	N	Y
Erigeron parishii	Parish's daisy	T	CA	Y	Y
Erigeron rhizomatus	Zuni fleabane	T	AZ, NM	N	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Plants (Cont.)					
Eriodictyon altissimum	Indian Knob Mountain balm	E	CA	N	Y
Eriodictyon capitatum	Lompoc yerba santa	E	CA	Y	N
Eriogonum apricum	Ione buckwheat	E	CA	N	N
Eriogonum diatomaceum	Churchill Narrows buckwheat	C	NV	N	N
Eriogonum gypsophilum	Gypsum wild-buckwheat	T	NM	Y	Y
Eriogonum kelloggii	Red Mountain buckwheat	C	CA	N	N
Eriogonum kennedyi var. *austromontanum*	Southern mountain wild-buckwheat	T	CA	Y	N
Eriogonum ovalifolium var. *vineum*	Cushenbury buckwheat	E	CA	Y	Y
Eriogonum ovalifolium var. *williamsiae*	Steamboat buckwheat	E	NV	N	Y
Eriogonum pelinophilum	Clay-loving wild-buckwheat	E	CO	Y	Y
Eriophyllum latilobum	San Mateo woolly sunflower	E	CA	N	Y
Eryngium aristulatum var. *parishii*	San Diego button-celery	E	CA	N	Y
Eryngium constancei	Loch Lomond coyote thistle	E	CA	N	Y
Erysimum capitatum var. *angustatum*	Contra Costa wallflower	E	CA	Y	Y
Erysimum menziesii	Menzies' wallflower	E	CA	N	Y
Erysimum teretifolium	Ben Lomond wallflower	E	CA	N	Y
Eutrema penlandii	Penland alpine fen mustard	T	CO	N	N
Fremontodendron californicum decumbens	Pine Hill flannelbush	E	CA	N	Y
Fremontodendron mexicanum	Mexican flannelbush	E	CA	Y	N
Galium californicum sierrae	El Dorado bedstraw	E	CA	N	Y
Gaura neomexicana var. *coloradensis*	Colorado butterfly plant	T	CO	Y	N
Gilia tenuiflora arenaria	Monterey gilia	E	CA	N	Y
Gilia tenuiflora hoffmannii	Hoffmann's slender-flowered gilia	E	CA	N	Y
Grindelia fraxino-pratensis	Ash Meadows gumplant	T	CA, NV	Y	Y
Hazardia orcuttii	Orcutt's hazardia	C	CA	N	N
Hedeoma todsenii	Todsen's pennyroyal	E	NM	Y	Y
Helianthus paradoxus	Pecos sunflower	T	NM	Y	Y
Hesperolinon congestum	Marin dwarf-flax	T	CA	N	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Plants (Cont.)					
Holocarpha macradenia	Santa Cruz tarplant	T	CA	Y	N
Howellia aquatilis	Water howellia	T	CA	N	Y
Ipomopsis polyantha	Pagosa skyrocket	C	CO	N	N
Ipomopsis sancti-spiritus	Holy Ghost ipomopsis	E	NM	N	Y
Ivesia kingii var. *eremica*	Ash Meadows ivesia	T	NV	Y	Y
Ivesia webberi	Webber ivesia	C	CA, NV	N	N
Lasthenia burkei	Burke's goldfields	E	CA	N	N
Lasthenia conjugens	Contra Costa goldfields	E	CA	Y	Y
Layia carnosa	Beach layia	E	CA	N	Y
Lepidium barnebyanum	Barneby ridge-cress	E	UT	N	Y
Lesquerella congesta	Dudley Bluffs bladderpod	T	CO	N	Y
Lesquerella kingii bernardina	San Bernardino Mountains bladderpod	E	CA	Y	Y
Lesquerella tumulosa	Kodachrome bladderpod	E	UT	N	Y
Lessingia germanorum	San Francisco lessingia	E	CA	N	Y
Lilaeopsis schaffneriana var. *recurva*	Huachuca water-umbel	E	AZ	Y	N
Lilium occidentale	Western lily	E	CA	N	Y
Lilium pardalinum pitkinense	Pitkin marsh lily	E	CA	N	Y
Limnanthes floccosa californica	Butte County meadowfoam	E	CA	Y	Y
Limnanthes vinculans	Sebastopol meadowfoam	E	CA	N	Y
Lupinus nipomensis	Nipomo Mesa lupine	E	CA	N	N
Lupinus tidestromii	Clover lupine	E	CA	N	Y
Mentzelia leucophylla	Ash Meadows blazingstar	T	NV	Y	Y
Monardella linoides viminea	Willowy monardella	E	CA	Y	N
Monolopia congdonii	San Joaquin wooly-threads	E	CA	N	Y
Navarretia fossalis	Spreading navarretia	T	CA	Y	Y
Navarretia leucocephala pauciflora	Few-flowered navarretia	E	CA	N	Y
Navarretia leucocephala plieantha	Many-flowered navarretia	E	CA	N	Y
Neostapfia colusana	Colusa grass	T	CA	Y	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Plants (Cont.)					
Nitrophila mohavensis	Amargosa niterwort	E	CA, NV	Y	Y
Oenothera avita eurekensis	Eureka Valley evening-primrose	E	CA	N	Y
Oenothera deltoides howellii	Antioch Dunes evening-primrose	E	CA	Y	Y
Opuntia treleasei	Bakersfield cactus	E	CA	N	Y
Orcuttia californica	California orcutt grass	E	CA	N	Y
Orcuttia inaequalis	San Joaquin orcutt grass	T	CA	Y	Y
Orcuttia pilosa	Hairy orcutt grass	E	CA	Y	Y
Orcuttia tenuis	Slender orcutt grass	T	CA	Y	Y
Orcuttia viscida	Sacramento orcutt grass	E	CA	Y	Y
Oxytheca parishii var. *goodmaniana*	Cushenbury oxytheca	E	CA	Y	Y
Parvisedum leiocarpum	Lake County stonecrop	E	CA	N	Y
Pediocactus bradyi	Brady pincushion cactus	E	AZ	N	Y
Pediocactus despainii	San Rafael cactus	E	UT	N	Y
Pediocactus knowltonii	Knowlton cactus	E	CO, NM	N	Y
Pediocactus peeblesianus peeblesianus	Peebles Navajo cactus	E	AZ	N	Y
Pediocactus peeblesianus fickeiseniae	Fickeisen plains cactus	C	AZ	N	N
Pediocactus sileri	Siler pincushion cactus	T	AZ, UT	N	Y
Pediocactus winkleri	Winkler cactus	T	UT	N	Y
Penstemon debilis	Parachute beardtongue	C	CO	N	N
Penstemon penlandii	Penland beardtongue	E	CO	N	Y
Penstemon scariosus albifluvis	White River beardtongue	C	CO, UT	N	N
Pentachaeta bellidiflora	White-rayed pentachaeta	E	CA	N	Y
Pentachaeta lyonii	Lyon's pentachaeta	E	CA	Y	Y
Phacelia argillacea	Clay phacelia	E	UT	N	Y
Phacelia formosula	North Park phacelia	E	CO	N	Y
Phacelia stellaris	Brand's phacelia	C	CA	N	N
Phacelia submutica	Debeque phacelia	C	CO	N	N
Phlox hirsuta	Yreka phlox	E	CA	N	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Plants (Cont.)					
Physaria obcordata	Dudley Bluffs twinpod	T	CO	N	Y
Piperia yadonii	Yadon's piperia	E	CA	Y	Y
Plagiobothrys strictus	Calistoga allocarya	E	CA	N	N
Poa atropurpurea	San Bernardino bluegrass	E	CA	Y	N
Poa napensis	Napa bluegrass	E	CA	N	N
Pogogyne abramsii	San Diego mesa-mint	E	CA	N	Y
Pogogyne nudiuscula	Otay mesa-mint	E	CA	N	Y
Polygonum hickmanii	Scotts Valley polygonum	E	CA	Y	N
Potentilla basaltica	Soldier Meadows cinquefoil	C	CA, NV	N	N
Potentilla hickmanii	Hickman's potentilla	E	CA	N	Y
Primula maguirei	Maguire primrose	T	UT	N	Y
Pseudobahia bahiifolia	Hartweg's golden sunburst	E	CA	N	N
Pseudobahia peirsonii	San Joaquin adobe sunburst	T	CA	N	N
Purshia subintegra	Arizona cliff-rose	E	AZ	N	Y
Ranunculus aestivalis	Autumn buttercup	E	UT	N	Y
Rorippa gambellii	Gambel's watercress	E	CA	N	Y
Rorippa subumbellata	Tahoe yellow cress	C	CA, NV	N	N
Schoenocrambe argillacea	Clay reed-mustard	T	UT	N	Y
Schoenocrambe barnebyi	Barneby reed-mustard	E	UT	N	Y
Schoenocrambe suffrutescens	Shrubby reed-mustard	E	UT	N	Y
Sclerocactus glaucus	Uinta Basin hookless cactus	T	CO, UT	N	Y
Sclerocactus mesae-verdae	Mesa Verde cactus	T	CO, NM	N	Y
Sclerocactus wrightiae	Wright fishhook cactus	E	UT	N	Y
Sedum eastwoodiae	Red Mountain stonecrop	C	CA	N	N
Senecio franciscanus	San Francisco Peaks groundsel	T	AZ	Y	Y
Senecio layneae	Layne's butterweed	T	CA	N	Y
Sidalcea keckii	Keck's checker-mallow	E	CA	Y	N
Sidalcea oregana valida	Kenwood marsh checker-mallow	E	CA	N	N

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Plants (Cont.)					
Sidalcea pedata	Pedate checker-mallow	E	CA	N	Y
Spiranthes delitescens	Canelo hills ladies'-tresses	E	AZ	N	N
Spiranthes diluvialis	Ute ladies'-tresses	T	CO, UT	N	Y
Streptanthus albidus albidus	Metcalf Canyon jewelflower	E	CA	N	Y
Streptanthus niger	Tiburon jewelflower	E	CA	N	Y
Suaeda californica	California seablite	E	CA	N	N
Swallenia alexandrae	Eureka dune grass	E	CA	N	Y
Taraxacum californicum	California taraxacum	E	CA	Y	N
Thelypodium stenopetalum	Slender-petaled mustard	E	CA	N	Y
Thlaspi californicum	Kneeland Prairie penny-cress	E	CA	Y	Y
Townsendia aprica	Last chance townsendia	T	UT	N	Y
Trichostema austromontanum compactum	Hidden Lake bluecurls	T	CA	N	N
Trifolium amoenum	Showy Indian clover	E	CA	N	N
Trifolium trichocalyx	Monterey clover	E	CA	N	Y
Tuctoria greenei	Greene's tuctoria	E	CA	Y	Y
Tuctoria mucronata	Solano grass	E	CA	Y	Y
Verbena californica	Red Hills vervain	T	CA	N	N
Verbesina dissita	Big-leaved crownbeard	T	CA	N	N
Mollusks					
Assiminea pecos	Pecos assiminea snail	E	NM	Y	N
Haliotis sorenseni	White abalone	E	CA	N	N
Helminthoglypta walkeriana	Morro shoulderband snail	E	CA	Y	Y
Juturnia kosteri	Koster's springsnail	E	NM	N	N
Oreohelix peripherica wasatchensis	Ogden mountainsnail	C	UT	N	N
Oxyloma haydeni kanabensis	Kanab ambersnail	E	AZ, UT	N	Y
Popenaias popei	Texas hornshell	C	NM	N	N
Pyrgulopsis chupaderae	Chupadera springsnail	C	NM	N	N

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Mollusks (Cont.)					
Pyrgulopsis gilae	Gila springsnail	C	NM	N	N
Pyrgulopsis morrisoni	Page springsnail	C	AZ	N	N
Pyrgulopsis neomexicana	Socorro springsnail	E	NM	N	Y
Pyrgulopsis roswellensis	Roswell springsnail	E	NM	N	N
Pyrgulopsis thermalis	New Mexico springsnail	C	NM	N	N
Pyrgulopsis thompsoni	Huachuca springsnail	C	AZ	N	N
Pyrgulopsis trivialis	Three Forks springsnail	C	AZ	N	N
Stagnicola bonnevillensis	Bonneville pondsnail	C	UT	N	N
Tryonia alamosae	Alamosa springsnail	E	NM	N	Y
Arthropods					
Ambrysus amargosus	Ash Meadows naucorid	T	NV	Y	Y
Ambrysus funebris	Nevares Spring naucorid bug	C	CA	N	N
Apodemia mormo langei	Lange's metalmark butterfly	E	CA	N	Y
Boloria acrocnema	Uncompahgre fritillary butterfly	E	CO	N	Y
Branchinecta conservatio	Conservancy fairy shrimp	E	CA	Y	Y
Branchinecta longiantenna	Longhorn fairy shrimp	E	CA	Y	Y
Branchinecta lynchi	Vernal pool fairy shrimp	T	CA	Y	Y
Branchinecta sandiegonensis	San Diego fairy shrimp	E	CA	Y	Y
Callophrys mossii bayensis	San Bruno elfin butterfly	E	CA	N	Y
Cicindela limbata albissima	Coral pink sand dunes tiger beetle	C	UT	N	N
Cicindela ohlone	Ohlone tiger beetle	E	CA	N	N
Desmocerus californicus dimorphus	Valley elderberry longhorn beetle	T	CA	Y	Y
Elaphrus viridis	Delta green ground beetle	T	CA	Y	Y
Euphilotes battoides allyni	El Segundo blue butterfly	E	CA	N	Y
Euphilotes enoptes smithi	Smith's blue butterfly	E	CA	N	Y
Euphydryas editha bayensis	Bay checkerspot butterfly	T	CA	Y	Y
Euphydryas editha quino	Quino checkerspot butterfly	E	CA	Y	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Arthropods (Cont.)					
Euproserpinus euterpe	Kern primrose sphinx moth	T	CA	N	Y
Gammarus desperatus	Noel's amphipod	E	NM	N	N
Glaucopsyche lygdamus palosverdesensis	Palos Verdes blue butterfly	E	CA	Y	Y
Hesperia leonardus montana	Pawnee montane skipper	T	CO	N	Y
Heterelmis stephani	Stephan's riffle beetle	C	AZ	N	N
Icaricia icarioides missionensis	Mission blue butterfly	E	CA	N	Y
Lepidurus packardi	Vernal pool tadpole shrimp	E	CA	Y	Y
Lycaeides argyrognomon lotis	Lotis blue butterfly	E	CA	N	Y
Pacifastacus fortis	Shasta crayfish	E	CA	N	Y
Polites mardon	Mardon skipper	C	CA	N	N
Polyphylla barbata	Mount Hermon june beetle	E	CA	N	Y
Pseudocopaeodes eunus obscurus	Carson wandering skipper	E	CA, NV	N	Y
Pyrgus ruralis lagunae	Laguna Mountains skipper	E	CA	Y	N
Rhaphiomidas terminatus abdominalis	Delhi sands flower-loving fly	E	CA	N	Y
Speyeria callippe callippe	Callippe silverspot butterfly	E	CA	N	N
Speyeria zerene behrensii	Behren's silverspot butterfly	E	CA	N	Y
Speyeria zerene hippolyta	Oregon silverspot butterfly	T	CA	Y	Y
Speyeria zerene myrtleae	Myrtle's silverspot butterfly	E	CA	N	Y
Streptocephalus woottoni	Riverside fairy shrimp	E	CA	Y	Y
Syncaris pacifica	California freshwater shrimp	E	CA	N	Y
Thermosphaeroma thermophilus	Socorro isopod	E	NM	N	Y
Trimerotropis infantilis	Zayante band-winged grasshopper	E	CA	Y	Y
Fishes					
Acipenser medirostris	North American Green Sturgeon	T	CA	N	N
Catostomus discobolus yarrowi	Zuni bluehead sucker	C	AZ, NM	N	N
Catostomus microps	Modoc sucker	E	CA	Y	Y
Catostomus santaanae	Santa Ana sucker	T	CA	Y	N

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Fishes (Cont.)					
Chasmistes brevirostris	Shortnose sucker	E	CA	N	Y
Chasmistes cujus	Cui-ui	E	NV	N	Y
Chasmistes liorus	June sucker	E	UT	Y	Y
Crenichthys baileyi baileyi	White River springfish	E	NV	Y	Y
Crenichthys baileyi grandis	Hiko White River springfish	E	NV	Y	Y
Crenichthys nevadae	Railroad Valley springfish	T	NV	Y	Y
Cyprinella formosa	Beautiful shiner	T	AZ, NM	Y	Y
Cyprinodon diabolis	Devils Hole pupfish	E	NV	N	Y
Cyprinodon macularius	Desert pupfish	E	AZ, CA	Y	Y
Cyprinodon nevadensis mionectes	Ash Meadows amargosa pupfish	E	NV	Y	Y
Cyprinodon nevadensis pectoralis	Warm Springs pupfish	E	NV	N	Y
Cyprinodon radiosus	Owens pupfish	E	CA	N	Y
Deltistes luxatus	Lost River sucker	E	CA	N	Y
Empetrichthys latos	Pahrump poolfish	E	NV	N	Y
Eremichthys acros	Desert dace	T	NV	Y	Y
Etheostoma cragini	Arkansas darter	C	CO	N	N
Eucyclogobius newberryi	Tidewater goby	E	CA	Y	Y
Gambusia nobilis	Pecos gambusia	E	NM	N	Y
Gasterosteus aculeatus williamsoni	Unarmored threespine stickleback	E	CA	N	Y
Gila bicolor mohavensis	Mohave tui chub	E	CA	N	Y
Gila bicolor snyderi	Owens tui chub	E	CA	Y	Y
Gila cypha	Humpback chub	E	AZ, CO, UT	Y	Y
Gila ditaenia	Sonora chub	T	AZ	Y	Y
Gila elegans	Bonytail chub	E	AZ, CA, CO, NV, UT	Y	Y
Gila intermedia	Gila chub	E	AZ, NM	Y	N
Gila nigra	Headwater chub	C	AZ, NM	N	N
Gila nigrescens	Chihuahua chub	T	NM	N	Y
Gila purpurea	Yaqui chub	E	AZ	Y	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Fishes (Cont.)					
Gila robusta jordani	Pahranagat roundtail chub	E	NV	N	Y
Gila seminuda	Virgin River chub	E	AZ, NV, UT	Y	Y
Hybognathus amarus	Rio Grande silvery minnow	E	NM	Y	Y
Hypomesus transpacificus	Delta smelt	T	CA	Y	Y
Ictalurus pricei	Yaqui catfish	T	AZ	Y	Y
Lepidomeda albivallis	White River spinedace	E	NV	Y	Y
Lepidomeda mollispinis pratensis	Big Spring spinedace	T	NV	Y	Y
Lepidomeda vittata	Little Colorado spinedace	T	AZ	Y	Y
Meda fulgida	Spikedace	T	AZ, NM	Y	Y
Moapa coriacea	Moapa dace	E	NV	Y	Y
Notropis girardi	Arkansas River shiner	T	NM	Y	N
Notropis simus pecosensis	Pecos bluntnose shiner	T	NM	Y	Y
Oncorhynchus aguabonita whitei	Little Kern golden trout	T	CA	Y	Y
Oncorhynchus apache	Apache trout	T	AZ	N	Y
Oncorhynchus clarkii henshawi	Lahontan cutthroat trout	T	CA, NV, UT	N	Y
Oncorhynchus clarkii seleniris	Paiute cutthroat trout	T	CA	N	Y
Oncorhynchus clarkii stomias	Greenback cutthroat trout	T	CO	N	Y
Oncorhynchus gilae	Gila trout	T	AZ, NM	N	Y
Oncorhynchus kisutch	Coho salmon[b]	T, E[c]	CA	Y	N
Oncorhynchus mykiss	Steelhead[b]	T, E[c]	CA	Y	N
Oncorhynchus tshawytscha	Chinook salmon[b]	T, E[c]	CA	Y	N
Plagopterus argentissimus	Woundfin	E	AZ, UT	Y	Y
Poeciliopsis occidentalis	Gila topminnow	E	AZ, NM	N	Y
Ptychocheilus lucius	Colorado pikeminnow	E	AZ, CA, CO, NM, NV, UT	Y	Y
Rhinichthys osculus lethoporus	Independence Valley speckled dace	E	NV	N	Y
Rhinichthys osculus nevadensis	Ash Meadows speckled dace	E	NV	Y	Y
Rhinichthys osculus oligoporus	Clover Valley speckled dace	E	NV	N	Y
Salvelinus confluentus	Bull trout	T	NV	Y	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Fishes (Cont.)					
Tiaroga cobitis	Loach minnow	T	AZ, NM	Y	Y
Xyrauchen texanus	Razorback sucker	E	AZ, CA, CO, NM, NV, UT	Y	Y
Amphibians					
Ambystoma californiense	California tiger salamander	T, E[c]	CA	Y	N
Ambystoma macrodactylum croceum	Santa Cruz Long-Toed Salamander	E	CA	N	Y
Ambystoma tigrinum stebbinsi	Sonora tiger salamander	E	AZ	N	Y
Batrachoseps aridus	Desert slender salamander	E	CA	N	Y
Bufo californicus	Arroyo toad	E	CA	Y	Y
Bufo canorus	Yosemite toad	C	CA	N	N
Rana aurora draytonii	California red-legged frog	T	CA	Y	Y
Rana chiricahuensis	Chiricahua leopard frog	T	AZ, NM	N	Y
Rana luteiventris	Columbia spotted frog	C	NV	N	N
Rana muscosa	Mountain yellow-legged frog	E, C[c]	CA, NV	Y	N
Rana onca	Relict leopard frog	C	AZ, NV, UT	N	N
Rana pretiosa	Oregon spotted frog	C	CA	N	N
Reptiles					
Crotalus willardi obscurus	New Mexican ridge-nosed rattlesnake	T	AZ, NM	Y	Y
Gambelia silus	Blunt-nosed leopard lizard	E	CA	N	Y
Gopherus agassizii	Desert tortoise	T	AZ, CA, NV, UT	Y	Y
Kinosternon sonoriense longifemorale	Sonoyta mud turtle	C	AZ, NM	N	N
Masticophis lateralis euryxanthus	Alameda whipsnake	T	CA	Y	Y
Sceloporus arenicolus	Sand dune lizard	C	NM	N	N
Thamnophis gigas	Giant garter snake	T	CA	N	Y
Thamnophis sirtalis tetrataenia	San Francisco garter snake	E	CA	N	Y
Uma inornata	Coachella Valley fringe-toed lizard	T	CA	Y	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Birds					
Brachyramphus marmoratus	Marbled murrelet	T	CA	Y	Y
Charadrius alexandrinus nivosus	Western snowy plover	T	CA	Y	Y
Charadrius melodus	Piping plover	T	CO	N	Y
Coccyzus americanus	Western yellow-billed cuckoo	C	AZ, CA, CO, NM, NV, UT	N	N
Colinus virginianus ridgwayi	Masked bobwhite	E	AZ	N	Y
Empidonax traillii extimus	Southwestern willow flycatcher	E	AZ, CA, CO, NM, NV, UT	Y	Y
Falco femoralis septentrionalis	Northern Aplomado falcon	E, XN	AZ, NM	N	Y
Grus americana	Whooping crane	E	CO	Y	Y
Gymnogyps californianus	California condor	E	AZ, CA, UT	Y	Y
Haliaeetus leucocephalus	Sonoran desert bald eagle	T	AZ	N	N
Pelecanus occidentalis	Brown pelican	E, PDL	CA	N	Y
Pipilo crissalis eremophilus	Inyo California towhee	T	CA	Y	Y
Polioptila californica californica	Coastal California gnatcatcher	T	CA	Y	N
Rallus longirostris levipes	Light-footed clapper rail	E	CA	N	Y
Rallus longirostris obsoletus	California clapper rail	E	CA	N	Y
Rallus longirostris yumanensis	Yuma clapper rail	E	AZ, CA, NV, UT	N	Y
Sterna antillarum	Interior least tern	E	CO, NM	N	Y
Sterna antillarum browni	California least tern	E	CA	N	Y
Strix occidentalis caurina	Northern spotted owl	T	CA	Y	Y
Strix occidentalis lucida	Mexican spotted owl	T	AZ, CO, NM, UT	Y	Y
Synthliboramphus hypoleucus	Xantus's murrelet	C	CA	N	N
Tympanuchus pallidicinctus	Lesser prairie-chicken	C	CO, NM	N	N
Vireo bellii pusillus	Least Bell's vireo	E	CA	Y	N
Mammals					
Antilocapra americana sonoriensis	Sonoran pronghorn	E	AZ	N	Y
Aplodontia rufa nigra	Point Arena mountain beaver	E	CA	N	N
Canis lupus	Gray wolf	E	AZ, CO, NM, NV, UT	Y	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Mammals (Cont.)					
Cynomys parvidens	Utah prairie dog	T	UT	N	Y
Dipodomys heermanni morroensis	Morro Bay kangaroo rat	E	CA	Y	Y
Dipodomys ingens	Giant kangaroo rat	E	CA	N	Y
Dipodomys merriami parvus	San Bernardino Merriam's kangaroo rat	E	CA	Y	N
Dipodomys nitratoides exilis	Fresno kangaroo rat	E	CA	Y	Y
Dipodomys nitratoides nitratoides	Tipton kangaroo rat	E	CA	N	Y
Dipodomys stephensi	Stephens' kangaroo rat	E	CA	N	Y
Eumetopias jubatus	Steller sea lion	T	CA	Y	N
Herpailurus yagouaroundi tolteca	Sinaloan jaguarundi	E	AZ	N	Y
Leopardus pardalis	Ocelot	E	AZ	N	Y
Leptonycteris curasoae yerbabuenae	Lesser long-nosed bat	E	AZ, NM	N	Y
Leptonycteris nivalis	Mexican long-nosed bat	E	NM	N	Y
Lynx canadensis	Canada lynx	T	CO, UT	N	N
Martes pennanti	West coast fisher	C	CA	N	Y
Microtus californicus scirpensis	Amargosa vole	E	CA	Y	Y
Microtus mexicanus hualpaiensis	Hualapai Mexican vole	E	AZ	N	Y
Mustela nigripes	Black-footed ferret	E	AZ, CO, UT	N	Y
Neotoma fuscipes riparia	Riparian woodrat	E	CA	N	Y
Ovis canadensis	Peninsular bighorn sheep	E	CA	Y	Y
Ovis canadensis sierrae	Sierra Nevada bighorn sheep	E	CA	Y	Y
Panthera onca	Jaguar	E	AZ, NM	N	Y
Perognathus longimembris pacificus	Pacific pocket mouse	E	CA	N	Y
Reithrodontomys raviventris	Salt marsh harvest mouse	E	CA	N	Y
Sorex ornatus relictus	Buena Vista Lake ornate shrew	E	CA	Y	Y
Spermophilus tereticaudus chlorus	Palm Springs round-tailed ground squirrel	C	CA	N	N
Sylvilagus bachmani riparius	Riparian brush rabbit	E	CA	N	Y
Tamiasciurus hudsonicus grahamensis	Mount Graham red squirrel	E	AZ	Y	Y

TABLE 4.10-4 (Cont.)

Scientific Name	Common Name	Listing Status[a]	State(s) in Which Species Could Occur	Designated Critical Habitat (Y/N)	Recovery Plan (Y/N)
Mammals (Cont.)					
Vulpes macrotis mutica	San Joaquin kit fox	E	CA	N	Y
Zapus hudsonius preblei	Preble's meadow jumping mouse	T	CO	Y	N

[a] C = candidate for listing; E = listed as endangered; PDL = proposed for delisting; PT = proposed for listing as threatened; T = listed as threatened; XN = experimental population.

[b] Includes one or more "evolutionarily significant units" that spawn in different river basins or at different times of year and that have been assigned separate listing status.

[c] More than one listing category indicates that the species has different status in different states.

Source: USFWS (2010).

- *Candidate*: species for which the USFWS or NMFS has sufficient information on their biological status and threats to propose them as threatened or endangered under the ESA but for which development of a proposed listing regulation is precluded by other higher priority listing actions.

- *Critical habitat*: critical habitat for listed species consists of: (1) the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of Section 4 of the ESA, on which are found those physical or biological features (constituent elements) (a) essential to the conservation of the species and (b) which may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of Section 4 of the ESA, upon a determination by the Secretary of the Interior that such areas are essential for the conservation of the species. Designated critical habitats are described in 50 CFR 17 and 226.

In the six-state study area, 241 plant species and 190 animal species are federally listed as threatened or endangered, proposed for listing, or candidates for listing under the ESA. The animals are 17 species of mollusks, 39 species of arthropods, 62 species of fishes, 10 species of amphibians, 9 species of reptiles, 21 species of birds, and 32 species of mammals. California has the largest number of listed plant and animal species (257); whereas Colorado has the fewest (31). Critical habitat has been designated for 158 of these species, and recovery plans have been developed for 302 species (Table 4.10-4). These plans must be followed where federal projects might affect those species.

The BLM has established a policy, as specified in BLM Manual 6840, *Special Status Species Management* (BLM 2008b), whose purpose is "to provide policy and guidance for the conservation of BLM special status species and the ecosystems upon which they depend on BLM-administered lands." Objectives of the BLM special status species policy are to (1) conserve and/or recover ESA-listed species and the ecosystems on which they depend so that ESA protections are no longer needed for these species and (2) initiate proactive conservation measures that reduce or eliminate threats to BLM sensitive species to minimize the likelihood of and need for listing of these species under the ESA. BLM special status species are "(1) species listed or proposed for listing under the ESA, and (2) species requiring special management consideration to promote their conservation and reduce the likelihood and need for future listing under the ESA, which are designated as Bureau sensitive by the State Director(s). All Federal candidate species, proposed species, and delisted species in the 5 years following delisting will be conserved as Bureau sensitive species." Each BLM state director maintains a list of sensitive species, and impacts on these species would have to be considered in project-specific assessments developed before approval of any activity that would affect listed or proposed species or critical habitat.

In implementing this policy, the BLM has designated certain areas throughout the six-state study region to protect important resources, including populations of special status species. These areas are referred to as Areas of Critical Environmental Concern (ACECs) and typically have specific protection or management requirements associated with them, including surface

occupancy restrictions, activity timing restrictions, and compatible uses depending on the resources contained in those areas.

Each of the six states in the study area has also identified species that are of concern in the state. Each state differs in the listing status designations it uses and in its regulations for protecting those species. Project-specific assessments would consider impacts on these state-listed species prior to project development. Many of these species are also listed as BLM sensitive species, and some are also listed under the ESA. In cooperation with the USFWS, the states are required to monitor, for no less than 5 years, the status of all species that have recovered to the point at which they are no longer listed as threatened or endangered (e.g., bald eagle).

4.11 AIR QUALITY AND CLIMATE

4.11.1 Meteorology

Climate varies substantially across the six-state study area and is influenced by variations in elevation, latitude, topographic features, moisture source, and proximity to water bodies. General meteorological conditions for each state, extracted from historic climatic information issued by the Western Regional Climate Center (WRCC 2008), are briefly described below, followed by a summary of temperature, precipitation, wind direction, and severe weather conditions across the six-state area.

4.11.1.1 Arizona

Arizona has three main topographic areas: (1) a mountainous region oriented southeast to northwest; (2) a high plateau in the northeast; and (3) lower mountain ranges and desert valleys in the southwest. A large portion of Arizona is classified as desert or semiarid. The air is generally dry and clear, with low relative humidity (annual averages ranging from 55% at Flagstaff to 33% at Yuma) and a high percentage of sunshine (annual averages ranging from 86 to 92%). Sometimes cold air masses from Canada penetrate into the state and bring temperatures well below zero (a lowest record of –35°F [–37°C]) in the high plateau and mountainous regions of central and northern Arizona. High temperatures are common throughout the summer months at the lower elevations, and the highest temperature of 125°F (52°C) was observed in the desert area. Great temperature extremes occur between day and night throughout Arizona with daily ranges as large as 50 to 60°F (10 to 16°C). The mountainous region averages 25 to 30 in. (64 to 76 cm) of precipitation per year, while the desert southwest averages as low as 3 or 4 in. (8 or 10 cm) per year. The plateau area receives about 10 in. (25 cm) of precipitation per year. Solar power resources are shown in Figures 4.11-1 and 4.11-2.

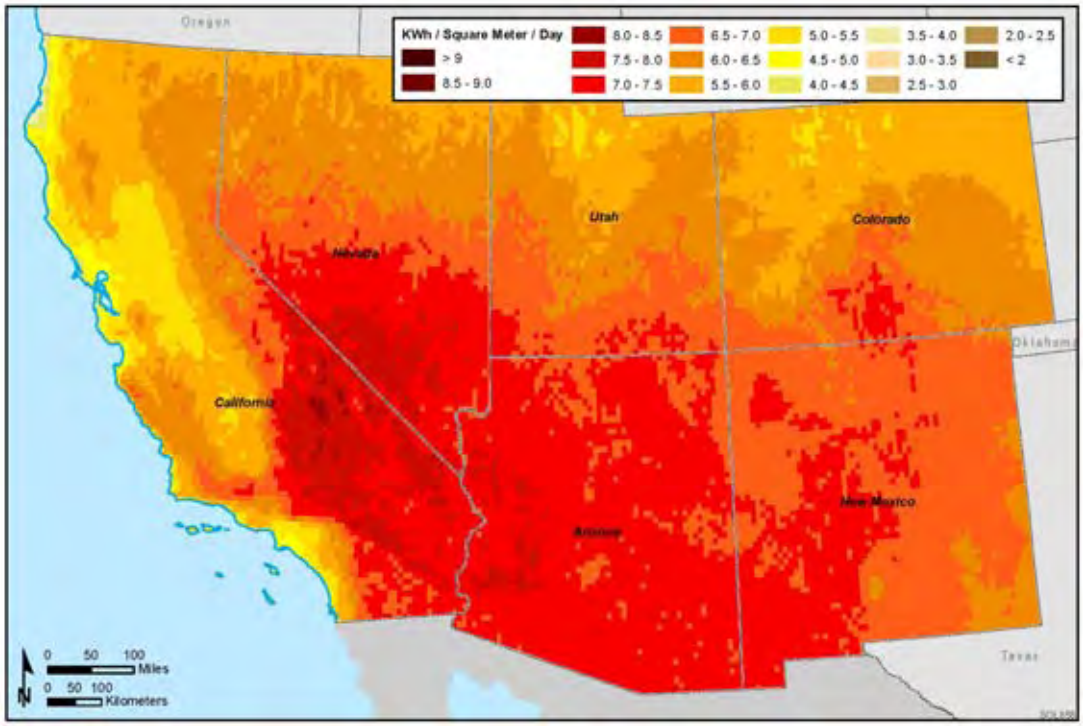

FIGURE 4.11-1 CSP Resources in Six Southwestern States (Source: NREL 2010)

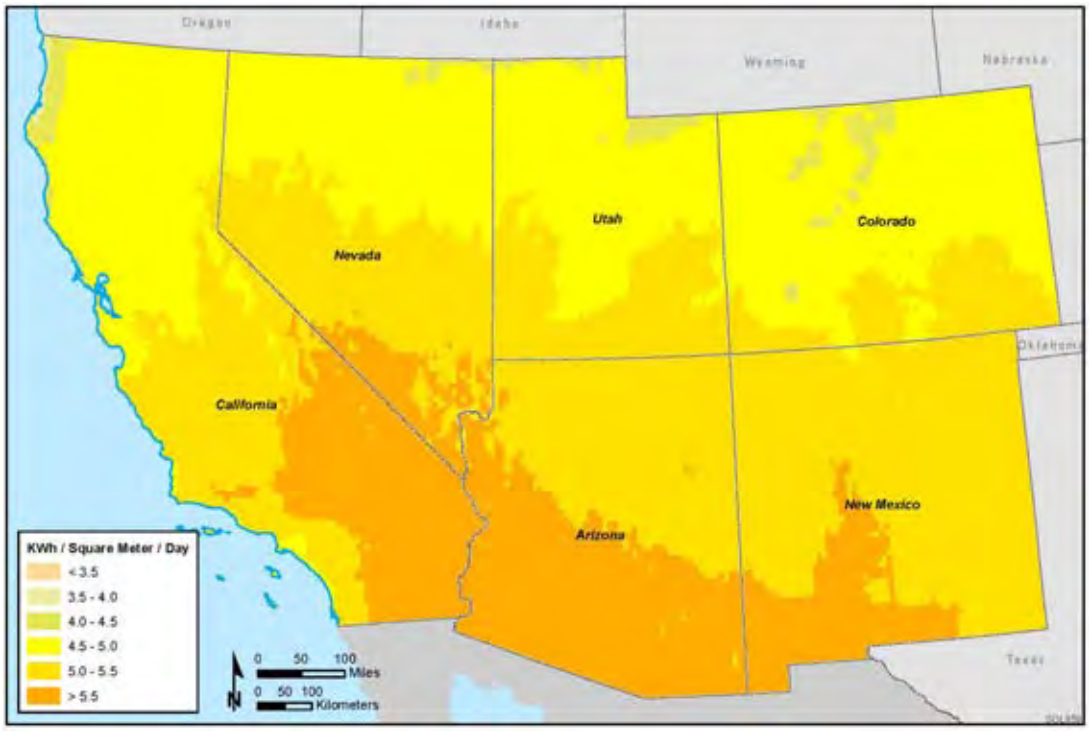

FIGURE 4.11-2 PV Solar Resources in Six Southwestern States (Source: NREL 2010)

4.11.1.2 California

Because of the size of California, a latitude span of almost 10 degrees, and complex topography, substantial spatial and temporal variations in climate exist within the state. The easternmost mountain chains form a barrier that protects much of the state from the extremely cold air of the Great Basin in winter. The ranges of mountains to the west offer some protection to the interior from the strong flow of air off the Pacific Ocean. Thus, precipitation is heavy (in excess of 50 in. [130 cm] per year) on the coastal or western side of both the Coast Range and the Sierra Nevada and lighter on the eastern slopes (under 9 in. [20 cm] in some areas). Between the two mountain chains and over much of the desert area, hot summers and moderate to cold winters are the rule. Along the coast, the climate is subject to wide variations within short distances because of the influence of topography on the circulation of marine air. Depending to some extent upon the amount of marine influence experienced, temperature ranges become wider. On the coast, temperature ranges are small from day to night and from winter to summer. Higher elevations in the mountains experience large temperature variations. Extreme temperatures have been recorded as low as –45°F (–43°C) and as high as 134°F (57°C). Annual precipitation at one station has exceeded 161 in. (409 cm), while other points have gone for more than a year with no measurable rain. Solar power resources are shown in Figures 4.11-1 and 4.11-2.

Solar Power Resources

Two types of data are available. The direct normal solar values represent the resource available to concentrating systems that track the sun throughout the day using two-axis concentrators. Flat plate insolation values represent the resource available to a flat plate collector, such as a photovoltaic panel, oriented due south at an angle from horizontal to equal to the latitude of the collector location.

4.11.1.3 Colorado

Colorado has an inland continental location in the middle latitudes, which is characterized by rugged mountain ranges in the west and level-to-rolling prairie in the east. Most of the state experiences a cool and invigorating mountain climate. In the western portion of the state, rugged topography causes large variations in climate within short distances and precludes climatic generalizations. The highest temperature can reach 90 to 95°F (32 to 35°C) in the summer, and temperatures on snow-covered mountain peaks and valleys can be as low as –50°F (–46°C). In the eastern plains, the climate is fairly uniform, with characteristic features of low relative humidity, abundant sunshine, light rainfall, moderate to high winds, and a large daily range in temperature. Summer daily maximum temperatures of 95 to 100°F (35 to 38°C) have been recorded, and the highest temperature, exceeding 115°F (46°C), occurred in the northeastern plains. Usual winter extremes are from 0 to –15°F (–18 to –26°C). For most of western Colorado, the greatest monthly precipitation occurs in the winter, while June is the driest month. In contrast, June is one of the wetter months in most of the eastern portions of the state. Solar power resources are shown in Figures 4.11-1 and 4.11-2.

4.11.1.4 Nevada

Nevada is predominantly a plateau and lies on the eastern side of the Sierra Nevada Range, a massive mountain barrier that causes air from the west to be warm and dry along with the prevailing westerlies. Prolonged cold weather is rare because mountains east and north of the state act as a barrier to prevent intrusions of extremely cold continental arctic air masses. Nevada has great climatic diversity, ranging from scorching lowland desert in the south to cool mountain forest in the north. Wide daily temperature ranges are caused by strong daytime surface heating and rapid nighttime cooling because of the dry air. The average range is about 30 to 35F° (17 to 19C°). Summer temperatures above 100°F (38°C) occur frequently in the south, and temperature extremes have ranged from –50 to 120°F (–46 to 49°C). Variation in precipitation is due primarily to differences in elevation and exposure to precipitation-bearing storms. Precipitation is lightest in the lower portions of the western plateau, opposite California's Death Valley and northward to Idaho. In valleys in this area, annual precipitation is less than 5 in. (13 cm), but reaches about 40 in. (102 cm) in the Sierra Nevadas. Solar power resources are shown in Figures 4.11-1 and 4.11-2.

4.11.1.5 New Mexico

New Mexico is divided into three major areas by mountain ranges and highlands, running generally in a north-south direction and merging in the north. It has a mild, arid or semiarid, continental climate characterized by light precipitation, abundant sunshine, low relative humidity, and relatively large annual and diurnal temperature ranges. During the summer, daytime temperatures often exceed 100°F (38°C) at elevations below 5,000 ft (1,500 m), but average monthly maximum temperatures range from the upper 70s°F (20s°C) at higher elevations to above 90°F (32°C) at lower elevations. During the winter, minimum temperatures below freezing are common throughout the state; subzero temperatures, however, are rare except in the mountains. The lowest recorded temperature was –50°F (–46°C) and the highest was 116°F (47°C). Average annual precipitation ranges from less than 10 in. (25 cm) over much of the southern desert and the Rio Grande and San Juan Valleys to more than 20 in. (51 cm) at higher elevations. Arid and semiarid climates are characterized by a wide variation in annual precipitation, as illustrated by annual extremes ranging from 3 to 34 in. (8 to 86 cm) at Carlsbad. From 75% to 80% of possible sunshine is received, with as much as 90% being received in November and some spring months. Relative humidity averages near 65% at sunrise and near 30% in mid-afternoon. It is often less than 20% and occasionally as low as 4% in the afternoon in warmer months. Solar power resources are shown in Figures 4.11-1 and 4.11-2.

4.11.1.6 Utah

The topography of Utah is extremely varied, with most of the state being mountainous. Along with prevailing westerly air masses, a large portion of the original moisture of the Pacific storms falls as precipitation while passing over the mountain ranges in the western United States, such as the Sierra Nevada and Cascade Ranges and the Rocky Mountains. Thus air masses reaching Utah are relatively dry, resulting in light precipitation over most of the state.

Temperatures vary with altitude and latitude. Temperatures below zero are uncommon in most of the state, and prolonged periods of extremely cold weather are rare. This is primarily because the mountains east and north of the state act as barriers to intensely cold continental arctic air masses. The lowest recorded temperature was –50°F (–46°C). Daily temperature ranges vary widely due to relatively strong daytime insolation and rapid nocturnal cooling. Precipitation varies greatly, from less than 5 in. (13 cm) over the Great Salt Lake Desert (west of Great Salt Lake) to more than 40 in. (102 cm) in some parts of the Wasatch Mountains, which run north-south in the middle of Utah. Solar power resources are shown in Figures 4.11-1 and 4.11-2.

4.11.1.7 Overview across the Study Area

Temperature and precipitation in the six-state study area vary widely with elevation, latitude, season, and time of day. Table 4.11-1 presents historical average temperatures and precipitation at selected locations throughout the six-state study area (WRCC 2008). Annual average temperatures range from mid-40s°F to mid-70s°F. Monthly temperature extremes range from a low of 10.8°F (–11.8°C) in Elko, Nevada, to a high of 105.6°F (40.9°C) in Phoenix, Arizona. Las Vegas, Nevada, averages only 4 in. (10 cm) of precipitation each year, compared with almost 3 ft (91 cm) in Redding, California. Many cities in Arizona and California, including Phoenix and Los Angeles, have no recorded snowfall, while Salt Lake City, Utah, and Denver, Colorado, have about 5 ft (152 cm) a year.

The predominant prevailing wind aloft is from the west, as in most of the United States. However, surface winds are greatly modified by local terrain and ground cover. The wind roses presented for selected locations in Figure 4.11-3 demonstrate the variation in surface winds over the six-state study area (NCDC 1997). As shown in the figure, the prevailing wind directions vary from site to site, and the distribution of wind frequencies between the various directions is also highly site dependent. The figure also shows substantial variation in wind speeds. Low wind speeds or calms are associated with conditions of poor atmospheric dispersion. Of the 10 stations shown, two—Sacramento and Phoenix—have calms more than 10% of the time. Grand Junction, Colorado, and Roswell, New Mexico, on the other hand, have calms less than 4% of the time.

Wind Rose

A *wind rose* summarizes wind speed and direction graphically as a series of bars pointing in different directions. The direction of each bar shows the direction *from* which the wind blows. Each bar is divided into segments, which represent wind speeds in a given range, for example, 1.1 to 4.7 mph (0.5 to 2.1 m/s). The length of a segment represents the percentage of the summarized hours that winds blew from the indicated direction with a speed in the given range.

TABLE 4.11-1 Temperature and Precipitation Summaries at Selected Meteorological Stations in the Six-State Study Area[a]

Station	Temperature (°F)[b]			Annual Precipitation (in.)[c]	
	Lowest Minimum[d]	Highest Maximum[d]	Mean[e]	Water Equivalent	Snowfall
Arizona					
Flagstaff	15.2	81.6	46.2	20.78	88.7
Phoenix	41.4	105.6	74.2	7.55	0.0
Tucson	38.6	99.6	68.7	11.59	1.1
California					
Bakersfield	38.4	98.6	65.0	6.17	0.1
Los Angeles	47.4	76.4	63.3	12.11	0.0
Redding	36.2	98.8	61.6	35.06	4.0
Sacramento	37.8	92.8	61.1	17.27	0.0
San Diego	48.0	76.3	64.4	10.17	0.0
San Francisco	42.4	73.3	57.3	20.17	0.0
Colorado					
Denver	16.9	88.2	50.1	15.47	59.6
Grand Junction	15.9	92.8	51.8	8.72	21.5
Pueblo	13.8	92.8	51.7	11.88	29.6
New Mexico					
Albuquerque	23.4	91.7	56.8	8.74	9.8
Farmington	19.3	91.1	52.1	8.62	11.1
Roswell	26.4	94.3	60.8	12.95	11.9
Nevada					
Elko	10.8	91.0	46.4	9.40	36.4
Las Vegas	34.3	104.5	68.1	4.19	0.9
Reno	20.6	91.5	51.3	7.29	22.9
Utah					
Moab	18.2	98.2	57.5	8.90	8.3
Salt Lake City	20.3	92.8	52.0	15.68	60.3
St. George	25.8	101.7	63.2	8.35	3.6

[a] Summary data presented in the table are based on a period of record from the inception of the meteorological station to December 31, 2007.

[b] To convert °F to °C use the following formula: °C = (°F – 32) × 5/9.

[c] To convert in. to cm, multiply by 2.54.

[d] "Lowest Minimum" denotes the lowest monthly average of the daily minimum during the period of record, which normally occurs in January. "Highest Maximum" denotes the highest monthly average of the daily maximum during the period of record, which normally occurs in July.

[e] National Climatic Data Center (NCDC) 1971 to 2000 monthly normals.

Source: WRCC (2008).

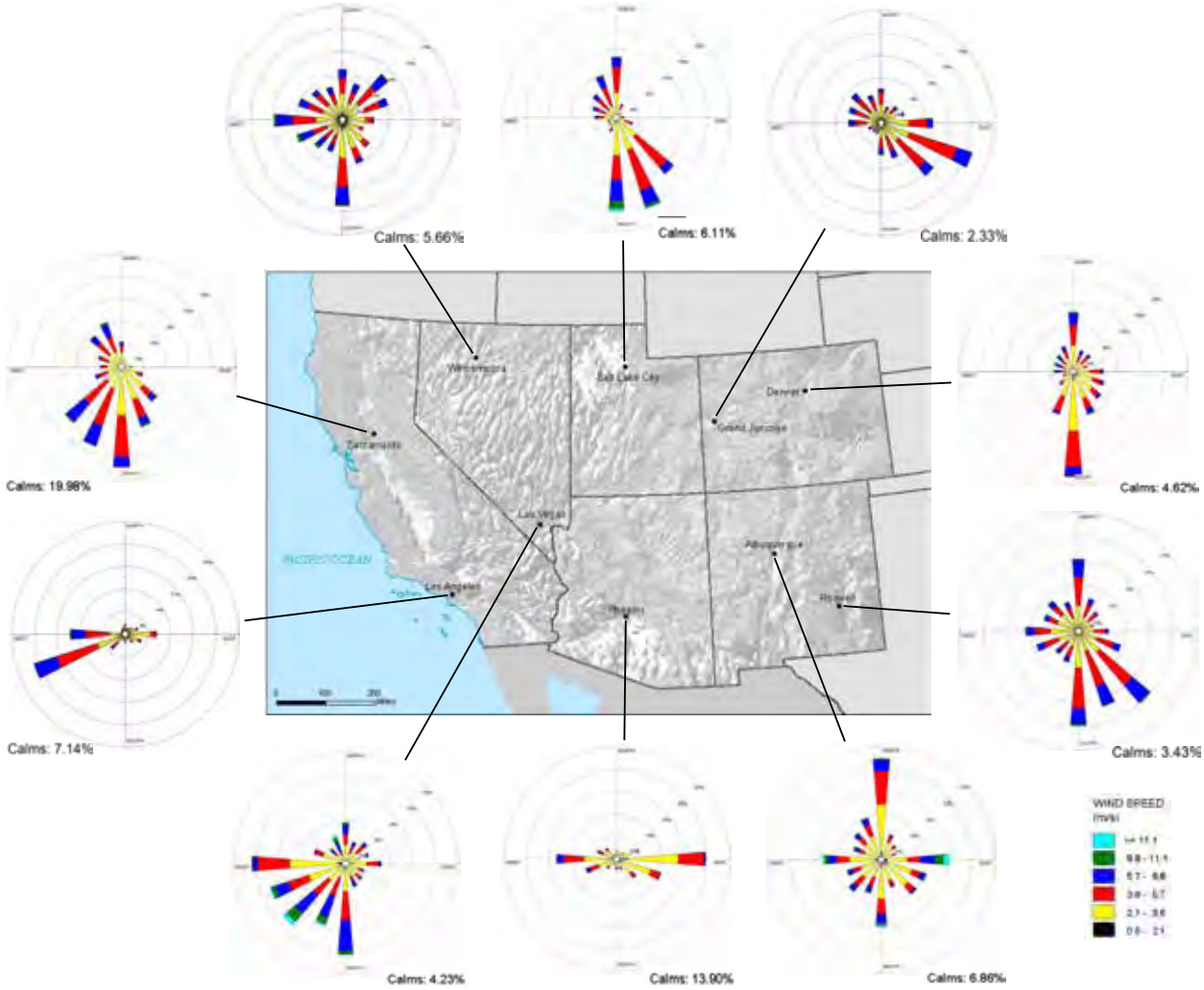

FIGURE 4.11-3 Wind Roses for Selected Meteorological Stations in the Six-State Study Area, 1990 to 1995 (Source: NCDC 1997)

Severe weather in the six-state study area includes thunderstorms, hail, dust storms, glaze, tornadoes, and hurricanes. Tornadoes and hurricanes are discussed collectively below.

Most of six-state study area has mountainous and rugged terrain, except for the easternmost low plains in Colorado and New Mexico, which are part of the tornado alley stretching from Texas to South Dakota. Complex terrain typically disrupts the mesocyclones associated with tornado-producing thunderstorms; thus tornadoes are less frequent and destructive in mountainous areas. Between January 1950 and June 2008, 2,984 tornadoes, with an annual average of 51, were reported in the six-state study area, as shown in Table 4.11-2 (NCDC 2008). The annual average number of tornadoes in the area was about 0.74 per 10,000 mi^2 (25,889 km^2), with the highest of 2.80 in Colorado and the lowest of 0.12 in Nevada. Most tornadoes that occurred in the area were relatively weak, mostly F0 to F2 on the Fujita

TABLE 4.11-2 Number of Tornadoes by Fujita Tornado Scale[a] in the Six-State Study Area for the Period of January 1, 1950 to June 30, 2008

	Number of Tornadoes by Fujita Tornado Scale								Number of Tornadoes per Year	
State	F[b]	F0	F1	F2	F3	F4	F5	Total	Mean	per 10,000 mi^2 [c]
Arizona	32	106	62	10	2	0	0	212	3.6	0.32
California	39	219	84	23	2	0	0	367	6.3	0.40
Colorado	55	1,006	508	111	18	1	0	1,699	29.0	2.80
Nevada	11	54	10	0	0	0	0	75	1.3	0.12
New Mexico	8	359	110	35	4	0	0	516	8.8	0.73
Utah	18	67	21	8	1	0	0	115	2.0	0.24
Total	163	1,811	795	187	27	1	0	2,984	51.0	0.74

[a] Fujita tornado scale is classified with the fastest 0.25-mi wind speeds:

F0 (gale): 40–72 mph (18–32 m/s)
1 (moderate): 73–112 mph (33–50 m/s)
2 (significant): 113–157 mph (51–70 m/s)
3 (severe): 158–206 mph (71–92 m/s)
4 (devastating): 207–260 mph (93–116 m/s)
5 (incredible): 261–318 mph (117–142 m/s).

[b] Not categorized by the Fujita tornado scale because damage level was not reported.

[c] To convert mi^2 to km^2, multiply by 2.590.

Source: NCDC (2008).

tornado scale. Twenty-seven "severe" F3 and one "devastating" F4 occurred, mostly on the eastern prairie of Colorado.

Hurricanes are a severe form of a tropical cyclone that can move inland from the Gulf of Mexico and the Pacific Ocean into the six-state study area. Because of the distance from the Gulf of Mexico and the Pacific Ocean and the rugged terrain, hurricanes seldom reach Colorado, Nevada, and Utah. On rare occasions, a tropical hurricane originating in the Gulf of Mexico may cause heavy rain in eastern and central New Mexico, but there is no record of serious wind damage from these storms (WRCC 2008). In the Pacific, hurricanes and tropical storms are formed off the coast of Central America and Mexico. Cold waters originating in the Arctic and moving south along the western coast will weaken any hurricane that moves toward the California coast. Accordingly, hurricanes generally dissipate before they reach California, although the state has infrequently been hit by the remnants of hurricanes and tropical storms. In addition, the general trend in hurricane motion is to the west-northwest because of the prevailing winds. Hurricanes that form in the Pacific follow this pattern, which directs hurricanes away from the West Coast of the United States. Historically, no hurricanes or tropical storms have hit the areas north of central California. Tropical storms hit southwestern Arizona next to the Gulf of California more than any other location in the six-state study area. Between 1851 and 2007,

14 storms (2 hurricanes and 12 tropical storms/depressions/lows) have passed within 100 mi (161 km) of southwestern Arizona (NOAA 2008).

4.11.2 Existing Emissions and Air Quality

This section provides general descriptions for existing emissions of criteria pollutants and volatile organic compounds (VOCs)[7] and the following federally based air quality programs likely to affect activities associated with solar energy development considered in this PEIS:

- National Ambient Air Quality Standards (NAAQS),
- Prevention of Significant Deterioration (PSD),
- Visibility Protection, and
- General Conformity.

4.11.2.1 Existing Emissions

Table 4.11-3 lists statewide criteria pollutant and VOC emissions for the six-state study area (WRAP 2006). The data upon which the table is based represent six source categories: point, area, onroad vehicles, nonroad vehicles, biogenic sources, and fire. Fire sources include wildfires, prescribed burning, and agricultural burning. Biogenic emissions are naturally occurring emissions from vegetation. Because of its large population and attendant industrial activities, California has the highest emissions of all criteria pollutants except sulfur dioxide (SO_2). Emissions from Arizona and Colorado are comparable for all criteria pollutants. Nevada generally has the lowest emissions among the six states. SO_2 emissions are the highest in Arizona, because of stationary "point" sources, primarily several coal-fired power plants.

4.11.2.2 National Ambient Air Quality Standards

The EPA has set National Ambient Air Quality Standards (NAAQS) for six criteria pollutants—SO_2, nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), PM (PM_{10} and $PM_{2.5}$),[8] and lead (Pb), as shown in Table 4.11-4. Primary NAAQS specify maximum ambient (outdoor air) concentration levels of the criteria pollutants with the aim of protecting public

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7 Volatile organic compounds (VOCs) are organic vapors in the air that can react with other substances, principally nitrogen oxides (NOx), to form ozone (O3) in the presence of sunlight.

8 Particulate matter (PM) is dust, smoke, and other solid particles and liquid droplets in the air. The size of the particulate is important and is measured in micrometers (μm). A micrometer is 1 millionth of a meter (0.000039 in.). PM_{10} is particulate matter with an aerodynamic diameter less than or equal to 10 μm, and $PM_{2.5}$ is particulate matter with an aerodynamic diameter less than or equal to 2.5 μm.

TABLE 4.11-3 Statewide Criteria Pollutant and VOC Emissions for 2002 and Carbon Dioxide Emissions for 2005

	Statewide Emissions[a] (10^3 tons/yr)[b]						
State	SO_2	NO_x	CO	VOCs	PM_{10}	$PM_{2.5}$	CO_2
Arizona	138	417	3,687	2,984	319	178	107,110
California	108	1,112	8,702	5,441	361	224	430,600
Colorado	118	412	3,474	1,619	349	173	103,990
Nevada	66	151	878	1,445	97	28	54,630
New Mexico	84	375	1,287	1,928	166	60	65,013
Utah	59	245	1,600	1,324	93	50	72,817
Total	573	2,712	19,628	14,741	1,385	773	834,160

[a] CO = carbon monoxide; CO_2 = carbon dioxide; NO_x = nitrogen oxides; $PM_{2.5}$ = particulate matter ≤ 2.5 μm; PM_{10} = particulate matter ≤ 10 μm; SO_2 = sulfur dioxide; VOC = volatile organic compound.

[b] To convert tons to metric tons, multiply by 0.907.

Sources: WRAP (2006); EPA (2008e).

health with an adequate margin of safety. Secondary NAAQS specify maximum concentration levels with the aim of protecting public welfare. The NAAQS specify different averaging times as well as maximum concentrations. Some of the NAAQS for averaging times of 24 hours or less allow the standard values to be exceeded a limited number of times per year, and others specify other procedures for determining compliance. States can have their own State Ambient Air Quality Standards (SAAQS), which must be at least as stringent as the NAAQS and they can include standards for additional pollutants (as is done in California, Nevada, and New Mexico). If a state has no standard corresponding to one of the NAAQS, the NAAQS apply.

An area where a criteria pollutant concentration exceeds NAAQS levels are is called a nonattainment area. Previous nonattainment areas where air quality has improved to meet the NAAQS are redesignated as maintenance areas and are subject to an air quality maintenance plan. Parts of the six-state study area have been in nonattainment for one or more of the NAAQS. Figure 4.11-4 shows these nonattainment areas for criteria pollutants, except for 1-hour O_3.[9] Currently, there are no nonattainment areas for NO_2 in the United States and no Pb NAAQS in the six-state study area. Eight-hour O_3 and PM_{10} account for more nonattainment areas than any other criteria pollutants and are in nonattainment over about half of California. Many counties in California have nonattainment areas for $PM_{2.5}$. Nonattainment areas for SO_2 and CO are limited to a few counties in the six-state study area.

[9] Within the six-state study area, only the Denver area in Colorado was subject to the old 1-hour O_3 NAAQS, designated as the Subpart 1 Early Action Compact (EAC) area; however, it was redesignated nonattainment for 8-hour ozone, effective November 20, 2007 (EPA 2008f).

TABLE 4.11-4 National Ambient Air Quality Standards (NAAQS) and State Ambient Air Quality Standards (SAAQS) for Criteria Pollutants in the Six-State Study Area[a]

Pollutant[b]	Averaging Time	NAAQS Value	NAAQS Type[c]	Arizona[d]	California[e]	Colorado	Nevada[f]	New Mexico[g]	Utah[d]
SO_2	1-hour	75 ppb[h]	P	*	0.25 ppm (655 μg/m^3)	–[i]	–	–	*
	3-hour	0.50 ppm (1,300 μg/m^3)	S	*	–	700 μg/m^3[j]	1,300 μg/m^3 (0.5 ppm)	–[k]	*
	24-hour	0.14 ppm (365 μg/m^3)	P	*	0.04 ppm (105 μg/m^3)	–[j]	365 μg/m^3 (0.14 ppm)	0.10 ppm[k]	*
	Annual	0.03 ppm (80 μg/m^3)	P	*	–	–[j]	80 μg/m^3 (0.03 ppm)	0.02 ppm[k]	*
NO_2	1-hour	100 ppb[l]	P	*	0.18 ppm (339 μg/m^3)	–	–	–	*
	24-hour	–	–	*	–	–	–	0.10 ppm	*
	Annual	0.053 ppm (100 μg/m^3)	P, S	*	0.030 ppm (57 μg/m^3)	100 μg/m^3	100 μg/m^3 (0.05 ppm)	0.05 ppm	*
CO	1-hour	35 ppm (40 mg/m^3)	P	*	20 ppm (23 mg/m^3)	40 mg/m^3	40,000 μg/m^3 (35 ppm)	13.1 ppm	*
	8-hour	9 ppm (10 mg/m^3)	P	*	9.0 ppm (10 mg/m^3) 6 ppm (7 mg/m^3)[m]	10 mg/m^3	10,000 μg/m^3 (9.0 ppm)[n] 6,670 μg/m^3 (6.0 ppm)[o]	8.7 ppm	*
O_3	1-hour	0.12 ppm[p]	P, S	*	0.09 ppm (180 μg/m^3)	235 μg/m^3	235 μg/m^3 (0.12 ppm) 195 μg/m^3 (0.10 ppm)[q]	–	*
	8-hour	0.075 ppm	P, S	*	0.070 ppm (137 μg/m^3)	–	–	–	*
PM_{10}	24-hour	150 μg/m^3	P, S	*	50 μg/m^3	150 μg/m^3	150 μg/m^3	–	*
	Annual	–	–		20 μg/m^3	50 μg/m^3	50 μg/m^3	–	*
$PM_{2.5}$	24-hour	35 μg/m^3	P, S	*	–	–	–	–	*
	Annual	15.0 μg/m^3	P, S	*	12 μg/m^3	–	–	–	*

TABLE 4.11-4 (Cont.)

Pollutant[b]	Averaging Time	NAAQS Value	NAAQS Type[c]	Arizona[d]	California[e]	Colorado	Nevada[f]	New Mexico[g]	Utah[d]
Pb	30-day	–	–	*	1.5 μg/m^3	1.5 μg/m^3	–	–	*
	calendar quarter	1.5 μg/m^3	P, S	*	–	–	1.5 μg/m^3	–	*
	rolling 3-month	0.15 μg/m^3 [r]	P, S	*	–	–	-	–	*

[a] Detailed information on attainment determination criteria for NAAQS and reference method for monitoring is available in 40 CFR 50. Attainment determination criteria for each state are similar to those for the NAAQS.

[b] 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.

[c] P = Primary standard whose limits were set to protect public health; S = Secondary standard whose limits were set to protect public welfare.

[d] An asterisk indicates same as the NAAQS.

[e] The State of California has standards for additional pollutants such as visibility-reducing particles, sulfates, hydrogen sulfide, and vinyl chloride, which are not presented in this table; also refer to CARB (2008) for additional pollutants for California.

[f] The State of Nevada has standards for additional pollutants such as visibility and hydrogen sulfide, which are not presented in this table; also refer to NDEP (2008) for additional pollutants for Nevada.

[g] The State of New Mexico has standards for additional pollutants such as total suspended particulates, hydrogen sulfide, and total reduced sulfur, which are not presented in this table; also refer to NMED (2008) for additional pollutants for New Mexico.

[h] Effective August 23, 2010.

[i] A dash indicates that no standard exists.

[j] Colorado has also established increments limiting the allowable increase in ambient concentrations over an established baseline.

[k] Different standards apply within 3.5 mi (5.6 km) of the Chino Mines Company smelter furnace stack at Hurley (0.50 ppm 3-hour; 0.14 ppm 24-hour; 0.03 ppm annual).

[l] Effective April 12, 2010.

[m] Lake Tahoe.

[n] Below 5,000 ft (1,500 m) above mean sea level.

[o] Above 5,000 ft (1,500 m) above mean sea level.

[p] Applies only in limited areas. As of June 15, 2005, the EPA revoked the 1-hour O_3 standard in all areas except the 8-hour O_3 nonattainment Early Action Compact (EAC) Areas.

[q] Lake Tahoe Basin.

[r] Effective January 12, 2009.

Sources: ADEQ (2008); CARB (2008); CDPHE (2008); EPA (2010); NDEP (2008); NMED (2008); UDEQ (2008).

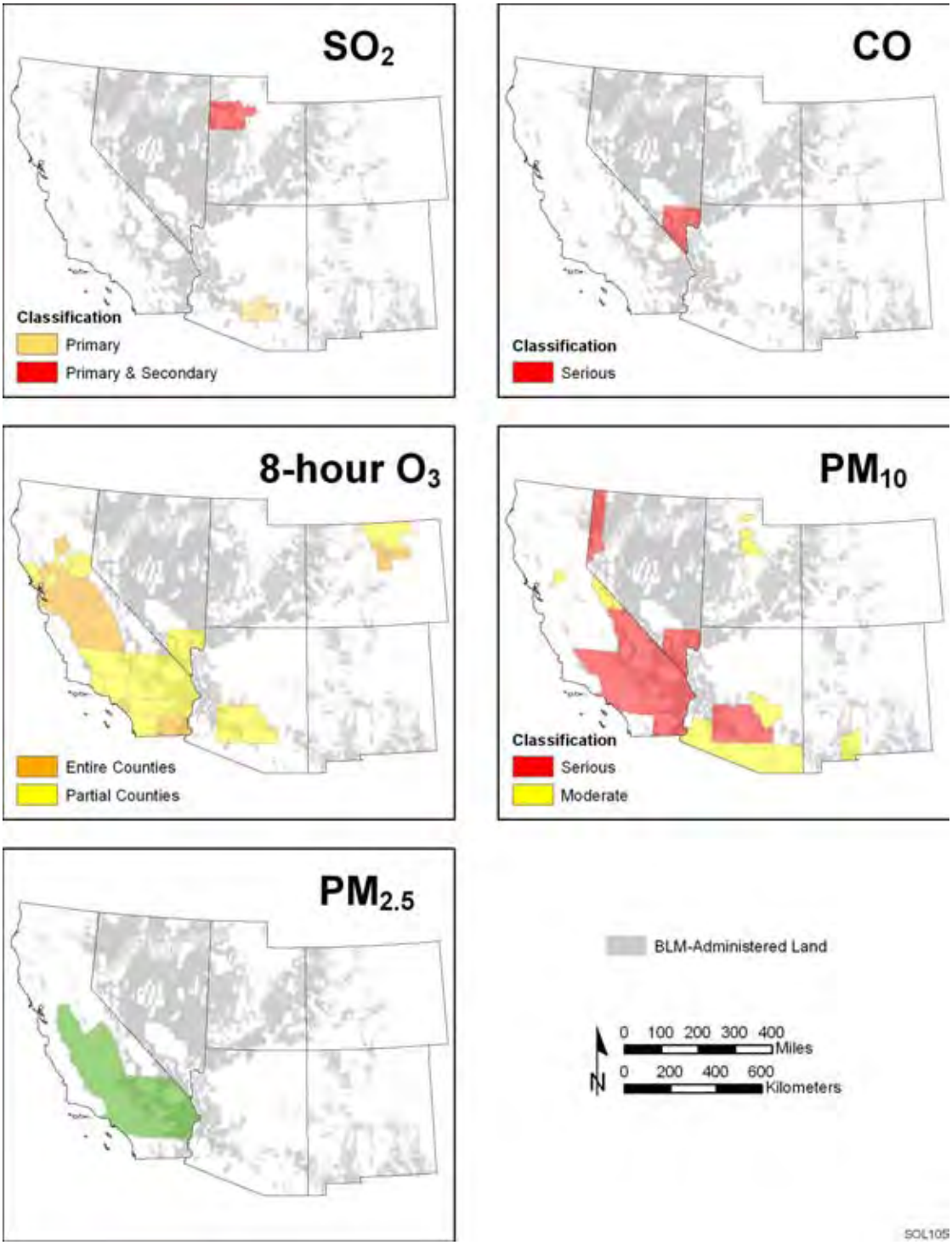

FIGURE 4.11-4 Nonattainment Areas for SO_2, CO, 8-hour O_3, PM_{10}, and $PM_{2.5}$ in the Six-State Study Area (For SO_2, CO, and PM_{10}, classification colors are shown for whole counties and denote the highest classification in that county. For O_3, partial counties, those with part of the county designated nonattainment and part attainment, are shown as full counties on the map. For $PM_{2.5}$, partial counties are shown as whole counties.) (Source: EPA 2008f)

4.11.2.3 Prevention of Significant Deterioration

While the NAAQS (and SAAQS) place upper limits on the levels of air pollution, Prevention of Significant Deterioration (PSD) regulations applying to attainment areas place limits on the total increase in ambient pollution levels above established baseline levels for SO_2, NO_2, and PM_{10}, thus preventing "polluting up to the standard" (see Table 4.11-5). These allowable increases are smallest in Class I areas, such as national parks and wilderness areas. The rest of the country is subject to larger Class II increments. States can choose a less stringent set of Class III increments, but they have not done so. Major (large) new and modified stationary sources must meet the requirements for the area in which they are locating and any areas they impact. Thus, a source locating in a Class II area near a Class I area would need to meet the more stringent Class I increment in the Class I area and the Class II increment elsewhere, as well as any other applicable requirements.

TABLE 4.11-5 Federal PSD Increments

Pollutant	Averaging Time	PSD Increment ($\mu g/m^3$) Class I	Class II
SO_2	3-hour	25	512
	24-hour	5	91
	Annual	2	20
NO_2	Annual	2.5	25
PM_{10}	24-hour	8	30
	Annual	4	17

Source: 40 CFR 52.21.

In addition to capping increases in criteria pollutant concentrations below the levels set by the NAAQS, the PSD program mandates stringent control technology requirements for new and modified major sources. In Class I areas, Federal Land Managers are responsible for protecting the air-quality-related values (AQRVs) of those areas, such as scenic, cultural, biological, and recreational resources. As stated in the Clean Air Act (CAA), the AQRV test requires the Federal Land Manager to evaluate whether the proposed project will have an adverse impact on the AQRVs, including visibility. As a matter of policy, EPA recommends that the permitting authority notify the Federal Land Managers when a proposed PSD source would locate within 62 mi (100 km) of a Class I area. If the source's emissions are considerably large (subjective), EPA recommends that sources beyond 100 km be brought to the attention of the Federal Land Manager. The Federal Land Manager then becomes responsible for demonstrating that the source's emissions could have an adverse effect on AQRVs.

Even if PSD increments are met, if the Federal Land Manager determines that there is an impact on an AQRV, the permit may not be issued. Figure 4.11-5 shows the locations of Class I PSD areas over the six-state study area. All BLM lands are currently designated as Class II areas, with few exceptions.[10]

[10] The BLM administers four mandatory federal PSD Class I areas: Domeland, San Gorgonio, and Yolla Bolly-Middle Eel in California, and Hells Canyon in Oregon. All of these areas represent congressional expansion of mandatory federal PSD Class I areas established in the August 7, 1977, amendments to the federal CAA. The original portions of these areas are administered by the USDA Forest Service (Archer 2010).

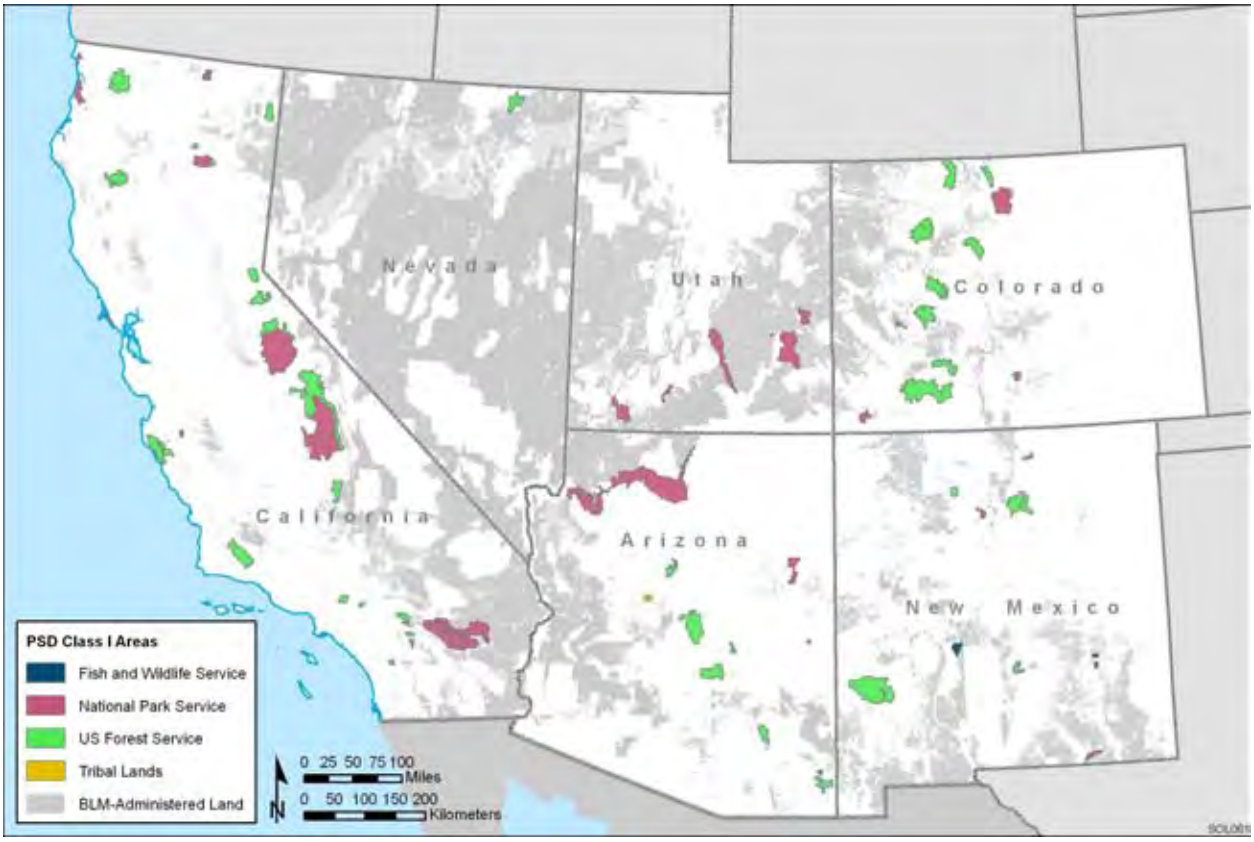

FIGURE 4.11-5 PSD Class I Areas in the Six-State Study Area (Source: EPA 2008g)

4.11.2.4 Visibility Protection

Visibility was singled out for particular emphasis in the Clean Air Act Amendments of 1977. Visibility in a Class I area is protected under two sections of the Act. Section 165 provides for the PSD program (described above) for new sources. Section 169(A), for older sources, describes requirements for both reasonably attributable single sources and regional haze that address multiple sources. Federal Land Managers have a particular responsibility to protect visibility in Class I areas. Even sources located outside a Class I area may need to obtain a permit that assures no adverse impact on visibility within the Class I area, and existing sources may need to retrofit controls. The EPA's 1999 Regional Haze Rule set goals of preventing future and remedying existing impairment to visibility in Class I areas. States had to revise their State Implementation Plans (SIPs) to establish emission-reduction strategies to meet a goal of natural conditions by 2064.

4.11.2.5 General Conformity

Federal departments and agencies are prohibited from taking actions in nonattainment and maintenance areas unless they first demonstrate that the actions would conform to the SIP as it applies to criteria pollutants. Transportation-related projects are subject to requirements for

transportation conformity. General conformity requirements apply to stationary sources. Conformity addresses only those criteria pollutants for which the area is in nonattainment or maintenance (e.g., VOCs and NO_x for O_3). If annual source emissions are below specified threshold levels, no conformity determination is required. If the emissions exceed the threshold, a conformity determination must be undertaken to demonstrate how the action will conform to the SIP. The demonstration process includes public notification and response and may require extensive analysis.

The EPA proposed new general conformity regulations on January 8, 2008 (58 FR 1402); there will be changes to the applicable general conformity requirements upon promulgation.

4.11.3 Greenhouse Gas Emissions and Climate Change

The "greenhouse effect" is a natural phenomenon occurring when certain gases (greenhouse gases [GHGs]) absorb much of the long-wave thermal radiation emitted by the land and ocean and reradiate it back to earth, keeping the atmosphere warmer than it otherwise would be. Atmospheres, including water vapor and clouds, are also a major contributor to the greenhouse effect. Without the greenhouse effect, the earth would not be warm enough to support its existing biota. However, if the greenhouse effect becomes stronger, the earth's average temperature will rise, resulting in global warming. Even a slight increase in temperature may cause problems for humans, plants, and animals. Historic data indicate that the global surface temperature has increased 0.74 ± 0.18C° (1.33 ± 0.32F°) during the last 100 years, and that the rate of warming has accelerated over the last 50 years (IPCC 2007). Global warming has occurred in the distant past as a result of natural influences, but it is now occurring, especially since the Industrial Revolution, as a result of increased anthropogenic emissions of GHGs. For example, concentrations of CO_2, a primary GHG in the atmosphere, have continuously increased from approximately 280 ppm in preindustrial times to 379 ppm in 2005, a 35% increase (IPCC 2007).

Because the global warming phenomenon is not distributed evenly across the Earth's surface, it is increasingly referred to as "global climate change." Climate change is a more flexible term than global warming, reflecting the fact that changes in the climate due to warming are not universal across the globe—some regions will warm, others will cool. Some of the critical climate changes already observed in the United States are increased numbers of heat waves; changes in annual precipitation and drought, with significant regional variability; regional changes in snow cover; sea level rises along the Atlantic and Gulf coasts; and increases in the number and intensity of tropical storms and hurricanes.

The GHGs include water vapor (H_2O), ozone (O_3), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and trace amounts of fluorinated gases, such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Along with clouds, water vapor (the most abundant GHG) accounts for the largest percentage of the greenhouse effect. However, water vapor concentrations fluctuate regionally, and human activity does not directly affect water vapor concentrations except at a local scale, such as near irrigated fields. Typically, water vapor is not included in climate change analyses.

The contribution of a given gas to the greenhouse effect is affected by both its abundance and its characteristics, such as the efficiency of the molecule as a GHG and its atmospheric lifetime. Global warming potential (GWP) is a relative measure of how much a given mass of a GHG is estimated to contribute to climate change compared with that of the same mass of CO_2. A GWP is calculated over a specific time interval. For example, CH_4 has a relatively high GWP during its short lifetime, and thus has a large GWP of 72 over a 20-year period but a GWP of 25 over a 100-year period (IPCC 2007). Over the 100-year time horizon, N_2O has a GWP of 298. Some GWPs, such as fluorinated gases, are emitted in smaller quantities relative to CO_2, but have high GWPs; SF_6 has the highest GWP—22,800.

GHGs are emitted into the atmosphere through natural processes and human activities. CO_2 occurs naturally and also enters the atmosphere through the burning of fossil fuels, solid wastes, and trees and wood products, and also as a result of chemical reactions (EPA 2008e). CH_4 is emitted during the production and transport of fossil fuels and is also released to the environment as emissions from microbes, livestock, agricultural practices, and volcanoes. Natural emissions of N_2O primarily result from bacterial breakdown of nitrogen in soils and in the earth's oceans. N_2O is also emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste. Fluorinated gases are powerful GHGs that are emitted from various industrial activities.

In general, GHG emissions are inventoried for CO_2, CH_4, N_2O, and high-GWP gases in terms of "CO_2 equivalent," which is computed by multiplying the weight of the gas being measured (e.g., CH_4) by its estimated GWP (e.g., 25 for CH_4). CO_2 equivalent emissions for 2005 from fossil fuel combustion are available for the GHGs listed above by state and for the entire United States (EPA 2008e). Data on emissions of all GHGs by state also are available, but the most recent inventory years are 2000 or 2002, and the units used differ among states. Therefore, only CO_2 emissions by state for 2005 are presented in this analysis. For the 1996-2005 period, CO_2 emissions accounted for about 83% of the total GHG emissions in terms of CO_2 equivalent, followed by CH_4 with about 10% of the total. N_2O and high-GWP gases were minor contributors (about 5% and 2%, respectively) to total GHG emissions because of their relatively low concentrations. Accordingly, total GHG emissions would be about 20% more than CO_2 emissions discussed below, and thus should be interpreted in that context.

Because CO_2 is widely emitted worldwide, uniformly mixed throughout the troposphere, and stable, its climatic impact does not depend on the geographic location of sources; that is, the global total is the important factor with respect to climate change. Therefore, a comparison between United States and global emissions and the total emissions from the six-state study area is useful in understanding whether CO_2 emissions are significant with respect to climate change. As shown in Table 4.11-3, California is the largest contributor to CO_2 emissions among the six states (about 52% of the total six-state emissions) because of its population and attendant industrial and human activities (EPA 2008e). Existing total CO_2 emissions from the six-state study area would be about 12.7% of 2005 total U.S. CO_2 emissions. In 2005, CO_2 emissions in the United States were about 21% of worldwide emissions (EIA 2008); current emissions for the six-state study area were about 2.7% of global emissions.

The EPA issued a rule on the Mandatory Reporting of Greenhouse Gases (generally referred to as the Greenhouse Gas Reporting Rule) (40 CFR Parts 86, 87, 89, 90, 94, 98, 1033, 1039, 1042, 1045, 1048, 1051, 1054, 1065) on October 30, 2009. The rule became effective on December 29, 2009, and requires suppliers of fossil fuels or industrial greenhouse gases, manufacturers of vehicles and engines, and facilities that emit 25,000 metric tons or more per year of GHG emissions to submit annual emissions reports to EPA beginning in calendar year 2010. Requirements for additional sources and source categories are under development.

The California Global Warming Solutions Act of 2006 (Health and Safety Code, 38500 et seq.) requires the state to reduce its GHG emissions to 1990 levels by 2020–a reduction of approximately 25% (173 million tons [157 million metric tons] of carbon dioxide equivalent) under a business as usual case. The law covers the Kyoto Protocol GHGs: CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6 and empowers the California Air Resources Board to develop regulations and market mechanisms to achieve the emissions reductions. Nevada requires electrical generating power plants in the state that produce electricity for sale, have a maximum output design capacity of 5 megawatts or greater, and produce greenhouse gases to annually report their emissions of Kyoto Protocol GHGs to The Climate Registry. Renewable energy sources are specifically exempted from the reporting requirement. Utah announced a goal of reducing its GHG emissions to 2005 levels by 2020 through various policy mechanisms.

The physical effects of climate change in the western United States include warmer springs (with earlier snowmelt), melting glaciers, longer summer drought, and increased wildland fire activity (Westerling et al. 2006). All these factors contribute to detrimental changes to ecosystems (e.g., increases in insect and disease infestations, shifts in species distribution, and changes in the timing of natural events). Adverse impacts on human health, agriculture (crops and livestock), infrastructure, water supplies (reduced stream flow and rising stream temperatures), energy demand (due to increased intensity of extreme weather and reduced water for hydropower), and fishing, ranching, and other resource use activities are also predicted (GAO 2007; Backlund et al. 2008; National Science and Technology Council 2008).

4.12 VISUAL RESOURCES

4.12.1 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 (or visual appeal) of the landscape. 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/season).

The BLM's responsibility for managing visual (scenic) resources of public lands is established by law. The National Environmental Policy Act requires that measures be taken to "assure for all Americans…aesthetically pleasing surroundings," and FLPMA states that "public lands will be managed in a manner which will protect the quality of scenic values of these lands." Some states and local jurisdictions also have laws, ordinances, and regulations to manage and protect visual resources within their jurisdictions, and where applicable, solar energy development would be assessed for compliance with these laws, ordinances, and regulations.

Methods have been developed to assist federal agencies responsible for visual resource planning and assessing visual resource impacts. The BLM conducts visual inventories and analyses within the guidelines established in its Visual Resource Management (VRM) System (BLM 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. Since 1980, the BLM has used the system to evaluate thousands of projects on public lands while minimizing their visual impacts.

The VRM system includes systematic processes for inventorying scenic values on BLM-administered lands, establishing visual resource management objectives for those values through the Resource Management Plan (RMP) process, and evaluating proposed activities to determine whether they conform with the management objectives. The primary components of BLM's VRM system include visual resource inventory (VRI), VRM class designation, and visual contrast rating (see Section 5.12 of this PEIS for more information about VRM class designation and visual contrast ratings).

BLM's VRI process provides BLM managers with a means for determining visual values for a tract of land. The inventory includes the following three components: scenic quality evaluation, sensitivity level analysis, and delineation of distance zones. These inventory components provide systematic processes for rating the visual appeal of a tract of land, measuring public concern for scenic quality, and determining whether the tract of land is visible from travel routes or observation points. The text box below provides more detailed information about the VRI process.

On the basis of the evaluation results, BLM-administered lands are placed into one of four VRI classes. These inventory classes represent the relative value of the visual resources. The VRI class values may be affected by visual impacts associated with land management activities, such as utility-scale solar energy development. More information about VRI methodology is available in *Visual Resource Inventory*, BLM Manual Handbook 8410-1 (BLM 1986a).

The results of the VRI become an important component of BLM's RMP for the area. The RMP establishes how the public lands will be used and allocated for different purposes, and the VRI classes provide the basis for considering visual values in the RMP land use allocation process. When a land use allocation is made, the area's visual resources are then assigned to VRM classes with established management objectives, including the degree of contrast resulting from a project or management activity permissible for that VRM classification. BLM activities must conform to the VRM objectives that apply to the project area as established in the RMP process. Once visual resources are inventoried and visual management classes are delineated, the

BLM Visual Resource Inventory

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 VRI uses three distance zones to account for this effect. It looks at locations (routes) such as highways, rivers, or other viewing locations from which a viewer could observe a particular site. The foreground-middleground zone includes areas at a distance of less than 3 to 5 mi (5 to 8 km) from the viewer. Viewed areas beyond the foreground-middleground zone but usually less than 15 mi (24 km) 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. After the analyses is performed for scenic quality, sensitivity level, and distance zones, an overlay process is used to assign visual resource inventory classes for the areas of concern. Class I is assigned to those areas where a management decision has been made previously to maintain a natural landscape. This includes areas such as national wilderness areas, the wild section of national wild and scenic rivers, and other congressionally and administratively designated areas where decisions have been made to preserve a natural landscape. Classes II, III, and IV are assigned relative visual values based on a combination of scenic quality, sensitivity level, and distance zones. Class II is the highest rating for lands without special designation; Class III represents a moderate value; and Class IV represents the least relative value. Inventory classes are informational in nature and provide the basis for considering visual values in the RMP process. They do not establish management direction and are not intended to be used as a basis for constraining or limiting surface-disturbing activities.

potential impacts of a proposed project can be evaluated relative to management objectives for the affected area. The vulnerability of visual resources to impact-producing visual contrasts then determines the need for adjustments to or mitigation of the proposed development.

4.12.2 BLM Visual Resource Management in the Six-State Study Area

The six states analyzed in this PEIS encompass a great variety of landscape types, determined by geology, topography, climate, soil type, hydrology, and land use. This vast region, which encompasses nearly 694,000 mi^2 (1.8 million km^2), includes spectacular landscapes such as the Grand Canyon and Sequoia, Yosemite, and Zion National Parks, as well as relatively flat and visually monotonous landscapes such as the High Plains of eastern Colorado. Although much of the region is sparsely populated, human influences have altered much of the visual

landscape, especially with respect to land use and land cover. In some places, intensive human activities, such as mineral extraction and energy development, have seriously degraded visual qualities. Large, fast-growing cities such as Las Vegas and Phoenix also contain heavily altered landscapes, with urban sprawl and associated visual blight spreading into what were recently relatively intact landscapes. Nonetheless, the various scenic attractions of the six-state study area help attract millions of tourists to the region each year and contribute to making tourism a major component of some regional and local economies.

Because scenic resources in a given area are largely determined by geology, topography, climate, soil type, and vegetation, such resources are generally homogenous within an ecoregion (an area that has a general similarity in ecosystems and is characterized by the spatial pattern and composition of biotic and abiotic features, including vegetation, wildlife, geology, physiography, climate, soils, land use, and hydrology [EPA 2007a]). Ecoregions of the United States as mapped and described by the EPA are presented in Appendix I of this PEIS as the basis for describing visual resources at a general level. The Level III ecoregion classification includes 22 ecoregions covering the six-state study area (Figure I.1, Appendix I). The ecoregion descriptions presented in Appendix I were primarily derived from EPA (2002), except where noted. Table 4.12-1 summarizes, by state, selected scenic resources (e.g., national parks, monuments, wilderness areas, historic trails, scenic highways) occurring within the six-state study area. Additional resource areas that may have important scenic qualities or sensitivities exist, such as ACECs designated for outstanding scenic values, Natural Heritage Areas, state and local parks, and others.

4.13 ACOUSTIC ENVIRONMENT

This section provides general descriptions of noise and vibration and the existing acoustic environment in the six-state study area. Potential impacts of noise and vibration on wildlife are discussed in Section 5.10.2.

4.13.1 Noise

Any pressure variation that the human ear can detect is considered sound; noise is unwanted sound. Sound is described in terms of amplitude (perceived as loudness) and frequency (perceived as pitch). Sound pressure levels are typically measured with the logarithmic decibel (dB) scale. To account for human sensitivity to frequencies of sound (i.e., less sensitivity to lower and higher frequencies, and most sensitivity to sounds between 1 and 5 kHz), A-weighting (denoted by dBA) is widely used and is correlated with a human's subjective reaction to sound (Acoustical Society of America 1983, 1985). To account for variations of sound with time, the equivalent continuous sound level (L_{eq}) is used. L_{eq} is the continuous sound level during a specific time period that would contain the same total energy as the actual time-varying sound. For example, L_{eq} (1-h) is the 1-hour equivalent continuous sound level. In addition, human responses to noise differ depending on the time of the day; humans experience more annoyance from noise during nighttime hours. The day-night average sound level (L_{dn} or DNL) is the average noise level over a 24-hour period, after the addition of 10 dB to sound levels from

TABLE 4.12-1 Summary of Selected Potentially Sensitive Visual Resource Areas within the Six-State Study Area[a]

Potentially Sensitive Visual Resource Areas	Arizona	California	Colorado	Nevada	New Mexico	Utah
National Parks[b]	3	8	4	2	2	5
National Monuments[c]	19	10	6	0	11	7
Wilderness Areas	87	130	38	70	25	32
Wilderness Study Areas	8	80	48	57	67	99
National Recreation Areas[d]	2	5	2	2	1	2
National Conservation Areas[e]	3	3	2	3	1	1
Other National Park Service Areas[f]	4	9	3	1	2	1
National Natural Landmarks	9	32	11	6	12	4
National Historic Landmarks	9	63	4	2	11	4
National Scenic Trails	0	1	1	0	1	0
National Historic Trails	2	4	3	3	2	4
National Scenic Highways[g]	5	7	10	3	8	7
National Scenic Areas	0	1	0	0	0	0
National Scenic Research Areas	0	0	0	0	0	1
National Wild and Scenic Rivers[h]	1	14	2	0	4	0
National Wildlife Refuges	9	35	7	8	7	4
State Totals	66	192	55	30	62	40

[a] Includes features wholly or partly within state boundaries.

[b] Does not include national historical parks.

[c] Includes national monuments managed by the NPS, USFS, BLM, and USFWS.

[d] Includes national recreation areas managed by the NPS and USFS.

[e] Includes Headwaters Forest Reserve.

[f] Includes national historical parks, national preserves, national reserves, national seashores, national historic sites, national battlefields, national memorials, national memorial parkways, and the San Francisco Presidio.

[g] Includes all-American roads and national scenic byways.

[h] The congressionally authorized wild and scenic study rivers are not included. See Section 4.9.1.2 for details on this classification.

10 p.m. to 7 a.m. to account for the greater sensitivity of most people to nighttime noise. The Community Noise Equivalent Level (CNEL) was introduced in the early 1970s by the State of California and gives 5-dB weighting to evening hours (7 to 10 pm), whereas L_{dn} has no weighting. As a practical matter, the CNEL and L_{dn} are almost equivalent, usually differing by less than 1 dB, and thus they can be used interchangeably.

People's responses to changes in sound levels generally exhibit the following characteristics (NWCC 2002). Except under laboratory conditions, a 1-dB change in sound level is not perceptible. Generally, a 3-dB change is considered a just-noticeable difference, and a

10-dB increase is subjectively perceived as a doubling in loudness and almost always causes an adverse community response.

Several important factors affect the propagation of sound in the outdoor environment (Anderson and Kurze 1992):

- *Source characteristics,* such as sound power, directivity, and configuration;
- *Geometric spreading* as the sound moves away from the source, which does not depend on frequency, and 6- and 3-dB reductions per doubling of distance for point (e.g., fixed equipment) and line (e.g., road traffic) sources, respectively;
- *Atmospheric absorption,* which depends strongly on frequency and relative humidity, somewhat on temperature, and slightly on pressure;
- *Ground effects,* which result from interferences of reflected sound by reflecting surfaces (e.g., ground surfaces) with direct sound;
- *Meteorological effects* due to turbulence and variations in vertical wind speed and temperature; and
- *Screening effects* by topography, structures, dense vegetation, and other natural or man-made barriers.

Among the factors listed above, meteorological effects due to vertical wind speed and temperature profiles are likely the most important in noise propagation over longer distances (say, beyond several hundred meters from the noise sources). Because of surface friction, wind speed typically increases with height, which will bend the path of sound downward to "focus" it on the downwind side and upward to make a "shadow"[11] on the upwind side of the source ("wind gradient effect"). Also, on a typical clear, sunny day, temperature tends to decrease with height due to solar heating on the ground, the condition known as "temperature lapse." Similar to the wind gradient effect, upward refraction of sound creates a "temperature gradient effect" shadow zone. Conversely, on a clear night with calm or low winds, temperature increases with height due to radiative cooling of surface air. This nocturnal temperature inversion is the strongest in winter months due to a longer nighttime period. Temperature inversions can cause downward refraction to create enhanced sound fields near a noise source, particularly because there would be little, if any, shadow zone within 1 or 2 mi (1.6 or 3.2 km) of the source in the presence of a strong temperature inversion (Beranek 1988). Temperature gradient effects are exerted omnidirectionally from the source, in contrast to wind gradient effects, which are limited to mostly upwind and downwind areas.

A refined noise analysis would employ a sound propagation model that integrates most of the sound attenuation mechanisms noted above along with detailed source-, receptor-, and

[11] A shadow zone is defined as the region where direct sound does not penetrate because of upward diffraction.

site-specific data, such as land use and topography. However, in many screening applications, only geometric spreading or geometric spreading combined with ground effects is considered when predicting noise levels. This method assumes a simplified uniform (isothermal) atmosphere with no wind, which is unusual for typically changing atmospheric conditions. For a temperature lapse condition typical of daytime, sound levels would be about 5 dB lower than those for the uniform condition (Saurenman et al. 2005). For a temperature inversion condition typical of nighttime, sound levels would be about 5 to 10 dB higher than those for the uniform condition. Just before sunrise, when the temperature inversion is the strongest, sound levels would be about 10 to 15 dB higher (but noise-producing operations at solar facilities are not anticipated to occur at this time of day).

The Noise Control Act of 1972, along with its subsequent amendments (Quiet Communities Act of 1978, USC 42 4901–4918), delegates to the states the authority to regulate environmental noise and directs government agencies to comply with local community noise statutes and regulations.

Many local noise ordinances are qualitative, such as prohibiting excessive noise or noise that results in a public nuisance. Because of the subjective nature of such ordinances, they are often difficult to enforce. However, several states and counties have established quantitative noise-level regulations, which typically specify environmental noise limits based on the land use of the property receiving the noise. Table 4.13-1 lists the maximum permissible noise levels for Colorado by land use zone and by time of day. In California, noise is regulated at the state and local level. The state requires each municipality and county to have a Noise Element of the General Plan, a substantial noise database and blueprint for making land use decisions in that jurisdiction (CGOPR 2003). State land use compatibility criteria for the community noise environment presented in terms of L_{dn} or CNEL are used to identify the noise levels that are compatible with various types of land uses. The Noise Element of the General Plan contains goals and policies to support land use planning that will allow the jurisdiction to ensure that these criteria are met for various land uses.

TABLE 4.13-1 Colorado Limits on Maximum Permissible Noise Levels

	Maximum Permissible Noise Level (dBA)[a]	
Zone	7 am to 7 pm[b]	7 pm to 7 am
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 5 dBA less than those tabulated.

[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 Revised Statutes, Title 25 "Health: Environmental Control," Article 12 "Noise Abatement."

The EPA has a noise guideline that recommends an L_{dn} of 55 dBA, which is sufficient to protect the public from the effect of broadband environmental noise in typical outdoor and residential areas (EPA 1974). These levels are not regulatory goals but are "intentionally conservative to protect the most sensitive portion of the American population" with "an additional margin

of safety." For protection against hearing loss in the general population from nonimpulsive noise, the EPA guideline recommends an L_{eq} of 70 dBA or less over a 40-year period.

Noise levels continuously vary with location and time. In general, noise levels are high around major transportation corridors (highways and railways), airports, industrial facilities, and construction activities. Countywide day-night sound levels (L_{dn} or DNL) were estimated based on population density (Miller 2002) and are presented in Figure 4.13-1. About 57% and 29% of counties in the six-state study area are less than 35 and 35 to 45 dBA, which corresponds to wilderness natural background and rural areas, respectively (Cavanaugh and Tocci 1998). As might be expected, higher sound levels occur in the counties with significant urban/suburban populations, such as Denver, Los Angeles, Salt Lake City, and San Francisco.

4.13.2 Vibration

Construction activities can result in varying degrees of ground vibration, depending on the equipment and methods employed. Construction activities that typically generate the most severe vibrations are blasting and impact pile-driving.

Three ground-borne vibration impacts are of general concern: (1) human annoyance, (2) interference with vibration-sensitive activities, and (3) damage to buildings. In evaluating ground-borne vibration, two descriptors are widely used:

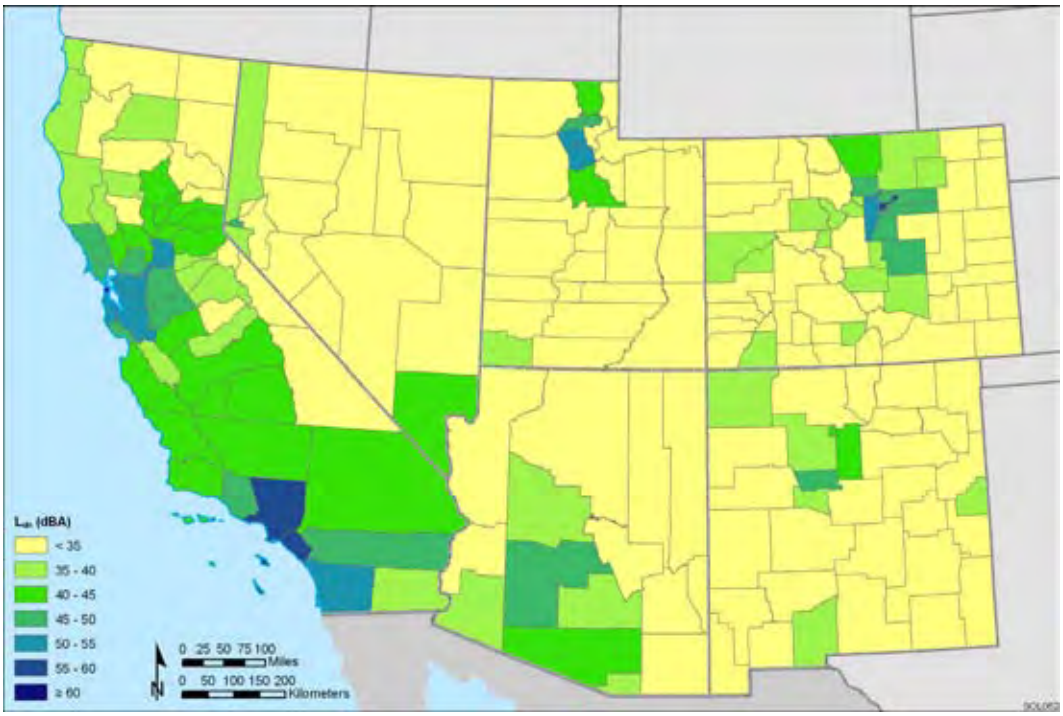

FIGURE 4.13-1 Day-Night Average Sound Level (L_{dn}) by County, Estimated on the Basis of Population Density (L_{dn} data based on the formula in Miller 2002)

- The peak particle velocity (PPV), measured as a distance per time (such as in./s), is the maximum peak velocity of the vibration and correlates with the stresses experienced by buildings.

- The vibration velocity level (L_V) represents a one-second average amplitude of the vibration velocity. It is typically expressed on a log scale in decibels (VdB) just as noise is measured in dB. This descriptor is suitable for evaluating human annoyance because the human body responds to average vibration amplitude.

In the United States, there are no widely adopted standards for acceptable levels of ground vibration generated by construction activities, although some jurisdictions elect to adopt vibration standards.

A background vibration velocity level in residential areas is usually 50 VdB or lower, well below the threshold of perception for humans, which is around 65 VdB (Hanson et al. 2006). However, vibration levels would typically be higher in the immediate vicinity of transportation corridors or construction/demolition sites. Human response is not usually significant unless the vibration exceeds 70 VdB. For evaluating interference with vibration-sensitive activities, the vibration impact criterion for general assessment is 65 VdB. For residential and institutional land use (primarily daytime use only, such as a school or church), the criteria range from 72 to 80 VdB and from 75 to 83 VdB, respective, depending on event frequency. For potential structural damage effects, guideline vibration damage criteria for various structural categories are provided in Hanson et al. (2006). Damage to buildings, however, would occur at much higher levels (0.12 in./s or higher, or about 90 VdB or higher) than human annoyance and interference with vibration-sensitive activities.

4.14 PALEONTOLOGICAL RESOURCES

Paleontological resources are fossilized remains, imprints, and traces of plants and animals preserved in rocks and sediments. Greater attention is often given to vertebrate fossils than to invertebrate and plant fossils because of their rarity; however, some plant and invertebrate fossils are also rare. The rarity of such specimens and fossil assemblages and the unique information that can be gleaned from these items emphasize their scientific value and the need to protect them. The area considered in this PEIS is extensive, including lands in six western states; therefore, there is a potential for paleontological resources (either individual specimens or larger assemblages of multiple fossils) to be present in sedimentary formations within these areas.

Various statutes, regulations, and policies govern the management of paleontological resources on public lands. Recently Congress passed a paleontology law, entitled *Paleontological Resources Preservation under the Omnibus Public Lands Act of 2009*. The law establishes three main points: (1) paleontological resources collected under a permit are U.S. property and must be available for scientific research and public education and preserved in an approved facility; (2) the nature and location of paleontological resources on public lands

must be kept confidential to protect those resources from theft and vandalism; and (3) theft and vandalism of paleontological resources on public lands can result in civil and criminal penalties, including fines and/or imprisonment. 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 FLPMA (P.L. 94–579, codified at 43 USC 1701–1782) and Theft and Destruction of Government Property (18 USC 641), which penalizes the theft or degradation of property of the U.S. government. 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 470(aa) et seq.)—protect fossils found in significant caves and/or in association with archeological resources.

The large number of productive fossil-bearing geological landforms 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 2007b) and for assessing potential impacts on paleontological resources (IM 2009-011) (BLM 2008c).[12] The PFYC system is described more fully below. The goal of the BLM program is to locate, evaluate, manage, and protect paleontological resources on public lands. Areas of critical environmental concern (ACECs) have been designated on BLM-administered lands containing exceptional paleontological resources, among other important resource values, such as scenic, ecological, and cultural resources (see Section 4.3). Those ACECs that are located near BLM-administered lands considered suitable for solar energy development and that have been designated specifically to protect paleontological resources are presented in Table 4.14-1.

Occurrences of paleontological resources are closely related to the geological units that contain them. Therefore, the potential for finding important paleontological resources can be predicted by the presence of the relevant geological units. The BLM recently adopted the PFYC system to provide baseline guidance for assessing the relative occurrence of important paleontological resources and the need for mitigation (BLM 2007b). Specifically, the system is used to classify geologic units at the formation or member level according to the probability of yielding paleontological resources of concern to land managers. Under the PFYC system, geologic units are classified from Class 1 to Class 5 on the basis of the relative abundance of

[12] 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.

TABLE 4.14-1 ACECs Designated for Protection of Paleontological Resource Values That Are near BLM-Administered Lands Suitable for Solar Energy Development

ACEC	State	BLM Field Office	ACEC Values	Distance from Nearest Solar-Suitable Area
Carrow Stephens Ranches	Arizona	Kingman	Historic sites and paleontological resources	Adjacent
Bear Springs Badlands	Arizona	Safford	Paleontological resources; scenic	Adjacent
111 Ranch RNA	Arizona	Safford	Paleontological	Adjacent
Manix	California	Barstow	Paleontological and cultural	Adjacent
Mountain Pass Dinosaur Trackway	California	Barstow	Historic and paleontological values	Adjacent
Rainbow Basin/Owl Canyon	California	Barstow	Outstanding scenery; unique geology and paleontology; prehistoric archaeology	6 mi (10 km)
Marble Mountain Fossil Bed	California	Needles	Paleontological	Adjacent
Mountain Pass Dinosaur Trackway	California	Needles	Paleontological	Adjacent
Garden Park	Colorado	Royal Gorge	Paleontological; historical	7.5 mi (12 km)
Stewart Valley	Nevada[a]	Carson City	Paleontological	Adjacent
Arrow Canyon	Nevada[a]	Las Vegas	Paleontological; geological; cultural	Adjacent
Alamo Hueco Mountains	New Mexico	Las Cruces	Biological; scenic; cultural; paleontological; special status species	0.2 mi (0.3 km)
Robledo Mountains	New Mexico	Las Cruces	Paleontological, cultural, and scenic values; endangered plant species	Adjacent
Ball Ranch	New Mexico	Rio Puerco	Special status plant habitat; paleontological	Adjacent
Ojito	New Mexico	Rio Puerco	Geological; paleontological; cultural; wildlife; rare plant habitat; geologic hazard	Adjacent
Pronoun Cave	New Mexico	Rio Puerco	Paleontological; cultural	Adjacent
Torreon Fossil Fauna East	New Mexico	Rio Puerco	Paleontological; natural system	Adjacent
Torreon Fossil Fauna West	New Mexico	Rio Puerco	Paleontological; natural system	Adjacent
Fossil Mountain	Utah	Fillmore	Prehistoric life form	1 mi (1.6 km)

[a] No data available for Battle Mountain, Ely, or Winnemucca District Offices.

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 (see text box).

Significant paleontological resources on public lands in the western United States are predominantly associated with geologic units (formations) from the Mesozoic and Cenozoic Eras (Table 4.14-2). Fossiliferous formations of the Mesozoic Era, particularly of the Jurassic and Cretaceous Periods (206 to 65 million years ago), are found in the Rocky Mountains and along canyons of the Colorado Plateau. The geologic units are of marine and nonmarine origin, representing alternating episodes of marine transgression and regression. They yield important vertebrate fossils, including fish, frogs, salamanders, turtles, crocodiles, pterosaurs, mammals, birds, and dinosaurs, and generally have a high PFYC ranking, which indicates a higher fossil yield potential and greater sensitivity to adverse impacts. Invertebrate fossils (e.g., ammonites) are more abundant.

Fossiliferous formations of the Cenozoic era, particularly from the Tertiary Period (65 to 1.8 million years ago), are found in the many sedimentary basins across the West. These formations contain important vertebrate fossils, including mammals, birds, reptiles, amphibians, and fish. Plants and invertebrates may also be important at some localities.

Although numerous localized paleontological resource projects have been completed, to date no comprehensive inventory of fossils and no systematic inventory of fossil-bearing areas on BLM-administered lands have been conducted. However, work is ongoing to prepare state-level PFYC maps. BLM paleontologists have completed PFYC mapping in Colorado, Utah, and New Mexico and will continue to refine those maps as more information is collected. The states of Arizona, California, and Nevada do not have completed PFYC maps at this time, although work has recently started in Nevada to complete this task. Most assessments and inventories of paleontological resources on public lands are conducted on a project-by-project basis. Some BLM field offices, along with various museums, geologic surveys, and other partners, maintain records of the paleontological finds made on the lands that they manage. Often this information is held by the primary state repository for fossil finds in that area. Site-specific information regarding paleontological resources would need to be collected to define the affected environment for an individual project.

4.15 CULTURAL RESOURCES

Cultural resources include archaeological sites and historic structures and features that are addressed under the National Historic Preservation Act (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 eligibility criteria for listing in the *National*

Potential Fossil Yield Classification

Class 1: Geologic units that are not likely to contain recognizable fossil remains. This includes units that are igneous or metamorphic in origin (but excludes reworked volcanic ash units), as well as units that are Precambrian in age or older. Management concern for paleontological resources in Class 1 units is negligible or not applicable. No assessment or mitigation is needed except in very rare or isolated circumstances. The occurrence of significant fossils in Class 1 units is nonexistent or extremely rare. The probability for impacting any fossils is negligible, and assessment or mitigation of paleontological resources is usually unnecessary.

Class 2: Sedimentary geologic units that are not likely to contain vertebrate fossils or scientifically significant nonvertebrate fossils. This includes units in which vertebrate or significant invertebrate or plant fossils are not present or are very rare, units that are younger than 10,000 years before present, units that are of recent aeolian deposits, and sediments that exhibit significant diagenetic alteration (i.e., physical and chemical changes). The potential for impacting vertebrate fossils or uncommon invertebrate or plant fossils is low. Management concern for paleontological resources is low, and the assessment or mitigation of paleontological resources is not likely to be necessary. Localities containing important resources may exist but would be rare and would not influence the classification. These important localities would be managed on a case-by-case basis.

Class 3: Fossiliferous sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence (Class 3a – Moderate Potential), or sedimentary units of unknown fossil potential (Class 3b – Unknown Potential). These units are often marine in origin with sporadic known occurrences of vertebrate fossils. Vertebrate fossils and scientifically significant invertebrate or plant fossils are known to occur inconsistently or intermittently, and predictability is known to be low. Class 3 includes units that are poorly studied and/or poorly documented, so that the potential yield cannot be assigned without ground reconnaissance. Management concern for paleontological resources in these units is moderate or cannot be determined from existing data. Management considerations cover a broad range of options that could include predisturbance surveys, monitoring, or avoidance. Surface-disturbing activities may require field assessment to determine a further course of action.

Class 4: Class 4 units are geologic units with a high occurrence of significant fossils that may vary in occurrence or predictability or have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation than Class 5 units. They include bedrock units with little or no soil or vegetative cover that are larger than 2 acres (0.008 km^2); bedrock units with extensive soil or vegetative cover; bedrock exposures that are limited or not expected to be impacted; units with areas of exposed outcrop that are smaller than two contiguous acres; units in which outcrops form cliffs of sufficient height and slope so that impacts are minimized by topographic effects; and units where other characteristics are present that lower the vulnerability of both known and unidentified fossil localities. Management concern for paleontological resources in Class 4 is moderate to high, depending on the proposed action, and mitigation considerations must include an assessment of the disturbance. A field survey by a qualified paleontologist is often needed to assess local conditions, and on-site monitoring or spot-checking may be necessary during construction activities. Management prescriptions for resource preservation and conservation through controlled access or special management designation should be considered.

Class 5: Highly fossiliferous geologic units that regularly and predictably produce vertebrate fossils or scientifically significant invertebrate or plant fossils and that are at risk of human-caused adverse impacts or natural degradation. These include units in which vertebrate fossils or uncommon invertebrate or plant fossils are known and documented to occur consistently, predictably, or abundantly. Class 5 pertains to highly sensitive units that are well exposed with little or no soil or vegetative cover, units in which outcrop areas are extensive, and exposed bedrock areas that are larger than two contiguous acres. Management concern for paleontological resources in Class 5 is high to very high. A field survey by a qualified paleontologist is usually necessary prior to surface-disturbing activities or land tenure adjustments. Mitigation will often be necessary before and/or during these actions. On-site monitoring may be necessary during construction activities. Official designation of areas of avoidance, special interest, and concern may be appropriate.

(Source: BLM 2007b, Attachment 1)

TABLE 4.14-2 Age of Geologic Units and Potential Fossil Yield

Era	Period (Ma)[a]	Epoch (Ma)[a]	Distinctive Fossils[b]	Examples of Geologic Units in the Study Area (PFYC Class[c])
Cenozoic	Quaternary (0–1.8)	Holocene (0–0.01)		Alluvium and colluvium (3) Dune sand (3) Eolian deposits (loess) (3) Lacustrine and playa deposits (3) Mud and salt flats (3) Terrace and flood gravels (3)
		Pleistocene (0.01–1.8)	Mammoths Bison and cows Horses Deer Squirrels and rabbits Invertebrates	Alluvium and colluvium (3) Dune sand (3) Eolian deposits (loess) (3) Glaciofluvial deposits (3) Lacustrine and playa deposits (3) Mud and salt flats (3) Terrace and flood gravels (3)
	Tertiary (1.8–65.0)	Pliocene (1.8–5.3)	Mammals Birds (eggs) Warm climate plankton (marine) Invertebrates	Ogallala Formation (4/5) CO, NM
		Miocene (5.3–23.8)	Mammals (rodents) Birds (eggs) Invertebrates	Browns Park Formation (4/5) UT Dry Union Formation (4/5) CO Muddy Creek Formation (3) AZ, CA, UT, NV Ogallala Formation (4/5) CO/NM Wagontongue Formation (4/5) CO
		Oligocene (23.8–33.7)	Mammals (early horses, primates, marsupials, carnivores) Crocodilians, alligators Lizards and turtles Amphibians and fish Invertebrates Birds (eggs) Plants and pollen	Bishop Conglomerate (3) CO Duchesne River Formation (4/5) CO, UT

TABLE 4.14-2 (Cont.)

Era	Period (Ma)[a]	Epoch (Ma)[a]	Distinctive Fossils[b]	Examples of Geologic Units in the Study Area (PFYC Class[c])
Cenozoic *(Cont.)*	Tertiary (1.8–65.0) *(Cont.)*	Eocene (33.7–54.8)	Mammals (early horses, primates, marsupials, carnivores, grazers) Crocodilians, alligators Lizards and turtles Amphibians and fish Invertebrates Birds (eggs) Plants and pollen	Bridger Formation (4/5) CO, UT Duchesne River Formation (4/5) CO, UT Green River Formation (4/5) CO, UT Uinta Formation (4/5) CO, UT Wasatch Formation (4/5) CO, UT
		Paleocene (54.8–65.0)	Small mammals Reptiles Amphibians and fish Birds (eggs) Insects Plants and pollen	Currant Creek Formation (4/5) UT Fort Union Formation (3) CO Nacimiento Formation (4/5) NM Ojo Alamo Formation (4/5) NM Wasatch Formation (4/5) CO, UT
Mesozoic	Cretaceous (65.0–144)		Terrestrial flora and fauna: – Dinosaurs – Birds – Early mammals – Diverse insects – Flowering plants – Freshwater fish and invertebrates Marine flora and fauna: – Plankton and diatoms – Cephalopods (ammonites, belemnites) – Marine reptiles – Fish – Sharks and rays	Burro Canyon Formation (4/5) AZ, CO, UT, NM Castlegate Formation (2) CO, UT Cliff House Sandstone (4/5) CO, NM Lewis Shale (4/5) CO, NM, UT Mowry Shale (3) CO, UT Niobrara Formation (4/5) CO Various volcanic units (1)

TABLE 4.14-2 (Cont.)

Era	Period (Ma)[a]	Epoch (Ma)[a]	Distinctive Fossils[b]	Examples of Geologic Units in the Study Area (PFYC Class[c])
Mesozoic (Cont.)	Jurassic (144–206)		Terrestrial flora and fauna: – Dinosaurs – Early mammals – Seed plants – Ferns Marine flora and fauna: – Plankton – Cephalopods (ammonites) – Marine reptiles – Fish – Sharks and rays	Kayenta Formation (4/5) AZ, CO, NV, UT Moenave Formation (4/5) AZ, NV, UT Morrison Formation (4/5) AZ, CO, NM, UT Navajo Sandstone (4/5) AZ, CO, NV, UT Summerville Formation (4/5) AZ, CO, NM, UT
	Triassic (206–248)		Terrestrial flora and fauna: – Dinosaurs – Early mammals – Seed plants – Conifers	Chinle Formation (4/5) AZ, CO, NV, NM, UT Chugwater Formation (3) CO Moenkopi Formation (3) AZ, CA, CO, NV, NM, UT Thaynes Limestone (2) UT Wingate Formation (4/5) AZ, CO, NM, UT
Paleozoic	Permian (248–290)		Terrestrial flora and fauna dominate: – Anapsids (turtles) – Diapsids – Archosaurs – Gymnosperms (conifers)	Coconino Sandstone (3) AZ, CA, NV, UT Kaibab Formation (2) AZ, CA, NV, UT San Andres Formation (4/5) NM Satanka Shale (2) CO Toroweap Formation (3) AZ, NV, UT

TABLE 4.14-2 (Cont.)

Era	Period (Ma)[a]	Epoch (Ma)[a]	Distinctive Fossils[b]	Examples of Geologic Units in the Study Area (PFYC Class[c])
Paleozoic (*Cont.*)	Carboniferous (*Cont.*)	Pennsylvanian (290–323)	Terrestrial flora and fauna dominate: – Freshwater clams – Seedless plants – Ferns – Winged insects (dragonflies) – Amniote species (lizards) – Diapsids (reptiles, snakes) – Archosaurs (crocodiles, dinosaurs, birds)	Belden Formation (2) CO Hermit Shale (2) AZ, CA, NV, UT Minturn Formation (2) CO Morgan Formation (2) CO, UT Oquirrh Formation (2) UT
		Mississippian (323–354)	Marine invertebrates (e.g., bryozoans and braciopods) dominate: – Foraminifera – Modern fish fauna	Brazer Formation (2) UT Deseret Limestone (2) UT Humbug Formation (2) CO, UT Madison Formation (3) CO, UT Redwall Limestone (2) AZ, CA, NM, UT
	Devonian (354–417)		Terrestrial plants (ferns, seed plants, trees) Terrestrial insects and spiders Diverse freshwater fish Marine vertebrates and invertebrates (see below)	Jefferson Limestone (2) UT, CO, NM Madison Formation (3) CO, UT Temple Butte Formation (2) AZ
	Silurian (417–443)		Coral reefs Marine invertebrates (see below) Marine fish Freshwater fish Terrestrial plants	

TABLE 4.14-2 (Cont.)

Era	Period (Ma)[a]	Epoch (Ma)[a]	Distinctive Fossils[b]	Examples of Geologic Units in the Study Area (PFYC Class[c])
Paleozoic (*Cont.*)	Ordovician (443–490)		Marine invertebrates: – Red and green algae – Bryozoans – Crinoids, blastoids – Corals – Graptolites – Trilobites – Brachiopods, snails, clams – Cephalopods – Archaeocyathids (sponges) Marine vertebrates: – Ostraderms (jawless, armored fish) Conodonts (early vertebrates) Terrestrial plants	Fishhaven Dolomite (2) UT Garden City Limestone (2) UT
	Cambrian (490–543)		Marine invertebrates: – Red and green algae – Trilobites – Brachiopods – Echinoderms – Archaeocyathids (sponges)	Bright Angel Shale (2) AZ, CA, NV, UT Tapeats Sandstone (2) AZ, CA, NV, UT
	Proterozoic (543–2,500)		Soft bodied fauna Carbon film Microbial mats (stromatolites)	Various igneous and metamorphic units (1)
	Archean (2,500–3,800?)		None	Various igneous and metamorphic units (1)

[a] Ma = millions of years before the present.

[b] Distinctive fossils are those characteristic of the geologic period listed and may or may not be present in the geologic units (formations) in the study area.

[c] The PFYC system ranks the highest potential fossil-yielding formations as Class 4 or Class 5, but assigns the lower rank (Class 4) to those formations for which potential impacts are reduced by the presence of a protective layer of soil or other mitigating circumstance. For this assessment, formations with the highest potential fossil yield were assigned to Class 4/5 since the presence of mitigating circumstances is unknown.

Sources: Adapted from Palmer and Geissman (1999); University of California Museum of Paleontology (2007).

Register of Historic Places (NRHP) are formally referred to as historic properties (see text box). Federal agencies must take into consideration the effects on historic properties of any undertakings under their direct or indirect jurisdiction before they approve expenditures or issue permits, ROWs, or other land use authorizations.

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.

Federal agencies are also required to consider the effects of their actions on sites, areas, and other resources (e.g., plants) that are of religious significance to Native Americans[13] as established under the American Indian Religious Freedom Act (P.L. 95-341). Archaeological sites on public lands and Indian lands are protected by the Archaeological Resources Protection Act of 1979, as amended (P.L. 96–95), and Native American graves and burial grounds are protected by the Native American Graves Protection and Repatriation Act of 1990 (P.L. 101-601). Cultural resources on federal lands are protected by laws penalizing the theft or degradation of property of the U.S. government (Theft of Government Property [62 Stat. 764, 18 USC 1361] and FLPMA). A list of these and other regulatory requirements pertaining to cultural properties is presented in Table 4.15-1. These laws are applicable to any project undertaken on federal land or requiring federal permitting or funding.

Cultural resources on BLM-administered land are managed primarily through the application of the laws identified in Table 4.15-1. As required by Section 106 of the NHPA, BLM offices work with land use applicants and interested consulting parties 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 Table 4.15-2).

The goal of the program is to locate, evaluate, manage, and protect cultural resources on public lands. To achieve this goal, some significant cultural resources have been identified as ACECs (see Section 4.3). Those ACECs that are located near BLM-administered lands considered suitable for solar energy development and have been designated specifically to protect cultural resources are presented in Table 4.15-3. 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

[13] These acts refer specifically to Native Americans, Native Alaskans, and Native Hawaiians.

TABLE 4.15-1 Cultural Resource Laws and Regulations

Law or Order Name	Intent
Antiquities Act of 1906	This law makes it illegal to remove cultural resources from federal land without permission and establishes a permitting process for conducting archaeological fieldwork on federal land. It also allows the President to establish historical monuments and landmarks.
Bald and Golden Eagle Protection Act of 1940, as amended	Section 668a of this act allows the Secretary of the Interior to permit the taking, possession, and transportation of bald eagle or golden eagle specimens for the religious purposes of Indian tribes, as well as other scientific or exhibition purposes. Otherwise the act prohibits the take, possession, sale, purchase, or transportation of any bald eagle or golden eagle (alive or dead), or any part, nest, or egg thereof.
National Historic Preservation Act of 1966, as amended (NHPA)	The NHPA creates the framework within which cultural resources are managed in the United States. The law requires that each state appoint a State Historic Preservation Officer (SHPO) to direct and conduct a comprehensive statewide survey of historic properties and maintain an inventory of such properties, and it created the Advisory Council on Historic Preservation, which provides national oversight and dispute resolution. Section 106 of the NHPA defines the process for identifying and evaluating cultural resources and determining whether a project will result in an adverse effect on the resource. It also addresses the appropriate process for resolving (mitigating) adverse effects to historic properties. Section 110 of the NHPA directs the heads of all federal agencies to assume responsibility for the preservation of listed or eligible historic properties owned or controlled by their agency. Federal agencies are directed to locate, inventory, and nominate properties to the NRHP, to exercise caution to protect such properties, and to use such properties to the maximum extent feasible. Additional provisions of Section 110 include documentation of properties adversely affected by federal undertakings, the establishment of trained federal preservation officers in each agency, and the inclusion of the costs of preservation activities as eligible agency project costs. The NHPA also establishes the processes for consultation among interested parties, the lead agency, and the SHPO, and for government-to-government consultation between U.S. government agencies and Native American Tribal governments.
Executive Order (E.O.) 11593, *Protection and Enhancement of the Cultural Environment (Federal Register* 36:8921, May 13, 1971)	E.O. 11593 requires federal agencies to inventory their cultural resources and to record, to professional standards, any cultural resource that may be altered or destroyed.

TABLE 4.15-1 (Cont.)

Law or Order Name	Intent
Archaeological and Historic Preservation Act of 1974 (AHPA)	The AHPA directly addresses impacts on cultural resources resulting from federal activities that would significantly alter the landscape. The focus of the law is data recovery and salvage of scientific, prehistoric, historic, and archaeological resources that could be damaged during the creation of dams and the impacts resulting from flooding, worker housing, creation of access roads, etc.; however, its requirements are applicable to any federal action.
Federal Land and Policy Management Act of 1976 (FLPMA)	The FLPMA requires the BLM to manage its lands for multiple use and sustained yield in a manner that will protect the quality of its environmental values, such as cultural resources.
American Indian Religious Freedom Act of 1978 (AIRFA)	The AIRFA protects the right of Native Americans to have access to their sacred places. It requires consultation with Native American organizations if an agency action will affect a sacred site on federal lands.
Archaeological Resources Protection Act of 1979, as amended (ARPA)	The ARPA establishes civil and criminal penalties for the destruction or alteration of cultural resources and establishes professional standards for excavation.
Native American Graves Protection and Repatriation Act of 1990 (NAGPRA)	The NAGPRA requires federal agencies to consult with the appropriate Native American Tribes prior to the intentional excavation of human remains and funerary objects. It requires the repatriation of human remains found on the agencies' land.
E.O. 13006, *Locating Federal Facilities on Historic Properties in our Nation's Central Cities* (*Federal Register* 61:26071, May 21, 1996)	E.O. 13006 encourages the reuse of historic downtown areas by federal agencies.
E.O. 13007, *Indian Sacred Sites (Federal Register* 61:26771, May 24, 1996*)*	E.O. 13007 requires that an agency allow Native Americans to worship at sacred sites located on federal property.
E.O. 13175, *Consultation and Coordination with Indian Tribal Governments* (*Federal Register* 65:67249, Nov. 9, 2000)	E.O. 13175 requires federal agencies to ensure meaningful and timely input by tribal officials in the development of federal policies that have tribal implications.
E.O. 13287, *Preserve America* (*Federal Register* 68:10635, March 5, 2003)	E.O. 13287 encourages the promotion and improvement of historic structures and properties to encourage tourism.

TABLE 4.15-2 BLM Guidance Regarding Cultural Resource Management

BLM 8100 Series Manuals and Handbooks
8100 Manual: *The Foundations for Managing Cultural Resources*
8110 Manual: *Identifying and Evaluating Cultural Resources*
8120 Manual: *Tribal Consultation under Cultural Resource Authorities*
H-8120-1: *General Procedural Guidance for Native American Consultation*
8130 Manual: *Planning for Uses of Cultural Resources*
8140 Manual: *Protecting Cultural Resources*
8150 Manual: *Permitting Uses of Cultural Resources*
8170 Manual: *Interpreting Cultural Resources for the Public*

guidance on the application of cultural resource laws and regulations is provided through the 1997 BLM National Programmatic Agreement (PA) developed among the BLM, the National Council of State Historic Preservation Officers (SHPOs), and the Advisory Council on Historic Preservation, and implemented through state-specific protocols with each SHPO for the management of cultural resources programs and the review of projects pursuant to Section 106 of the NHPA. A National PA for addressing solar energy development on BLM-administered lands is currently under development among the BLM, each represented state SHPO (Arizona, California, Colorado, Nevada, New Mexico, and Utah), and the Advisory Council on Historic Preservation (see Appendix K).

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 or eligible for listing in the NRHP in the broad six-state study area for this PEIS include, but are not limited to, archaeological sites and features, historic buildings, bridges, trails, prehistoric dwellings, historic districts, water features (e.g., canals and ditches), traditional cultural properties, and cultural landscapes.

Traditional cultural properties and other areas of concern to various cultural groups, including Native Americans, can include a wide range of tangible and intangible resources (e.g., archaeological sites, funerary objects, places of religious ceremony, medicinal plants, and sacred landscapes). Government-to-government consultation, in addition to Section 106 consultation, provides a means of identifying the affected environment for a particular site-specific project for Native American governments. The public scoping and comment processes are avenues for other distinct cultural groups to make their concerns known regarding traditional cultural properties. It is difficult, if not impossible, to place hard boundaries on locations of traditional significance. Where boundaries might be defined, members of the cultural group may not be willing to disclose such information for a variety of reasons. Cultural sensitivity to the need to protect important places is required. Types of valued traditional resources may include, but are not limited to, archaeological sites, burial sites, religious sites, traditional harvest areas, trails, certain prominent geological features that may have spiritual significance (i.e., sacred landscapes), and viewsheds of sacred locations (including all of the above).

TABLE 4.15-3 ACECs Designated for Protection of Cultural Resource Values That Are near BLM-Administered Lands Suitable for Solar Energy Development

ACEC	State	BLM Field Office	ACEC Values	Distance[a] from Nearest Solar-Suitable Area
Johnson Spring	Arizona	Arizona Strip	Cultural resources, Siler pincushion cactus, scenic	Adjacent
Kanab Creek	Arizona	Arizona Strip	Cultural resources, endangered bird species, riparian, scenic	Adjacent
Little Black Mountains	Arizona	Arizona Strip	Cultural resources	Adjacent
Lost Spring Mountain	Arizona	Arizona Strip	Cultural resources, Siler pincushion cactus	Adjacent
Marble Canyon	Arizona	Arizona Strip	Cultural resources, Brady pincushion cactus, raptors, scenic	Adjacent
Moonshine Ridge	Arizona	Arizona Strip	Cultural resources, Siler pincushion cactus, scenic	Adjacent
Virgin River Corridor	Arizona	Arizona Strip	Cultural resources, endangered fish, riparian, scenic	Adjacent (0.1 mi [0.2 km])
Black Butte	Arizona	Hassayampa	Cultural resources, raptor habitat, scenic	Adjacent
Harquahala	Arizona	Hassayampa	Cultural resources, biological resources	Adjacent
Tule Creek	Arizona	Hassayampa	Cultural resources, Sonoran Desert riparian environment	1 mi (1.6 km)
Beale Slough	Arizona	Lake Havasu	Cultural resources, riparian habitat	Adjacent
Bullhead Bajada	Arizona	Lake Havasu	Cultural resources, desert tortoise	Adjacent
Crossman Peak	Arizona	Lake Havasu	Cultural resources, Traditional cultural properties, scenic, big horn sheep	Adjacent
Swansea Historic District	Arizona	Lake Havasu	Cultural resources	Adjacent
Black Mountains Ecosystem Management	Arizona	Kingman	Bighorn sheep and wild burro habitat, federal candidate plant species habitat, outstanding scenic values, open space near major population centers, rare and outstanding cultural resources, high locatable mineral potential	Adjacent
Burro Creek	Arizona	Kingman	Outstanding riparian resources, rare and outstanding cultural resources, important threatened and endangered species	Adjacent
Carrow Stephens Ranches	Arizona	Kingman	Historic site and paleontological resources	Adjacent
Joshua Tree Forest-Grand Wash Cliffs	Arizona	Kingman	Unique vegetation, outstanding scenic values, rare cultural resources, peregrine falcon aerie	Adjacent
Wright-Cottonwood Creeks	Arizona	Kingman	Rare and outstanding cultural resources, outstanding potential riparian resources	Adjacent

TABLE 4.15-3 (Cont.)

ACEC	State	BLM Field Office	ACEC Values	Distance[a] from Nearest Solar-Suitable Area
San Pedro Riparian	Arizona	Phoenix/ Tucson	Riparian vegetation and wildlife, significant archaeological, historic and paleontological resources	Adjacent
White Canyon	Arizona	Phoenix/ Tucson	Outstanding scenic, wildlife and cultural resources	5 mi
Bowie Mountain Scenic	Arizona	Safford	Scenic backdrop to historic Fort Bowie	4 mi
Dos Cabezas Peaks	Arizona	Safford	Historic landmark, scenic	5 mi
Swamp Springs Hot Springs Watershed	Arizona	Safford	Riparian areas, threatened and endangered species, bighorn sheep, native fish, cultural resources	Adjacent
Big Marias	Arizona/ California	Yuma	Cultural resources, riparian habitat	Adjacent
Dripping Springs	Arizona	Yuma	Perennial spring, desert bighorn sheep, cultural resources	Adjacent
Sears Point (Gila River Cultural Area)	Arizona	Yuma	Cultural resources, historic and prehistoric trails, migratory birds, riparian habitat	Adjacent
Calico Early Man Site	California	Barstow	Prehistoric human occupation	2 mi
Clark Mountain	California	Barstow	Prehistoric and historic values; outstanding scenery; wildlife habitat	Adjacent
Cronese Basin	California	Barstow	Cultural resources; wildlife habitat	Adjacent
Dead Mountains	California	Barstow	Native American values	Adjacent
Manix	California	Barstow	Paleontological and Cultural	Adjacent
Mesquite Lake	California	Barstow	Prehistoric values	Adjacent
Mountain Pass Dinosaur Trackway	California	Barstow	Historic and paleontological values	Adjacent
Rainbow Basin/Owl Canyon	California	Barstow	Outstanding scenery; Unique geology and paleontology; Prehistoric archaeology	6 mi
Rodman Mountains Cultural Area	California	Barstow	Cultural	7 mi
Salt Creek Hills	California	Barstow	Wildlife; prehistoric and historic values	Adjacent
Bodie Bowl	California	Bishop	Historic resources; wildlife; mining deposits; livestock grazing	2 mi
Cerro Gordo	California	Bishop	Prehistoric and historic values; vegetation	5 mi
Travertine Springs	California	Bishop	Recreation use; cultural and Native American values; wildlife habitat; geologic features	3 mi
East Mesa	California	El Centro	Prehistoric values; wildlife habitat	Adjacent

TABLE 4.15-3 (Cont.)

ACEC	State	BLM Field Office	ACEC Values	Distance[a] from Nearest Solar-Suitable Area
Gold Basin/Rand Intaglios	California	El Centro	Prehistoric values	Adjacent
Indian Pass	California	El Centro	Prehistoric values	Adjacent
Lake Cahuilla A	California	El Centro	Prehistoric values	Adjacent
Lake Cahuilla B	California	El Centro	Prehistoric values	1 mi
Lake Cahuilla C	California	El Centro	Prehistoric values	Adjacent
Lake Cahuilla D	California	El Centro	Prehistoric values	Adjacent
Pilot Knob	California	El Centro	Prehistoric and Native American values	Adjacent
Plank Road	California	El Centro	Unique historic road	2 mi
San Sebastian Marsh/San Fellipe Creek	California	El Centro	Prehistoric; historic and Native American resources; riparian and wildlife values	1 mi
West Mesa	California	El Centro	Wildlife and cultural values	2 mi
Mesquite Hills/Crucero	California	Needles	Prehistoric values	Adjacent
Mopah Spring	California	Needles	Outstanding scenery; cultural resources	7 mi
Patton's Iron Mountain Division Camp	California	Needles	Historic military camp	Adjacent
Haloran Wash	California	Needles	Prehistoric values	2 mi
Whipple Mountains	California	Needles	Native American values	4 mi
Alligator Rock	California	Palm Springs/ South Coast	Archaeological resources	4 mi
Corn Springs	California	Palm Springs/ South Coast	Outstanding scenery; prehistoric/historic values; wildlife habitat; vegetation	5 mi
Mule Mountain	California	Palm Springs/ South Coast	Prehistoric values	Adjacent
Palen Dry Lake	California	Palm Springs/ South Coast	Prehistoric values	Adjacent
Cumbres & Toltec Railroad Corridor	Colorado	La Jara	Historic; scenic	Adjacent
Cucharas Canyon	Colorado	Royal Gorge	Scenic; cultural	2 mi
Garden Park	Colorado	Royal Gorge	Historic; paleontology	7.5 mi
Cane Man Hill	Nevada	Battle Mountain	Cultural	Adjacent[b]
Rhyolite	Nevada	Battle Mountain	Historic	Adjacent[b]

TABLE 4.15-3 (Cont.)

ACEC	State	BLM Field Office	ACEC Values	Distance[a] from Nearest Solar-Suitable Area
Tybo-McIntyre Charcoal Kilns	Nevada	Battle Mountain	Historic	3 mi[b]
Pah Rah High Basin Petroglyph	Nevada	Carson City	Cultural; scenic	Adjacent (0.1 mi)
Baker Archaeological Site	Nevada	Ely	Cultural	3 mi[b]
Honeymoon Hill/City of Rocks	Nevada	Ely	Cultural	Adjacent[b]
Mount Irish	Nevada	Ely	Cultural	1.5 mi[b]
Pahroc Rock Art	Nevada	Ely	Cultural	Adjacent[b]
Shooting Gallery	Nevada	Ely	Cultural	2.5 mi[b]
Snake Creek Indian Burial Cave	Nevada	Ely	Zooarchaeology; geology; archaeology	2 mi[b]
Swamp Cedar	Nevada	Ely	Special plant species; prehistoric sites; historic site	Adjacent[b]
Arden	Nevada	Las Vegas	Historic	Adjacent
Arrow Canyon	Nevada	Las Vegas	Paleontological; Geological; Cultural	Adjacent
Bird Springs	Nevada	Las Vegas	Cultural	0.5 mi
Crescent Townsite	Nevada	Las Vegas	Historic	1 mi
Gold Butte Part A	Nevada	Las Vegas	Cultural; scenic; wildlife habitat; sensitive species	Adjacent
Hidden Valley	Nevada	Las Vegas	Cultural	1 mi
Rainbow Gardens		Las Vegas	Geological; scientific; scenic; cultural; sensitive plants	Adjacent
Sloan Rock	Nevada	Las Vegas	Cultural	1.5 mi
Stump Springs	Nevada	Las Vegas	Cultural; historic	Adjacent
Virgin River	Nevada	Las Vegas	Threatened and Endangered species; riparian habitat; cultural resources	Adjacent
Pecos River/Canyons Complex	New Mexico	Carlsbad	Scenic; cultural; natural	7 mi
Adams Canyon	New Mexico	Farmington	Cultural	0.7 mi
Ah-shi-sle-pah Road	New Mexico	Farmington	Cultural	2 mi
Albert Mesa	New Mexico	Farmington	Cultural	6 mi
Andrews Ranch	New Mexico	Farmington	Cultural	0.7 mi
Ashii Nala'a' (Salt Point)	New Mexico	Farmington	Cultural	Adjacent
Bee Burrow	New Mexico	Farmington	Cultural	3 mi
Bis sa'ani	New Mexico	Farmington	Cultural	Adjacent
Bi Yaazh	New Mexico	Farmington	Cultural	Adjacent
Blanco Mesa	New Mexico	Farmington	Cultural	0.3 mi
Blanco Star Panel	New Mexico	Farmington	Cultural	2.5 mi

TABLE 4.15-3 (Cont.)

ACEC	State	BLM Field Office	ACEC Values	Distance[a] from Nearest Solar-Suitable Area
Cagle's Site	New Mexico	Farmington	Cultural	1 mi
Canyon View	New Mexico	Farmington	Cultural	Adjacent
Casa del Rio	New Mexico	Farmington	Cultural	4 mi
Cedar Hill	New Mexico	Farmington	Cultural	4 mi
Chacra Mesa	New Mexico	Farmington	Cultural	Adjacent
Cho'li'l (Gobernador Knob)	New Mexico	Farmington	Cultural	2 mi
Christmas Tree	New Mexico	Farmington	Cultural	5 mi
Church Rock Outlier	New Mexico	Farmington	Cultural	5 mi
Cottonwood Divide	New Mexico	Farmington	Cultural	1.5 mi
Crow Canyon	New Mexico	Farmington	Cultural	1 mi
Crown Point Steps and Herradura	New Mexico	Farmington	Cultural	2 mi
Deer House	New Mexico	Farmington	Cultural	0.5 mi
Delgadita/Pueblo Canyons	New Mexico	Farmington	Cultural	1 mi
Devils Spring Mesa	New Mexico	Farmington	Cultural	Adjacent
Dogie Canyon School	New Mexico	Farmington	Cultural	2.5 mi
Dzil'na'oodlii	New Mexico	Farmington	Cultural	Adjacent
East Rincon	New Mexico	Farmington	Cultural	4 mi
Encierro Canyon	New Mexico	Farmington	Cultural	0.3 mi
Encinada Mesa- Carrizo Canyon	New Mexico	Farmington	Cultural	1 mi
Farmer's Arroyo	New Mexico	Farmington	Cultural	2 mi
Four Ye'i	New Mexico	Farmington	Cultural	Adjacent (0.1 mi)
Frances Mesa	New Mexico	Farmington	Cultural	3 mi
Gonzales Canyon–Vigil Homestead	New Mexico	Farmington	Cultural	0.2 mi
Gould Pass Camp	New Mexico	Farmington	Cultural	4.5 mi
Halfway House	New Mexico	Farmington	Cultural	Adjacent
Haynes Trading Post	New Mexico	Farmington	Cultural	Adjacent
Holmes Group	New Mexico	Farmington	Cultural	0.7 mi
Hummingbird	New Mexico	Farmington	Cultural	Adjacent
Hummingbird Canyon	New Mexico	Farmington	Cultural	4 mi
Jacques Chacoan Community	New Mexico	Farmington	Cultural	0.8 mi

TABLE 4.15-3 (Cont.)

ACEC	State	BLM Field Office	ACEC Values	Distance[a] from Nearest Solar-Suitable Area
Kachina Mask	New Mexico	Farmington	Cultural	2 mi
Kin Nizhoni	New Mexico	Farmington	Cultural	0.5 mi
Kin Yazhi	New Mexico	Farmington	Cultural	Adjacent
Kiva	New Mexico	Farmington	Cultural	1.5 mi
Lake Valley	New Mexico	Farmington	Cultural	3.5 mi
Largo Canyon Star Ceiling	New Mexico	Farmington	Cultural	2.5 mi
Margarita Martinez Homestead	New Mexico	Farmington	Cultural	Adjacent
Martin Apodaco Homestead	New Mexico	Farmington	Cultural	0.7 mi
Martinez Canyon	New Mexico	Farmington	Cultural	2 mi
Morris 41	New Mexico	Farmington	Cultural	4 mi
Moss Trail	New Mexico	Farmington	Cultural	0.4 mi
Muñoz Canyon	New Mexico	Farmington	Cultural	0.4 mi
North Road	New Mexico	Farmington	Cultural	Adjacent
Pierre's Site	New Mexico	Farmington	Cultural	Adjacent
Pointed Butte	New Mexico	Farmington	Cultural	Adjacent
Pork Chop Pass	New Mexico	Farmington	Cultural	1.5 mi
Pregnant Basketmaker	New Mexico	Farmington	Cultural	2 mi
Pretty Woman	New Mexico	Farmington	Cultural	Adjacent
Rincon Largo District	New Mexico	Farmington	Cultural	Adjacent
Rincon Rockshelter	New Mexico	Farmington	Cultural	0.5 mi
Rock House- Nestor Martin Homestead	New Mexico	Farmington	Cultural	Adjacent
San Rafael Canyon	New Mexico	Farmington	Cultural	Adjacent
Santos Peak	New Mexico	Farmington	Cultural	2 mi
Shield Bearer	New Mexico	Farmington	Cultural	2 mi
Simon Canyon	New Mexico	Farmington	Natural; wildlife habitat; cultural; scenic	5 mi
Shield Bearer	New Mexico	Farmington	Cultural	2 mi
Star Rock	New Mexico	Farmington	Cultural	0.4 mi
Star Spring-Jesus Canyon	New Mexico	Farmington	Cultural	0.6 mi
String House	New Mexico	Farmington	Cultural	0.3 mi
Superior Mesa Community	New Mexico	Farmington	Cultural	Adjacent

TABLE 4.15-3 (Cont.)

ACEC	State	BLM Field Office	ACEC Values	Distance[a] from Nearest Solar-Suitable Area
Tapacito and Split Rock District	New Mexico	Farmington	Cultural	1.5 mi
Truby's Tower	New Mexico	Farmington	Cultural	Adjacent
Twin Angels	New Mexico	Farmington	Cultural	1 mi
Alamo Hueco Mountains	New Mexico	Las Cruces	Biological; scenic; cultural; paleontological; special status species	0.2 mi
Apache Box	New Mexico	Las Cruces	Biological; scenic; cultural; special status species; riparian	5.5 mi
Cooke's Range	New Mexico	Las Cruces	Biological; scenic; cultural; historic; recreation	Adjacent
Cornudas Mountain	New Mexico	Las Cruces	Visual; cultural; sensitive plants	4.5 mi
Dona Ana Mountains	New Mexico	Las Cruces	Scenic; recreation; biological; cultural	1.5 mi
Los Tules	New Mexico	Las Cruces	Cultural	Adjacent
Old Town	New Mexico	Las Cruces	Cultural; recreation	5 mi
Organ/Franklin Mountains	New Mexico	Las Cruces	Biological; scenic; cultural; special status species; riparian; recreation	Adjacent
Rincon	New Mexico	Las Cruces	Cultural	Adjacent
San Diego Mountain	New Mexico	Las Cruces	Cultural	0.4 mi
Three Rivers Petroglyph	New Mexico	Las Cruces	Cultural	Adjacent
Wind Mountain	New Mexico	Las Cruces	Visual; cultural; unique wildlife	6 mi
Cabezon Peak	New Mexico	Rio Puerco	Scenic; cultural; rare plant habitat; natural system geologic feature	1 mi
Casamero Community	New Mexico	Rio Puerco	Cultural	1 mi
Jones Canyon	New Mexico	Rio Puerco	Cultural; scenic; riparian	Adjacent
Ojito	New Mexico	Rio Puerco	Geological; paleontological; cultural; wildlife; rare plant habitat; geologic hazard	Adjacent
Mescalero Sands	New Mexico	Roswell	Biological; archaeological; scenic	7 mi
Agua Fria	New Mexico	Socorro	Biological; scenic; cultural; geological; recreation	Adjacent
Tinajas	New Mexico	Socorro	Cultural; recreation; scenic	Adjacent
Cottonwood Canyon	Utah	Kanab	Scenic; cultural; wildlife; natural processes; plant; geologic; Fredonia surface water watershed	Adjacent
Ten-Mile Wash	Utah	Moab	Cultural; wildlife	2 mi
Alkali Ridge	Utah	Monticello	Archaeological	Adjacent
Cedar Mesa	Utah	Monticello	Archaeological; scenic; primitive recreation	Adjacent

TABLE 4.15-3 (Cont.)

ACEC	State	BLM Field Office	ACEC Values	Distance[a] from Nearest Solar-Suitable Area
Hovenweep	Utah	Monticello	Archaeological; riparian	Adjacent
San Juan River	Utah	Monticello	Scenic; archaeological; wildlife	Adjacent
Shay Canyon	Utah	Monticello	Archaeological; riparian	1.5 mi
Dry Lake Archaeological District	Utah	Price	Archaeological; geologic	4 mi
Muddy Creek ACEC	Utah	Price	Scenic; mining; riparian	2.5 mi
Picotgraphs	Utah	Price	Archaeological	1 mi
Swasey Cabin	Utah	Price	Historic ranching	2 mi
Temple Mountain Historic District	Utah	Price	Mining; historic	1.5 mi)
Canaan Mountain	Utah	St. George	Scenic; cultural	0.5 m
Little Creek Mountain	Utah	St. George	Archaeological	Adjacent
Lower Virgin River	Utah	St. George	Endangered fish; archaeological	1.5 mi
Santa Clara Gunlock	Utah	St. George	Riparian; archaeological	3 mi

[a] To convert from mi to km, multiply by 1.609.

[b] Nevada ACEC distances to solar-suitable areas for Battle Mountain and Ely Field/District Offices are approximate; based on GIS data currently available at time of preparation.

4.15.1 Archaeological and Historic Resources

Through archaeology and ethnographic research, scientists have developed a historic framework for understanding how North America was settled and how Native American peoples lived on this continent prior to the arrival of Europeans. The history of Native Americans in the West is commonly approached by dividing the American West into culture areas (see Figure 4.15-1). These areas generally correspond to the major physiographic regions of the American West. The Native groups in a given culture area had to adapt to the regional climate and environment in order to survive. As a result, there are certain shared ways of life that characterize each region. Table 4.15-4 summarizes the major prehistoric periods and the types of cultural resources associated with each culture area. The cultural resource types presented in Table 4.15-4 represent the most common remains associated with each time period, not the total range of cultural resources associated with each time period.

Historic period cultural resources occur across the six-state study area. As with the prehistoric periods, Euro-American settlement and use of the West also can be understood through adaptation to the culture areas that loosely correspond to the major physiographic regions of the West. While considerable overlap exists in the general types of cultural resources that are found in the West, there also is considerable regional variability. Table 4.15-5 lists the culture areas and historic era cultural resource types by state. Again, this list of cultural resource types is not comprehensive; instead it is intended to provide the most common property types. Figure 4.15-1 also shows the locations of historic trails in addition to the culture areas.

Within BLM-administered lands, several cultural resource surveys have been conducted either for specific projects or for NHPA Section 110 requirements to inventory resources on federal lands. Each year the BLM is required to provide Congress with an annual reporting of their NHPA-related activities. Table 4.15-6 lists the number of acres surveyed on BLM-administered lands within the six-state study area and the number of cultural properties recorded since 1970.

4.15.2 *National Register of Historic Places* and Congressionally Designated Properties

As discussed above, cultural resources that meet the eligibility criteria for listing in the NRHP are formally referred to as historic properties. Many historic properties are located in the six-state region. The BLM has made eligibility determinations on many properties within their lands in accordance with Section 110 requirements of the NHPA. Table 4.15-7 lists the total numbers of BLM properties determined eligible since 1998 in their annual reporting requirements to Congress. Certain sites of significance have been given National Historic Landmark status by the Secretary of the Interior and are shown on Figure 4.15-1. The National Historic Landmarks within 25 mi (40 km) of solar suitable areas are included in Table 4.15-8. Congressionally designated National Historic Trails are listed in Table 4.15-9.

FIGURE 4.15-1 Major Culture Areas, Congressionally Designated National Historic Trails, and National Historic Landmarks within the Six-State Study Area

4.15.3 Traditional Cultural Properties

Traditional cultural properties are historic properties (that is, they are eligible for listing in the NRHP) that are important to a community's practices and beliefs and that are necessary for maintaining the community's cultural identity. Locations of specific traditional cultural properties within the BLM-administered lands considered suitable for solar energy development are not currently available but are part of the ongoing discussions during government-to-government consultations with Native American Tribes and through the public comment process for all cultural groups (also see Section 4.16).

TABLE 4.15-4 Time Periods and Examples of Characteristic Cultural Resources for Culture Areas in the Six-State Study Area

Culture Area	Paleoindian	Middle Period or Archaic	Late or Sedentary Period
California	*9000 (?) to 6000 BC* Open campsites Animal kill or processing sites	*6000 to 3000 BC* Open campsites Coastal villages Plant and seafood processing sites	*3000 BC to AD 1750* Large coastal villages Burial mounds Extensive seafood and sea mammal processing sites Intensive plant processing sites Prehistoric trails Geoglyphs/Intaglios
Great Basin	*9500 + to 6000 BC* Open campsites Cave occupation sites Lithic processing sites Animal kill or processing sites Isolated projectile points	*6000 to 2000 BC* Cave or rockshelter occupation sites Pithouse villages Plant processing sites Fishing sites Lithic processing sites Animal kill or processing sites	*2000 BC to AD 1750* Cave or rockshelter occupation sites Tipi ring sites Cave burials Cairns and cairn lines Small pithouse villages Plant processing sites Storage pits Lithic processing sites Pictograph and petroglyph sites Animal kill or processing sites Prehistoric roads
Southwest	*12,000 to 6000 BC* Open campsites Animal kill or processing sites Cave occupation sites Lithic processing sites Isolated projectile points	*6000 to 1 BC* Open campsites Cave or rockshelter occupation sites Pithouses and storage pits Wattle-and-daub structures Lithic processing sites Pictograph and petroglyph sites	*AD 1 to 1750* Pithouse villages Storage pits Aboveground structures (pueblos) Belowground structures (kivas) Irrigation ditches Roads Navajo hogans and pueblitos Pictograph and petroglyph sites Intaglios Prehistoric roads or trails
Plains	*10,000 to 6000 BC* Open campsites Cave or rockshelter occupation sites Animal kill or processing sites Lithic processing sites Isolated projectile points	*6000 to 1 BC* Open campsites Cave or rockshelter occupation sites Pithouses and storage pits Tipi ring sites Cairns and cairn lines	*AD 1 to 1750* Open campsites Tipi ring sites Wattle-and-daub structures Earthlodge villages Burial mounds Storage pits

TABLE 4.15-4 (Cont.)

Culture Area	Paleoindian	Middle Period or Archaic	Late or Sedentary Period
Plains (Cont.)		Animal kill or processing sites Lithic processing sites Plant processing sites	Cave or rockshelter occupation sites Small pithouse villages Cairns and cairn lines Animal kill and processing sites Lithic processing sites Plant processing sites Pictograph and petroglyph sites Prehistoric trails

Source: Modified from BLM (2007a).

TABLE 4.15-5 Major Culture Areas and Historic Period Site Types (AD 1550 to present) Listed by State

State	Culture Areas	Range of Historic Resources
Arizona	Southwest, Great Basin	Historic trails, buildings, structures, towns, fur trade sites, agricultural sites, ranching sites, mining-related sites, logging sites, military camps and outposts, missions, Civilian Conservation Corps (CCC) camps, and railroads
California	California, Great Basin	Historic trails, missions, buildings, structures, towns, forts, mining-related sites, logging-related sites, agricultural sites, railroads, CCC camps, and military camps and outposts
Colorado	Great Basin, Plains, Southwest	Historic trails, buildings, structures, towns, fur trade sites, agricultural sites, ranching sites, mining-related sites, logging sites, military outposts, CCC camps, and railroads
Nevada	Great Basin	Historic trails, buildings, structures, towns, fur trade sites, agricultural sites, ranching sites, mining-related sites, logging sites, military outposts, missions, and railroads
New Mexico	Southwest, Plains	Historic trails, buildings, structures, towns, fur trade sites, agricultural sites, ranching sites, mining-related sites, logging sites, military outposts, and railroads
Utah	Great Basin	Historic trails, buildings, structures, towns, fur trade sites, agricultural sites, ranching sites, mining-related sites, logging sites, military outposts, and railroads

TABLE 4.15-6 Reportable Inventory Data for BLM-Administered Lands

State	BLM Acres Surveyed in State	Number of BLM Properties in State
Arizona	918,830	13,334
California	1,955,127	30,528
Colorado	1,749,469	44,263
Nevada	2,627,612	51,529
New Mexico	1,657,095	37,806
Utah	2,508,075	45,411

Source: Lasell (2010).

TABLE 4.15-7 BLM Properties Determined Eligible for the NRHP in the Six-State Study Area

State	Number of Eligible Sites
Arizona	1,624
California	919
Colorado	4,958
Nevada	3,334
New Mexico	7,777
Utah	8,493

Source: Lasell (2010).

4.16 NATIVE AMERICAN CONCERNS

Federally recognized Tribes have a unique relationship with the federal government on the basis of their original sovereign and independent status as defined in treaties, statutes, Executive Orders, and court decisions. The federal government is required to take into account the interests of federally recognized Native American Tribes when proposing actions that could affect those interests. Interests of Native Americans include not only cultural resources but economic development, access to energy resources, health and safety, environmental justice, and protection of the environment. While these interests are common to all segments of society and are treated throughout the PEIS, federal laws require federal agencies to consult on a government-to-government basis with affected Native American Tribes regarding environmental issues and to take into account Native American concerns. All federally recognized Tribes that

TABLE 4.15-8 National Historic Landmarks within 25 mi (40 km) of BLM-Administered Lands Suitable for Solar Energy Development in the Six-State Study Area[a]

National Historic Landmark	Distance[b] to Nearest Solar-Suitable Area
Arizona	
Air Force Facility Missile Site 8 (571-7) Military Reservation	5 mi
El Tovar Hotel	10 mi
Grand Canyon Power House	10 mi
Grand Canyon Railroad Station	9 mi
Grand Canyon Park Operations Building	10 mi
Navajo Nation Council Chamber	10 mi
Painted Desert Inn	8 mi
Phelps Dodge General Office Building	5 mi
Tumacacori Museum	21 mi
California	
Parson's Memorial Lodge	20 mi
Colorado	
Mesa Verde Administrative District	12 mi
Pike's Stockade	5 mi
Nevada	
Fort Churchill	1 mi
Senator Francis G. Newlands House	9 mi
New Mexico	
Georgia O'Keefe Home and Studio	23 mi
Hawikuh	12 mi
Launch Complex 33	13 mi
Mesilla Plaza	2.5 mi
Utah	
Bryce Canyon Lodge	7 mi

[a] National Historic Landmarks in this list are based on a GIS coverage of landmarks in each state and may not be a complete list.

[b] To convert mi to km, multiply by 1.609.

TABLE 4.15-9 Congressionally Designated National Historic Trails within the Six-State Study Area

National Historic Landmark	Distance[a] to Nearest Solar-Suitable Area
Arizona	
Juan Bautista de Anza National Historic Trail	Adjacent (0.25 mi)
Old Spanish National Historic Trail	Adjacent (0.25 mi)
California	
California National Historic Trail	14 mi
Juan Bautista de Anza National Historic Trail	1.5 mi
Old Spanish National Historic Trail	Adjacent (0.25 mi)
Pony Express National Historic Trail	45 mi
Colorado	
Old Spanish National Historic Trail	Adjacent (0.25 mi)
Santa Fe National Historic Trail	26 mi
Nevada	
California National Historic Trail	Adjacent (0.25 mi)
Old Spanish National Historic Trail	Adjacent (0.25 mi)
Pony Express National Historic Trail	Adjacent (0.25 mi)
New Mexico	
El Camino Real de Tierra Adentro National Historic Trail	Adjacent (0.25 mi)
Old Spanish National Historic Trail	Adjacent (0.25 mi)
Santa Fe National Historic Trail	1.4 mi
Utah	
California National Historic Trail	65 mi
Mormon Pioneer National Historic Trail	111 mi
Old Spanish National Historic Trail	Adjacent (0.25 mi)
Oregon National Historic Trail	159 mi
Pony Express National Historic Trail	3 mi

[a] To convert mi to km, multiply by 1.609.

have traditional territory within solar-suitable areas are listed in Tables 4.16-1 and 4.16-2. Appendix K contains a listing of all federally recognized Tribes in the six-state study area that were contacted regarding this PEIS, copies of the letters sent to the Tribes, a complete listing of each Tribe receiving the letter, and responses from Tribes.

Resources important to Tribes fall into several categories with distinct management requirements derived from federal legislation, Executive Orders, and court decisions (see Table 4.16-3). These resources may be distinguished on the basis of whether they are located on Tribal or on federal lands, and whether they are Tribal assets or are nonassets that legally must be managed in consultation with Tribes. In general, cultural resources located on federal lands that are important to Tribes, unless specifically reserved in treaties

TABLE 4.16-1 Tribes Whose Traditional Tribal Use Area Includes BLM-Administered Lands Being Analyzed for Solar Development

Culture Area	Tribe
California	Cahuilla
	Kamia
	Kitanemuk
	Kumeyaay
	Serrano
Great Basin	Chemhuevi
	Kawaiisu
	Northern Paiute
	Owens Valley Paiute
	Southern Paiute
	Ute
	Washoe
	Western Shoshone
Great Plains	Arapaho
	Cheyenne
Southwest	Acoma
	Akimel O'odham (Pima)
	Chiricahua Apache
	Cocopah
	Halchidoma
	Havasupai
	Hopi
	Hualapai
	Jacome
	Jano
	Jemez
	Jicarilla Apache
	Laguna
	Maricopa
	Mescalero Apache
	Mohave
	Navajo
	Pecos
	Piro
	Quechan (Yuma)
	Rio Grande Keresans
	South Tiwa
	Tohono O'odham (Papago)
	Tompiro
	Yavapai
	Zuni

TABLE 4.16-2 Tribes Contacted for this PEIS with Traditional Territory in Solar-Suitable Areas

State	Organization
Arizona	Ak Chin Indian Community Council
	Cocopah Tribal Council
	Colorado River Indian Tribes Museum
	Colorado River Tribal Council
	Fort McDowell Yavapai Tribal Council
	Fort Yuma Quechan Tribe
	Gila River Indian Community Council
	Havasupai Tribal Council
	Hopi Tribal Council
	Hualapai Tribal Council
	Kaibab Paiute Tribal Council
	Navajo Nation
	Pascua Yaqui Tribal Council
	Salt River Pima-Maricopa Indian Community Council
	San Carlos Tribal Council
	San Juan Southern Paiute Council
	Tohono O'odham Nation
	Tonto Apache Tribal Council
	White Mountain Apache Tribe
	Yavapai-Apache Nation Tribal Council
	Yavapai-Prescott Board of Directors
California	Agua Caliente Band of Cahuilla Indians
	Augustine Band of Mission Indians
	Barona Group of the Capitan Grande
	Benton Paiute Reservation
	Big Pine Paiute Tribe of the Owens Valley
	Big Sandy Rancheria
	Bishop Paiute Tribe
	Bridgeport Indian Colony
	Cabazon Band of Cahuilla Mission Indians
	Cahuilla Band of Mission Indians
	Campo Band of Mission Indians
	Cedarville Rancheria
	Chemehuevi Tribal Council
	Cold Springs Rancheria
	Ewiiaapaayp Band of Kumeyaay Indians
	Fort Bidwell Reservation
	Fort Independence Indian Reservation
	Fort Mojave Tribal Council
	Inaja-Cosmit Reservation
	Kern Valley Indian Community
	Kwaaymii Laguna Band of Indians
	La Jolla Band of Luiseño Indians
	La Posta Band of Mission Indians

TABLE 4.16-2 (Cont.)

State	Organization
California *(Cont.)*	Lone Pine Paiute Shoshone Reservation
	Los Coyotes Band of Cahuilla & Cupeno Indians
	Manzanita Band of Mission Indians
	Morongo Band of Mission Indians
	North Fork Rancheria
	Pala Band of Mission Indians
	Pauma/Yuima Band of Mission Indians
	Pechanga Band of Mission Indians
	Picayune Rancheria of Chukchansi Indians
	Ramona Band of Mission Indians
	San Manuel Band of Mission Indians
	San Pasqual Band of Mission Indians
	Santa Rosa Band of Mission Indians
	Santa Ysabel Band of Diegueno Indians
	Soboba Band of Luiseño Indians
	Sycuan Band of the Kumeyaay Nation
	Timbi-sha Shoshone Tribe
	Torres-Martinez Desert Cahuilla Indians
	Tubatulabals of Kern Valley
	Twenty-Nine Palms Band of Mission Indians
	Viejas Band of Mission Indians
	Woodfords Community Council
Colorado	Southern Ute Tribe
	Ute Mountain Ute Tribe
Idaho	Shoshone-Bannock Tribes
Montana	Northern Cheyenne Tribal Council
North Dakota	Standing Rock Sioux Tribal Council
New Mexico	Jicarilla Apache Nation
	Mescalero Apache Tribe
	Navajo Nation, Alamo Chapter
	Navajo Nation, Ramah Chapter
	Ohkay Owingeh
	Pueblo of Acoma
	Pueblo of Cochiti
	Pueblo of Isleta
	Pueblo of Jemez
	Pueblo of Laguna
	Pueblo of Nambe
	Pueblo of Picuris
	Pueblo of Pojoaque
	Pueblo of San Felipe

TABLE 4.16-2 (Cont.)

State	Organization
New Mexico *(Cont.)*	Pueblo of San Ildefonso
	Pueblo of Sandia
	Pueblo of Santa Ana
	Pueblo of Santa Clara
	Pueblo of Santo Domingo
	Pueblo of Taos
	Pueblo of Tesuque
	Pueblo of Zia
	Pueblo of Zuni
Nevada	Battle Mountain Band Council
	Carson Community Council
	Dresslerville Community Council
	Duckwater Tribal Council
	Elko Band Council
	Ely Shoshone Tribe
	Fallon Paiute Shoshone Tribal Business Council
	Fort McDermitt Tribal Council
	Inter-Tribal Council of Nevada
	Las Vegas Tribal Council
	Lovelock Tribal Council
	Moapa Business Council
	Pahrump Paiute Tribe
	Pyramid Lake Paiute Tribal Council
	Reno-Sparks Tribal Council
	Shoshone-Paiute Business Council
	South Fork Band Council
	Stewart Community Council c/o Washoe Tribe of Nevada/California
	Summit Lake Paiute Tribal Council
	Te-Moak Tribe of Western Shoshone Tribal Council
	Walker River Paiute Tribal Council
	Washoe Tribal Council
	Wells Indian Colony Band Council
	Winnemucca Tribal Council
	Yerington Paiute Tribe
	Yomba Tribal Council
Oklahoma	Apache Tribe of Oklahoma
	Cheyenne-Arapaho Tribes of Oklahoma
	Comanche Nation
	Fort Sill Apache Tribe of Oklahoma
	Kiowa Tribe of Oklahoma
South Dakota	Cheyenne River Lakota Sioux Tribe
	Crow Creek Sioux Tribal Council
	Oglala Sioux Tribal Council
	Rosebud Sioux Tribal Council

TABLE 4.16-2 (Cont.)

State	Organization
Texas	Ysleta del Sur Pueblo
Utah	Goshute Business Council
	Northwestern Band of Shoshone Nation
	Paiute Indian Tribe of Utah Tribal Council
	Paiute Indian Tribe of Utah, Cedar Band
	Paiute Indian Tribe of Utah, Indian Peak Band
	Paiute Indian Tribe of Utah, Kanosh Band
	Paiute Indian Tribe of Utah, Koosharem Band
	Paiute Indian Tribe of Utah, Shivwits Band
	Skull Valley Band of Goshute Indians General Council
	Ute Indian Tribe
	White Mesa Ute Tribe
Wyoming	Eastern Shoshone Business Council
	Northern Arapaho Business Council

or statutes, are neither Indian trust assets nor Indian trust resources. Federal regulations characterize them as "properties of traditional religious and cultural importance to an Indian Tribe" (36 CFR 800.16(1)(1)). They are to be managed by federal agencies in consultation with affected federally recognized Tribes. Cultural resources important to Tribes include cemeteries, campsites, and dwelling places associated with Tribal ancestors; traditional hunting, fishing, and gathering places; traditionally important plant and animal species and their habitats; and sacred places, landscapes, and resources important to the free practice of traditional Native American religions and the preservation of traditional Native American cultures.

Cultural resources are trust resources when a fiduciary obligation on the part of the United States has been defined in treaties, statues, or Executive Orders. For example, a treaty may guarantee the right to Native Americans to exploit fisheries or minerals on lands they are ceding. In addition, the Native American Graves Protection and Repatriation Act (NAGPRA) establishes Native Americans as owners of Native American burials and associated artifacts on federal lands and requires that they be repatriated in consultation with the affected Tribal group.

Native Americans tend to view their environment holistically. Rather than stressing the division of their environment into its constituent parts, each part is intrinsically and inextricably connected to the whole. From this perspective, the whole is more than the sum of its parts and damage to one part damages the whole (Stoffle and Zedeño 2001). Often this holistic view extends beyond the physical environment. Distinctions between the natural and the cultural and the animate and the inanimate as viewed by Western societies may have little meaning from a traditional Native American perspective. Because of this world view, resources important to them generally extend beyond cultural resources to natural resources, including plants, animals, ecosystems, geophysical features, water, and air. Elements of many of these concerns are shared

TABLE 4.16-3 Resources Important to Tribes

Resource Type	Description
Archaeological sites	The physical remains of human activities, including artifacts, structures, and special use sites. All prehistoric and some historic archaeological sites in the United States are associated with ancestral Native American populations. These sites often include a buried (subsurface) component.
Indian trust assets	Lands, natural resources, or other assets held in trust or restricted against alienation by the United States for Native American Tribes or individual Native Americans (DOI 2000).
Indian trust resources	Those natural resources, either on or off Indian lands, retained by or reserved by or for Indian Tribes through treaties, statutes, judicial decisions, and Executive Orders, which are protected by a fiduciary obligation on the part of the United States (DOI 2008).
NAGPRA remains	Native American human remains, funerary objects, sacred objects, or objects of cultural patrimony found on federal lands or residing in museums receiving federal funding.
Properties of traditional religious and cultural importance to an Indian Tribe	Often referred to as "traditional cultural properties," these features may be eligible for listing on the NRHP. They include sacred sites, burial grounds, ancestral sites, traditional gathering places, and culturally important landscapes and natural resources (36 CFR 800.16(l)(1)).
Sacred sites	Any specific location on federal land that is identified by an Indian Tribe or Indian individual determined to be an appropriately authoritative representative of an Indian religion, as sacred by virtue of its established religious significance to, or ceremonial use by, an Indian religion (GSA 1999).
Tribal lands	All lands within the exterior boundaries of an Indian reservation and all dependent Indian communities (36 CFR 800.16(x)).
Treaty rights	Rights reserved to Native Americans by treaties, including hunting, fishing, gathering, and mineral rights.
Traditional cultural properties	Properties eligible for inclusion in the NRHP because of their association with cultural practices or beliefs of a living community that are rooted in the community's history and are important in maintaining the continuing cultural identity of the community (Parker and King 1998).

TABLE 4.16-4 Natural Resources Traditionally Widely Used by Native Americans in the Arid Southwest

Resource	On Valley Floors	In Surrounding Terrain
Animals	Black-tailed jackrabbit Desert cottontail Pronghorn Badger Fox Porcupine Wood rats Desert tortoise Chuckwalla	Bighorn sheep Mule Deer
Birds	Golden eagle Hawks Burrowing owl Quail Doves	Golden eagle[a] Hawks Migrating water fowl
Plants	Mesquite Agave (mescal) Cactus fruit Buckwheat Seed-bearing grasses Berries Greasewood Sagebrush Saltbush Cat's claw Desert Willow	Pine nuts Acorns
Minerals	Clay for pottery Salt	Turquoise Quartz crystals Mineral pigments

[a] Eagles, eagle parts, eagle nests, and eagle habitat are culturally significant resources for some Tribes. Existing and former nesting sites may be regarded as sacred sites or traditional cultural properties.

Source: Stoffle and Zedeño (2001).

with the population as a whole and are discussed elsewhere in Chapter 4. Archaeological sites, structures, landscapes, trails, and traditional cultural properties are discussed in Section 4.15; mineral resources in Section 4.8; water resources in Section 4.9; ecological resources in Section 4.10; air quality in Section 4.11; visual resources in Section 4.12; and the acoustic environment in Section 4.13. This section focuses on concerns that are specific to Native Americans or to which Native Americans bring a distinct perspective. For example, in the arid areas considered in this PEIS, water is a concern that crosses all ethnic boundaries. Over the years, Native Americans have lost access to the water resources upon which they traditionally depended. This situation has severely restricted and altered their traditional resource base. In addition, water sources such as springs, tanks, wells, and rivers often have religious importance. Additional resources of importance are listed in Table 4.16-4 for the arid Southwest, but the list is not intended to be exhaustive for the broad six-state region covered in this PEIS.

4.17 SOCIOECONOMICS

The socioeconomic environment potentially affected by the development of solar resources on federal land encompasses the six western states in which the SEZs considered in this PEIS are located. Nine key measures of economic development are described in the following sections: (1) employment, (2) unemployment, (3) personal income, (4) sales tax revenues, (5) individual income tax revenues, (6) population, (7) vacant rental housing, (8) state and local government expenditures, and (9) state and local government employment. For each development measure, data are presented for 2010, the first year during which construction impacts associated with solar developments would be assessed, and for a recent preceding period. Forecasts for each measure are based on population forecasts produced by the U.S. Census Bureau for the period 2004 to 2030 (U.S. Bureau of the Census 2008a).

4.17.1 Employment

In 2007, almost 66% (17.2 million) of all employment in the six-state study area (26.2 million) was concentrated in California (Table 4.17-1). Employment in Arizona and Colorado stood at 2.9 million and 2.6 million, respectively; the remaining states supported 3.5 million jobs. Employment in the six-state study area as a whole is projected to increase to 27.3 million in 2010.

Over the period 1990 to 2007, annual employment growth rates were higher in Nevada (4.3%), Arizona (3.2%), and Utah (3.1%) than elsewhere in the six-state study area. At 1.1%, the growth rate in California was somewhat less than the average rate of 1.5%.

TABLE 4.17-1 State Employment (millions, except where noted)[a]

State	1990	2007	Average Annual Growth Rate, 1990–2007 (%)	2010 (projected)
Arizona	1.7	2.9	3.2	3.1
California	14.3	17.2	1.1	17.8
Colorado	1.7	2.6	2.6	2.7
Nevada	0.6	1.3	4.3	1.4
New Mexico	0.7	0.9	1.9	0.9
Utah	0.8	1.3	3.1	1.4
Total	19.7	26.2	1.7	27.3

[a] Because of rounding, column totals may not be exact.

Source: U.S. Department of Labor (2008a).

4.17.2 Unemployment

In the majority of the states in the study area, unemployment rates declined over the period 1996 to 2007 (Table 4.17-2). Current unemployment rates in California (7.3%), Colorado (5.2%), and Nevada (6.6%) were slightly higher than the corresponding average for the preceding 17-year period. With the exception of California, relatively small labor forces exist in each state. However, there are fairly large numbers of local workers who are presently unemployed in each state and, therefore, potentially are available to work on the proposed energy developments within the states.

4.17.3 Personal Income

California generated almost 70% of the total personal income in the six-state study area, producing almost $1.5 trillion in 2006 (Table 4.17-3). The state was expected to generate more than $1.5 trillion in 2009. For the six states combined, personal income is expected to rise from $2.1 trillion in 2006 to $2.2 trillion in 2010.

Annual growth in personal income was highest in Nevada (6.0%) over the period 1990 to 2006. Personal income growth rates in Arizona (4.5%), Utah (4.1%), and Colorado (4.0%) were all more than one percentage point higher than the six-state average rate of 2.8%.

TABLE 4.17-2 Unemployment Data[a]

State	Average 1990–2007 (%)	Current Rate (%)	Currently Unemployed Persons
Arizona	5.2	5.1	158,189
California	6.7	7.3	1,351,959
Colorado	4.5	5.2	144,133
Nevada	5.2	6.6	92,890
New Mexico	6.0	4.1	39,003
Utah	4.1	3.5	48,928

[a] Data for current unemployment rates and the number of unemployed persons are for July 2008.

Source: U.S. Department of Labor (2008a–c).

TABLE 4.17-3 State Personal Income ($ billions 2007, except where noted)[a]

State	1990	2006	Average Annual Growth Rate, 1990–2006 (%)	2010 (projected)
Arizona	99.4	202.5	4.5	223.4
California	1,028.2	1,477.1	2.3	1,542.6
Colorado	102.7	193.5	4.0	200.6
Nevada	39.4	99.9	6.0	111.2
New Mexico	36.0	59.8	3.2	61.7
Utah	40.9	78.0	4.1	82.5
Total	1,346.6	2,110.8	2.8	2,222.0

[a] Because of rounding, column totals may not be exact.

Sources: U.S. Department of Commerce (2008); U.S. Department of Labor (2008d).

4.17.4 Sales Tax Revenues

Sales tax revenues are projected to grow for the six states as a whole from $79.0 billion in 2002 to $88.7 billion in 2010 (Table 4.17-4). Growth is also expected in each individual state over the period 2002 through 2009, with revenues in the largest generating state, California, projected to reach $57.1 billion in 2010.

Higher than average annual growth in sales tax revenues during the period 1992 to 2002 occurred in Nevada (7.8%), Arizona (6.4%), Utah (5.6%), and Colorado (5.1%). The average annual growth rate for the six states as a whole during the period 1992 to 2002 was 3.8%.

TABLE 4.17-4 State Sales Taxes ($ billions 2007, except where noted)[a]

State	1992	2002	Annual Growth Rate 1990–2002 (%)	2010 (projected)
Arizona	5.0	9.2	6.4	11.3
California	39.0	52.1	2.9	57.1
Colorado	3.8	6.2	5.1	6.8
Nevada	2.5	5.3	7.8	6.7
New Mexico	2.3	3.0	2.7	3.2
Utah	1.8	3.2	5.6	3.6
Total	54.4	79.0	3.8	88.7

[a] Because of rounding, column totals may not be exact.

Sources: U.S. Bureau of the Census (2008b); U.S. Department of Labor (2008d).

4.17.5 Individual Income Tax Revenues

In 2002, California generated 81% of state individual income tax revenues in the six-state study area, producing $41.9 billion (Table 4.17-5). Colorado was the second largest state income tax producer, with $3.9 billion in 2002. Revenues for the entire region are projected to increase from $51.7 billion in 2002 to $57.0 billion in 2010. Revenues in California are expected to reach $46.0 billion in 2010.

Most of the six states experienced moderately large annual increases in state individual income tax revenues (see Table 4.17-5). Growth rates in New Mexico (5.8%), Utah (5.4%), and California (5.2%) were all higher than the average of 5.1% for the six-state study area. Relatively slow growth in individual income tax revenues (3.8%) was experienced in Arizona during this period.

4.17.6 Population

Total population in the six-state study area stood at 49.4 million people in 2000; it is expected to reach 56.8 million by 2010 (Table 4.17-6). Population in the region is concentrated in California, which at 33.9 million people, had almost 70% of the total regional population in 2000. Population in California is expected to increase to 38.1 million by 2010. In 2000, each of the remaining states, with the exception of Arizona (5.1 million), had less than 5 million persons.

TABLE 4.17-5 State Individual Income Taxes ($ billions 2007, except where noted)[a]

State	1992	2002	Annual Growth Rate 1990–2002 (%)	2010 (projected)
Arizona	1.8	2.7	3.8	3.3
California	25.2	41.9	5.2	46.0
Colorado	2.4	3.9	5.1	4.3
Nevada	0.0	0.0	–[b]	–
New Mexico	0.7	1.2	5.8	1.2
Utah	1.2	1.9	5.4	2.2
Total	31.2	51.7	5.1	57.0

[a] Because of rounding, column totals may not be exact.

[b] A dash indicates that there is currently no state individual income tax in Nevada.

Sources: U.S. Bureau of the Census (2008b); U.S. Department of Labor (2008d).

TABLE 4.17-6 State Population (millions, except where noted)[a]

State	1990	2000	Annual Growth Rate 1990–2000 (%)	2010 (projected)
Arizona	3.7	5.1	3.4	6.6
California	29.8	33.9	1.3	38.1
Colorado	3.3	4.3	2.7	4.8
Nevada	1.2	2.0	5.2	2.7
New Mexico	1.5	1.8	1.8	2.0
Utah	1.7	2.2	2.6	2.6
Total	41.2	49.4	1.8	56.8

[a] Because of rounding, column totals may not be exact.

Source: U.S. Bureau of the Census (2008a,c).

Population in the six-state study area grew at an annual average rate of 1.8% from 1990 to 2000. Growth within the region was fairly uneven over the period, with relatively high annual growth rates in Nevada (5.2%) and Arizona (3.4%). Growth rates in Colorado and Utah were closer to the average for the region, with lower than average rates in California (1.3%).

4.17.7 Vacant Rental Housing

With the largest population in the six-state study area, California also has the largest housing market and the largest number of vacant rental housing units (Table 4.17-7). The total number of vacant rental units in the state stood at 190,000 in 2000 (53% of the six-state total) and is expected to reach 213,600 in 2010. Elsewhere in the region, Arizona (61,900 units) had the second largest number of vacant rental units in 2000. The number of units in the six-state study area as a whole stood at 356,000 in 2000 and is expected to reach 417,200 by 2010.

The total number of vacant rental units in the six-state study area slightly declined over the period 1990 to 2000 (annual rate of –2.5%). Three states, Colorado (–5.3%), California (-3.5%), and Arizona (–1.9%), have seen higher than average declines in vacant units; Utah has experience a slight decline (-0.7%); while Nevada (5.1%) and New Mexico (2.8%) have experienced relatively large increases in vacant rental units.

4.17.8 State and Local Government Expenditures

The distribution of funding for state and local government services is concentrated in California, with $378.0 billion in government expenditures in 2002, which was almost 74% of all

TABLE 4.17-7 Vacant Rental Housing Units (thousands, except where noted)[a]

State	1990	2000	Annual Growth Rate 1990–2000 (%)	2010 (projected)
Arizona	75.0	61.9	–1.9	80.1
California	271.9	190.0	–3.5	213.6
Colorado	55.3	31.9	–5.3	35.8
Nevada	19.2	31.7	5.1	42.6
New Mexico	20.2	26.7	2.8	29.0
Utah	14.7	14.0	–0.7	16.0
Total	456.3	356.0	–2.5	417.2

[a] Because of rounding, column totals may not be exact.

Source: U.S. Bureau of the Census (2008c).

government expenditures in the six-state study area (Table 4.17-8). Expenditures in California are expected to reach $414.7 billion in 2010. Other states with fairly large state and local government expenditures are Arizona ($41.6 billion in 2002) and Colorado ($39.6 billion in 2002). Expenditures in the six-state study area as a whole totaled $513.3 billion in 2002 and are expected to reach $562.7 billion by 2010.

Annual growth rates in state and local government expenditures have been fairly high throughout the six-state study area, with an overall annual average rate of 5.0% for the period 1990 to 2002. A number of the states, notably Nevada (7.0%) and Utah (6.0%), were more than one percentage point higher than the regional average, while growth rates in California (4.7%) were slightly lower than average during the period.

4.17.9 State and Local Government Employment

The majority (67%) of state and local government employment in the six-state study area region in 2006 was centered in California (Table 4.17-9). Government employment in the state stood at 1.8 million in 2002 and is projected to reach 1.9 million in 2010. Other states with fairly large government employment in 2006 were Arizona (285,100) and Colorado (255,000). Total state and local government employment in the six-state study area was 2.7 million in 2006 and is expected to reach 2.9 million in 2010.

Growth in government employment in the six states has varied over the period 1990 to 2006. While the average for the region stood at 2.0% over the period, government in

TABLE 4.17-8 Total State and Local Government Expenditures ($ billions 2007, except where noted)[a]

State	1992	2002	Annual Growth Rate 1990–2002 (%)	2010 (projected)
Arizona	24.0	41.6	5.6	51.0
California	239.7	378.0	4.7	414.7
Colorado	22.7	39.6	5.7	43.4
Nevada	9.4	18.6	7.0	23.6
New Mexico	10.0	16.2	5.0	17.3
Utah	10.8	19.3	6.0	12.7
Total	316.6	513.3	5.0	562.7

[a] Because of rounding, column totals may not be exact.

Sources: U.S. Bureau of the Census (2008b); U.S. Department of Labor (2008d).

TABLE 4.17-9 Total State and Local Government Employment (thousands, except where noted)[a]

State	1995	2006	Annual Growth Rate 1990–2006 (%)	2010 (projected)
Arizona	218.8	285.1	2.4	314.5
California	1,479.6	1,818.7	1.9	1,899.5
Colorado	204.9	255.0	2.0	264.3
Nevada	73.5	103.3	3.1	115.0
New Mexico	110.7	127.9	1.3	132.0
Utah	104.8	128.8	1.9	136.2
Total	2,192.3	2,718.8	2.0	2,861.5

[a] Because of rounding, column totals may not be exact.

Source: U.S. Bureau of the Census (2008b).

Nevada, for example, increased employment by 3.1%, with a smaller increase in Arizona (2.4%). Most of the states were within half a percentage point of the regional average, while New Mexico (1.3%) experienced slower growth rates in government employment.

4.18 ENVIRONMENTAL JUSTICE

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," formally requires federal agencies to incorporate environmental justice as part of their missions (*Federal Register*, Volume 59, page 7629, February 16, 1994). Specifically, it directs them 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 solar energy development on environmental justice issues follows guidelines described in the Council on Environmental Quality's (CEQ's) *Environmental Justice Guidance under the National Environmental Policy Act* (CEQ 1997). The analysis method has three steps: (1) description of the geographic distribution of low-income and minority populations in the affected area; (2) assessment of whether the impacts of construction and operation would produce impacts that are high and adverse; and (3) if impacts are high and adverse, determination as to whether these impacts disproportionately affect minority and low-income populations.

Construction and operation of energy projects in the six-state study area could affect environmental justice if any adverse health and environmental impacts resulting from any phase of development were significantly high. If the analysis determines that health and environmental

impacts on the general population are not significant, there can be no disproportionate impacts on minority and low-income populations. If impacts are significant, disproportionality would be determined by comparing the proximity of any high and adverse impacts to the location of low-income and minority populations.

The analysis of environmental justice issues associated with the development of solar facilities considered impacts at the state level in six western states: Arizona, California, Colorado, Nevada, New Mexico, and Utah. A description of the geographic distribution of minority and low-income groups was based on demographic data from the 2000 Census (U.S. Bureau of the Census 2008b) to describe the minority and low-income composition in the affected area. The following definitions were used to identify 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, (2) Black (not of Hispanic 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 origin. 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 origin and as White or “Other Race” (U.S. Bureau of the Census 2008c).

  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.

  The PEIS applies both criteria in using the Census Bureau data for census block groups, wherein consideration is given to the minority population that is both more than 50% and 20 percentage points higher than in the state (as a whole) (the reference geographic unit).

- **Low-Income.** Individuals who fall below the poverty line are in the low-income category. The poverty line takes into account family size and age of individuals in the family. In 2009, for example, the poverty line for a family of five with three children below the age of 18 was $25,603. For any given 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 2008c).

Data in Table 4.18-1 show the minority and low-income composition of total population located in the six 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 can be of any race, this number includes individuals also identifying themselves as being part of one or more of the population groups listed in the table.

A large number of minority individuals reside in four of the six states potentially affected by solar developments on BLM land. In New Mexico, 55% of the population is classified as minority, with 53% in California, 36% in Arizona, and 35% in Nevada. While the state percentage of minority individuals does not exceed the six-state national average by 20 percentage points or more in any of the states, the number of minority persons in New Mexico and California exceeds 50% of the total population, meaning that these states have minority populations according to CEQ guidelines.

The proportion of low-income individuals does not exceed the six-state average by 20 percentage points or more in any of the states and does not exceed 50% of the total population in any of the states, meaning that there are no low-income populations in these states, according to CEQ guidelines.

TABLE 4.18-1 State Minority and Low-Income Populations for the Six-State Study Area

Category	Arizona	California	Colorado	Nevada	New Mexico	Utah
Total population	5,130,632	33,871,648	4,301,261	1,998,257	1,819,046	2,233,169
White, Non-Hispanic	3,274,258	15,816,790	3,202,880	1,303,001	813,495	1,904,265
Hispanic or Latino	1,295,617	10,966,556	735,601	393,970	765,386	201,559
Non-Hispanic or Latino minorities	560,757	7,088,302	362,780	301,286	240,165	127,345
One race	484,385	6,185,307	290,059	252,055	214,372	96,037
Black or African American	149,941	2,181,926	158,443	131,509	30,654	16,137
American Indian or Alaska Native	233,370	178,984	28,982	21,397	161,460	26,663
Asian	89,315	3,648,860	93,277	88,593	18,257	36,483
Native Hawaiian or other Pacific Islander	5,639	103,736	3,845	7,769	992	14,806
Some other race	6,120	71,681	5,512	2,787	3,009	1,948
Two or more races	76,372	903,115	72,721	49,231	25,793	31,308
Total minority	1,856,374	18,054,858	1,098,381	695,256	1,005,551	328,904
Low-income	698,669	4,706,130	388,952	205,685	328,933	206,328
Percent minority	36.2	53.3	25.5	34.8	55.3	14.7
Percent low-income	13.6	13.9	9.0	10.3	18.1	9.2

Source: U.S. Bureau of the Census (2008c).

4.19 REFERENCES

Note to Reader: This list of references identifies Web pages and associated URLs where reference data were obtained for the analyses presented in this PEIS. 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. The original information has been retained and is available through the Public Information Docket for this PEIS.

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5 IMPACTS OF SOLAR ENERGY DEVELOPMENT AND POTENTIAL MITIGATION MEASURES

5.1 INTRODUCTION

This chapter discusses potential positive and negative environmental, social, and economic impacts of utility-scale solar energy development. The types of solar technologies evaluated include those considered to be most likely to be developed at the utility scale during the 20-year study period evaluated in this programmatic environmental impact statement (PEIS), considering technological and economic limitations. These technologies include parabolic trough, power tower, dish engine, and photovoltaic (PV) technologies.

The purpose of this chapter is to describe a broad possible range of impacts for individual solar facilities, associated transmission facilities, and other off-site infrastructure that might be required to support utility-scale solar energy development. This impact analysis will inform the design of the U.S. Department of the Interior (DOI) Bureau of Land Management's (BLM's) Solar Energy Program and the U.S. Department of Energy's (DOE's) programmatic guidance, including the identification of measures to avoid, minimize, and mitigate potential impacts associated with solar energy development (see Sections 2.2.2 and 2.3.2, respectively)

This chapter identifies the range of possible impacts on resources present in the six-state study area. The assessment considers both direct and indirect impacts. Direct impacts are those effects that result solely and directly from the proposed solar energy development, such as soil disturbance, habitat fragmentation, or noise generation. Indirect impacts are those effects that are related to the proposed development but are the result of some intermediate step or process, such as changes in surface water quality because of soil erosion at the construction site. The impact assessment is discussed in terms of common impacts (impacts that occur for all types of solar energy facilities) and technology-specific impacts.

Since most locations on eligible BLM-administered lands are within 25 mi (40 km) of existing transmission lines (see Appendix G) and the distance to state or U.S. highways is generally less than that, land disturbance for transmission and road construction associated with solar facility development is likely to be limited to corridors of 25 mi (40 km) length or less. However, in this chapter impacts from construction and operation of new transmission lines are described generically, without assumptions on the length of the new transmission lines or new roadways that would be required for solar energy facilities. Land disturbance impacts from transmission line upgrades that might be required are conservatively assumed to be similar to those from new transmission line construction (this could be the case if it is a large upgrade, for example, from a 69-kilovolt (kV) line to a 230-kV or larger line). Any transmission line construction associated with solar facilities that would occur on federally managed lands would comply with requirements contained in the Memorandum of Understanding regarding coordination in federal agency review of transmission facilities on federal land (USDA et al. 2009). New transmission line construction within Section 368 corridors designated in the Record of Decision (ROD) for the *Programmatic Environmental Impact Statement for*

Designation of Energy Corridors on BLM-administered Lands in the 11 Western States (DOI and DOE 2008) would be subject to the Interagency Operating Procedures (IOPs) adopted for transmission lines in Appendix B of that ROD.

The assumed range of capacities in megawatts (MW) for the solar energy facilities evaluated was based on a review of existing and planned facilities. The assumptions on the range of facility capacities and corresponding land use and water requirements are presented in Section 3.1.5. These assumptions have been used to establish likely ranges of impacts in this chapter.

For each resource, potential mitigation measures that could be used to avoid, eliminate, or minimize impacts from solar energy development have been identified. These potential mitigation measures were derived from comprehensive reviews of solar energy development activities (as described in Chapter 3); published data regarding solar energy development impacts; existing, relevant mitigation guidance (see Section 3.7); and standard industry practices. Many of these measures are accepted practices known to be effective when implemented properly at the project level. Their applicability and effectiveness cannot be fully assessed except at the project-specific level when the project location and design are known.

Many of the potential mitigation measures indicate the need for project-specific plans (see Table 5.1-1). The content of these plans will depend on specific project requirements and locations, and their applicability and effectiveness also needs to be evaluated at the project-specific level. The authorizing agency or agencies (e.g., BLM, DOE, or state agencies) would need to determine the adequacy of such plans for specific projects.

The relevant potential mitigation measures described in Sections 5.2 through 5.21 have been further evaluated by the BLM to identify those appropriate for adoption as design features for inclusion in BLM's Solar Energy Program. Design features are defined as those specific means, measures, or practices that have been incorporated into the proposed action and alternatives to avoid or reduce adverse impacts (BLM 2008a); they can also be described as required best management practices. The proposed design features are listed in Appendix A, Section A.2.2.

5.2 LANDS AND REALTY

The specific impacts of development of utility-scale solar energy facilities would depend on project location, solar technology employed, size of the development, and proximity to existing roads and transmission lines. On the basis of the assumptions on size of facilities given in Section 3.1.5, the maximum area of land disturbance for single facilities would be about 2,000 acres (8 km^2) for a 400-MW parabolic trough facility and about 3,600 acres (14.6 km^2) for a 400-MW power tower, dish engine, or PV facility. The following sections discuss the common impacts on different types of resources and land uses and potential mitigation measures that may be applicable on a site-by-site basis.

TABLE 5.1-1 Mitigation Plans to Minimize Environmental Impacts of Utility-Scale Solar Energy Facilities[a]

Access Road Siting and Management Plan
Compensatory Mitigation and Monitoring Plan
Construction and Operation Waste Management Plan
Cultural Data Recovery Plan
Cultural Resources Monitoring and Mitigation Plan
Decommissioning and Site Reclamation Plan
Drainage, Erosion, and Sedimentation Control Plan
Dust Abatement Plan
Ecological Resource Mitigation and Monitoring Plan
Fire Management and Protection Plan
Glint and Glare Assessment, Mitigation, and Monitoring Plan
Habitat Restoration and Management Plan
Hazardous Materials and Waste Management Plan
Heliostat Positioning Plan
Historic Properties Treatment Plan
Integrated Vegetation Management Plan
Lighting Plan
Nuisance Animal and Pest Control Plan
Paleontological Resources Management Plan
Spill Prevention and Emergency Response Plan
Stormwater Management Plan
Traffic Management Plan
Trash Abatement Plan
Unanticipated Burial Contingency Plan
Water Resources Monitoring and Mitigation Plan
Wind Erosion Management Plan

[a] The need for each plan will need to be determined for specific projects.

5.2.1 Common Impacts

Public lands within the six-state study area where utility-scale solar energy development might occur support a wide variety of activities, as described in Chapter 4. Many of these uses have been established by the BLM in existing land use plans that were prepared in concert with the public, states, Tribes, and other interested entities. Uses of public lands have also been authorized through the issuance of rights-of way (ROWs). The objective of the BLM's Lands and Realty Program is to issue ROWs on public lands to any qualified individual, business, or government entity consistent with existing land use plans and pursuant to the applicable regulations. Examples of some of the uses of public lands include transmission lines, roads and highways, public buildings, pipelines, and various types of communication facilities. Most facilities are authorized for a specific time period, commonly 30 years, and for that period of time the authorized facility has a prior existing right for use of the public land. Development of

solar energy facilities would be subject to the rights of holders of existing ROWs, and the BLM may not force changes in existing ROW authorizations. If a holder of a ROW agreed to modify an existing ROW, the solar energy project developer likely would be financially responsible for the cost of any modifications. Once a solar facility is authorized, the area would be excluded from use for other lands and realty purposes inconsistent with operation of the solar facility. Because of the potentially large size of utility-scale solar facilities, these exclusions could serve as substantial barriers to other lands and realty uses.

In addition to direct impacts, there may also be indirect impacts on lands and realty associated with solar energy development. The indirect impacts would be associated with changes to existing uses on public, state, and private lands that surround or are near solar energy facilities. Examples of these indirect impacts could include conversion of land in and around local communities from agricultural, open space, or other uses to provide services and housing for employees and families who move to the region in support of solar energy development. Increased traffic and increased access to previously remote areas also could change the overall character of the landscape, including the visual quality of large areas. These indirect impacts would likely vary project by project and would need to be analyzed at the site-specific level.

Because of the large land area needed for solar facilities, solar energy development would fragment large blocks of public land and may create isolated public land parcels that would be hard to manage. Topography, land ownership pattern, existing land use designations (e.g., wilderness), and new access routes or transmission facilities are examples of features that could all combine with a solar energy development to create fragmentation of public lands. Private and state lands, where they are present in close proximity to solar energy facilities, could also be affected. There is also the potential to sever access routes and to adversely affect uses of other public, state, and private lands including lands managed by other federal agencies. The potential magnitude and nature of these impacts should be considered in project-specific analyses.

In most areas of public land in the study area, solar energy development would create an industrial landscape in stark contrast to the character of the existing undeveloped landscape. These developments would be visually intrusive and would affect lands that surround them. This would be especially true for lands with special designations based on wilderness and scenic values, including National Parks and Monuments and components of the National Landscape Conservation System (NLCS). If commercial-scale solar energy facilities are widely spread throughout the study area, there is a high likelihood a treasured quality of many western public lands, the long vistas of undeveloped land, would be substantially altered.

There is potential for impact on land values in areas near solar energy facilities and associated ROWs. Some reasons that land values could be reduced include aesthetic concerns, changes in the amount of vehicular traffic, or changes in current operations (e.g., the removal of a substantial or critical part of a grazing operation). Alternatively, land values could increase because of additional demand for developable private lands to support solar development. Potential impacts on land values are further discussed in Section 5.17.

Access to electrical transmission facilities is a major factor in siting utility-scale solar facilities, and availability of established and adequate transmission corridors is becoming critical, especially as the demand for renewable energy sources increases. The potential exists for requests for solar facilities to be located within existing designated corridors. If approved, these facilities would result in a reduction of the land available for use for other transmission facilities, unless the solar energy application is amended to accommodate other transmission facilities or the corridor itself is modified to maintain its planned capacity

The BLM is the agency responsible for maintaining the nation's cadastral survey system, the public land surveys that create, mark, define, retrace, or re-establish the boundaries and subdivisions of the public lands of the United States. Evidence of these surveys is found throughout the six-state study area, principally in the form of small monuments that mark section corners and smaller subdivisions of the land. Protection of these monuments is a matter of law (*United States Code*, Title 18, Section 1858 [18 USC 1858] [62 Statute 789]) and of great importance. Because of the surface disturbance associated with solar energy development, arrangements will need to be made to protect or relocate these monuments wherever they are found.

5.2.1.1 Construction and Operations

There are no impacts on lands and realty specific to construction and operation of solar energy facilities. Impacts on other uses of lands are discussed above in Section 5.2.1 on common impacts.

5.2.1.2 Transmission Lines and Roads

Utility-scale solar energy facilities would require ROWs and construction of additional transmission facilities to connect to regional energy grids. Connection to existing transmission facilities requires analysis by the transmission line owner to determine capacity of the existing line and to determine how the additional input to the line might affect overall reliability. These complex processes can take months to complete. The reliability requirements for these studies are set by the Federal Energy Regulatory Commission (FERC), but construction of new transmission facilities is regulated by state utility commissions and is subject to each state's requirements including review processes.

Additional new road construction or upgrades of existing roads to provide for reliable construction and operations access to solar development sites would be required in many cases. Connection of new roads on solar energy sites to existing roads would require permits from the federal, state, or local authorities with responsibility for management of the roads.

Although transmission corridors and related facilities and roads already exist on public lands in many parts of the study area, new corridors, additional transmission facilities, and new or upgraded roads would be needed. Transmission facilities and roads could be built on public, state, Tribal, or private lands. In the construction of such facilities on private, state, or Tribal

lands, cooperation of the landowners would be required. In any construction of these facilities on state or private land, prime or unique farmland could be affected, and impacts on these classes of land would have to be evaluated as part of the environmental analysis process.

Transmission facilities, although they do not completely exclude other uses, limit the uses of the land on which they are located and would have a long-lasting impact on future land uses. Construction of new transmission facilities would result in both direct and indirect impacts. Direct impacts, such as the loss of land to physical structures, effects on wildlife from keeping ROWs free of major vegetation, maintenance of service roads, and increased traffic along transmission maintenance roads, would last as long as the transmission lines are in place. Indirect impacts, such as the introduction of or an increase in recreational use due to improved access, avoidance of an area for recreational use for aesthetic reasons, introduction of invasive species along service roads, and adverse impacts on scenic viewsheds, also would occur.

5.2.2 Technology-Specific Impacts

On the basis of the assumed amount of land required for comparable electricity-generating capacity, power tower, dish engine, and PV technologies could require about 80% more land area than parabolic trough technologies, resulting in larger areas being excluded from other uses. However, the technology-specific land use estimates are primarily based on proposals for solar facilities on BLM-administered lands. The actual amount of land required for specific solar energy facilities will vary based on site-specific assessments of areas that need to be avoided and required distance from other pre-existing structures.

5.2.3 Potentially Applicable Mitigation Measures

- Where there are existing BLM ROW authorizations within solar energy development areas, pursuant to Title 43, Part 2807.14 of the *Code of Federal Regulations* (43 CFR 2807.14), the BLM would notify ROW holders that an application that might affect their existing ROW has been filed and would request their comments. Early discussion with existing ROW holders should occur to ensure their rights are protected and any issues are resolved.

- Where a designated transmission corridor is located within the area of proposed solar energy development project, the need for future transmission capacity in the corridor should be reviewed to determine whether the corridor should be excluded from solar development or whether the capacity of the designated transmission corridor can be reduced. Partially relocating the corridor to retain the current planned capacity would also be an option to consider, as will relocating the solar project outside the designated corridor.

- Legal access to private, state, and public lands surrounding the solar facilities should be retained to avoid creating areas that are inaccessible to the public and/or that would be difficult to manage. The effect on the manageability and

uses of public lands remaining around boundaries of solar energy facilities should be considered during the environmental analysis of project applications.

- Coordination with federal, state, and county agencies; Tribes; property owners; and other stakeholders should be accomplished as early as possible in the planning process to identify potentially significant land use conflicts and issues and state and local rules that govern solar energy development. Significant issues that are raised, and potential modifications to proposed projects to eliminate or mitigate these issues, should be considered in the environmental analysis of the project application.

- Consolidation of access and other supporting infrastructure should be required for single projects and for cases in which there is more than one project in close proximity to another to maximize the efficient use of public land.

- The protection and preservation of evidence of the Public Land Survey System (PLSS) and related federal property boundaries are required of project developers. Prior to commencing any action, evidence of the PLSS and related property boundaries will be marked for protection. Coordination with BLM cadastral survey staff should be accomplished to help provide data, search for and evaluate evidence, locate monuments of the PLSS and related property boundaries, and protect them from destruction. If a proposed action is within one-quarter mile of any project boundary, a Chain of Survey Certificate, conformal to the departmental standard, must be issued. In some cases, Land Description Reviews, Certificates of Inspection and Possession, Boundary Assurance Certificates, resurveys, re-monumentation, and/or referencing of PLSS corners may be required before the start of any action.

- If a proposed action might have an adverse effect on prime and unique farmland, this possibility should be discussed in the associated environmental analysis, along with a consideration of alternatives or appropriate mitigation measures.

- For solar energy and related transmission facilities, the hazards associated with the heights of facilities and the glare from reflective surfaces should be evaluated through coordination with local airport operators. Proposed construction of any facility that is taller than 200 ft (61 m) must be submitted to the Federal Aviation Administration (FAA) for evaluation of safety hazards.

5.3 SPECIALLY DESIGNATED AREAS AND LANDS WITH WILDERNESS CHARACTERISTICS

As defined in Section 4.3, specially designated lands under BLM administration include components of the NLCS, Special Recreation Management Areas (SRMAs), Desert Wildlife

Management Areas (DWMAs, found only in California), and Areas of Critical Environmental Concern (ACECs) are excluded from solar energy development because they contain outstanding cultural, ecological, resource, or scientific values. Categories of NLCS lands include Wilderness Areas (WAs), Wilderness Study Areas (WSAs), Instant Study Areas (ISAs), National Conservation Areas (NCAs), National Monuments, Wild and Scenic Rivers (WSRs), and National Historic and Scenic Trails. SRMAs, DWMAs, and ACECs are designated at the BLM field office level through the BLM's land use planning process to protect the identified values within these areas (see Section 2.2). In addition, areas that the BLM has determined to possess wilderness characteristics, and for which decisions have been made to manage so as to protect wilderness characteristics through the land use planning process, are also excluded from solar energy development.

Impacts on additional areas considered in this section include public lands that BLM has determined to possess wilderness characteristics; areas that have been proposed by citizens' groups for wilderness designation; and areas managed or designated by other federal, state, and local agencies that could be indirectly affected by development of utility-scale solar energy development on public lands adjacent to or near these areas. Examples of such areas include units of the National Park and National Refuge Systems and state parks.

5.3.1 Common Impacts

While the BLM has excluded certain specially designated areas with sensitive resources from application for solar development and these areas would not incur direct impacts from solar energy development, these excluded areas may, however, incur indirect impacts from solar energy development on BLM-administered lands adjacent to and/or within the viewshed of the excluded areas. These impacts could include adverse visual effects on the viewshed of these areas (including impacts on the night sky viewing), adverse impacts on wilderness characteristics, reduced recreation use, fragmentation of biologically linked areas, and loss of public access.

A category of lands available for application for solar energy development and associated ROWs is land that has been recognized by the BLM as possessing wilderness characteristics,[1] but that is not identified as a WSA and for which planning decisions have not been made to protect those wilderness characteristics. Another category of lands available for application include those that have not been inventoried recently for wilderness characteristics and lands that have been identified in a citizen's wilderness proposal. Utility-scale solar energy development activities and the development of associated transmission facilities, within, adjacent to, or near

[1] These may also be described as wilderness values or character. Wilderness characteristics include (1) *naturalness*: the area generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) *outstanding opportunities*: the area has either outstanding opportunities for solitude or outstanding opportunities for primitive and unconfined types of recreation; (3) *size*: the area is at least 5,000 acres (20 km^2) of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) *values*: the area may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value (BLM 2010).

these areas likely would adversely affect or eliminate the wilderness characteristics in all or portions of these areas depending site- and project-specific conditions. BLM field offices would make decisions regarding the management of these areas with wilderness characteristics, either for solar energy development or for protection of their wilderness character, through the BLM planning process and National Environmental Policy Act of 1969 (NEPA) analyses for site-specific solar energy proposals.

There are other specially designated areas with sensitive resources not administered by the BLM that would be subject to indirect impacts from development of solar energy facilities similar to those listed above. These include units of the National Park System, National Heritage Areas, units of the National Wildlife Refuge System, scenic byways, scenic highways, un-inventoried (or un-evaluated) portions of historic trails, state parks and wildlife areas and other locally significant areas or attractions. Public lands adjacent to these areas may be open to application for solar energy development. Specific impacts on these areas would be assessed as part of the analysis of individual solar projects. Additional information on indirect impacts on these resources can be found in other sections in this chapter.

5.3.2 Technology-Specific Impacts

The impact on specially designated areas or areas with wilderness characteristics either adjacent to solar energy facilities or transmission facilities, or within the viewshed of such development, could vary by technology. A primary impact of the solar facilities would be on the visual resources of the area(s), affecting the visitor experience within these areas and the level of visitor use. Impacts on wilderness characteristics would largely involve reduced opportunities for solitude or outstanding opportunities for primitive and unconfined types of recreation. If views of heavily developed, industrial-looking areas from within wilderness areas are considered, it is also likely that the naturalness of wilderness areas would also be adversely affected. These same impacts may apply to other specially designated areas, including units of the National Park System, some SRMAs, and some state and local areas. Specific visual impacts of solar facilities would include high contrast with surrounding, undeveloped areas, glint and glare, plumes of dust or steam, and presence of night lighting. The visibility of solar energy and transmission facilities is dependent upon the height, contrast, and proximity of the facilities to the sensitive areas; the character of the land in which the facilities are located; the height and distance from which solar facilities would be viewed; and other factors (see Section 5.12 for more detailed discussion of visibility factors).

Depending on the size and location of the solar energy development and the species present in nearby specially designated areas, biological connectivity between specially designated areas could be severe, which could lead to genetic isolation of populations and eventually to a reduction in the values for which the areas were designated. The same loss of connectivity could affect recreational use in some areas, as well as the values for which the areas have been designated.

5.3.3 Potentially Applicable Mitigation Measures

- Solar facilities should be located and designed to minimize impacts on specially designated areas and lands with wilderness characteristics.

- Protection of existing values of specially designated areas and lands with wilderness characteristics should be evaluated during the environmental analysis of solar energy project applications, and the results should be incorporated into the project planning and design to minimize off-site impacts.

- Any lands that have not been recently inventoried for wilderness characteristics or any lands that have been identified in any citizen's wilderness proposal should be inventoried for wilderness characteristics prior to any solar development action being approved within these areas.

5.4 RANGELAND RESOURCES

Rangeland resources would be affected by utility-scale solar energy development in several ways. All or portions of current livestock grazing allotments within solar development areas would be closed to grazing. Solar energy facilities would also affect wild horse and burro management areas; facilities also would have implications for management of wildland fire. These topics are discussed in the following subsections with respect to common impacts of solar development projects from the construction and operation of solar energy facilities and in terms of impacts of specific solar technologies. Potentially applicable mitigation measures addressing these impacts are then presented.

5.4.1 Livestock Grazing

5.4.1.1 Common Impacts

5.4.1.1.1 Construction and Operations. Many BLM-administered lands within the six-state study area are classified as open to livestock grazing; however, grazing activities would be excluded from areas developed for utility-scale solar energy production. On public lands being considered in this PEIS, about 104,929,097 acres (424,623 km^2) is located within grazing allotments. Where grazing occurs on public lands, it is authorized either through a grazing permit or lease. BLM grazing regulations provide that permits or leases can be cancelled with a 2-year notification to the grazing permittee (CFR 4110.4-2(b)). The grazing regulations also provide for reimbursement to grazing permittees for their share of the value of grazing improvements. All or portions of grazing permits or leases within areas developed for solar energy production would be cancelled or modified. Depending on conditions unique to an individual grazing operation, reductions in authorized grazing use may be necessary because of the loss of all or a portion of the forage base and/or range improvements (e.g., fencing, water development, seedings)

supporting the grazing operation within the solar energy development area. Livestock grazing on public lands is the main source of livelihood for many public land ranchers, and significant reductions in permitted grazing would adversely affect the economic value of ranches and could threaten their continued viability.

Indirect impacts on livestock grazing such as loss of forage due to spread of noxious weeds and increases in occurrence of wildland fire from construction and operation activities could also occur. There could also be negative impacts on livestock distribution from noise and disturbance during each phase of project construction, which in turn could negatively affect vegetation within the allotment. With increased traffic in an allotment, there also is potential for fence gates to be left open, increasing the difficulty and cost of managing livestock

In addition to economic impacts, cultural or social impacts may also result from the modification or loss of grazing privileges since for many permittees and their families having grazing allotments on public lands has been a longstanding and important tradition.

5.4.1.1.2 Transmission Lines and Roads. Transmission line ROWs associated with solar facilities would not prevent the use of the land for grazing other than in the areas physically occupied by transmission towers and service roads. Construction of additional roads and increased traffic accessing solar development sites or transmission line roads would increase the possibility of cattle being injured or killed.

5.4.1.2 Technology-Specific Impacts

On the basis of the amount of land required for comparably rated facilities, power tower, dish engine, and PV technologies require about 80% more land area than parabolic trough technologies, resulting in larger areas being excluded from grazing use.

5.4.1.3 Potentially Applicable Mitigation Measures

- Contact with grazing permittees should be initiated at the earliest possible time to explore whether modifications could be made to a solar development proposal to minimize impacts on grazing use; especially impacts related to water availability, livestock improvements, access road location, and movement of livestock between pastures. Compensation for or relocation of range improvements also should be discussed. The ROW applicant and permittee/lessee should be strongly encouraged to enter into an agreement that addresses mitigation and compensation for range improvements.

- Access roads should be constructed, improved, and maintained to minimize their impact on grazing operations. Road design would include appropriate fencing, cattle guards, and signs.

- Wherever there are reductions in grazing use, opportunities for mitigating this loss through changes in livestock management or installation of range improvements should be considered.

5.4.2 Wild Horses and Burros

5.4.2.1 Common Impacts

5.4.2.1.1 Construction and Operations. Areas available for application for solar energy development may overlap with BLM wild horse or burro herd management areas (HMAs). The management of wild horses (*Equus caballus*) and burros (*E. asinus)* is not compatible with utility-scale solar energy development. Animals would be displaced from the areas of solar development, and depending upon the conditions in the individual HMA, it might be necessary to reduce the appropriate management level (AML, the maximum number of animals sustainable on a yearlong basis) to match forage availability on the remaining portion(s) of HMAs. A reduction of AML could necessitate the gathering, care, and holding of animals in excess of the revised AML. This would be subject to the requirements of the Wild Free-Roaming Horses and Burros Act of 1971 and can be a lengthy, time-consuming effort that would be subject to manpower and budget constraints. Excess animals could be put up for adoption, sold (if more than 10 years old or previously passed up for adoption), or sent to federally funded sanctuaries or long-term holding facilities. If horses or burros migrate outside HMA boundaries because of the disturbance within the HMA due to solar energy development activities, they could also be gathered, removed, and placed in the BLM wild horse and burro adoption program.

Construction noise could cause a localized disruption to wild horses, particularly during the foaling season (BLM 2009a). In addition, vegetation clearing, habitat fragmentation, disturbance by human activities, and blockage of movement due to solar facility development could affect wild horses and burros, depending on the proximity of the HMAs to solar development locations.

5.4.2.1.2 Transmission Lines and Roads. During construction of transmission lines and roads, potential loss of forage for wild horses and burros would occur in the areas being cleared of vegetation. Disturbances caused by construction activities could also displace wild horses and burros. Once constructed, transmission line facilities would not prevent use of the land by horses or burros other than in the areas physically occupied by the facilities such as the support towers and substations. However, they could be subject to disturbance or harassment from people using the ROWs for access. Construction of additional roads and increased traffic would increase the possibility of horses and burros being hit and killed in areas near the solar facilities.

5.4.2.2 Technology-Specific Impacts

On the basis of the amount of land required for comparably rated facilities, power tower, dish engine, and PV technologies require about 80% more land area than parabolic trough technologies, resulting in larger areas being excluded from use by wild horses or burros.

5.4.2.3 Potentially Applicable Mitigation Measures

- Activities of project developers should be coordinated with the managing agency to ensure that impacts on wild horses and burros and their management areas are minimized. Issues that would need to be addressed could include the installation of fencing and access control, provision for movement corridors, delineation of open range, traffic management (e.g., vehicle speeds), compensatory habitat restoration, and access to or development of water sources.

- Access roads should be appropriately constructed, improved, and maintained and should employ appropriate signs to minimize potential horse and burro collisions. Fences should be built (as practicable) to exclude wild horses and burros from all project facilities, including all water sites built for the development of facilities and roadways.

5.4.3 Wildland Fire

5.4.3.1 Common Impacts

5.4.3.1.1 Construction and Operations. Many areas within the six-state PEIS study area are currently susceptible to wildland fire and have established fire regimes. Solar energy facilities are generally designed to eliminate flammable vegetation within the development perimeter and generally pose little threat of increasing wildland fire risk during their operation. However, the electrical substations of solar energy facilities do present a potential fire hazard associated with the modification of the voltage and current phase of the generated electrical power to be compatible with conditions on the grid to which the facility is connected. Additionally, any solar facility can indirectly create increased fire risk because of the operation of internal combustion vehicles and equipment in dry desert environments or because invasive species are allowed to become established within the facility's footprint from improper vegetation management.

During construction, the storage and dispensing of vehicle and equipment fuels on site, the presence of other flammable or combustible materials used in construction, and welding and other activities involving open flames can increase fire risk. Specifically for fire safety, material and equipment laydown areas, as well as active construction areas, are typically cleared of

vegetation to lessen the fire risk. Limiting the amount of flammable materials on site, suspending certain activities during weather conditions most conducive to fires (hot, dry, windy periods), and properly designed and maintained fuels and material storage facilities are common practices intended to lessen fire risk during construction.

5.4.3.1.2 Transmission Lines and Roads. Additional roads providing access to solar energy sites and supporting construction and maintenance of transmission facilities could increase fire occurrence because of increased human activity and vehicle traffic. New or increased vehicle use could also inadvertently aid in the spread of noxious weeds. Because of the wide variety in vegetative types in areas where solar development might occur, assessment of added fire risk must be conducted at the site-specific level and take into account the vegetative types present, historical fire patterns, and any additional factors that might affect wildland fire activity. Should fire activity increase because of human activity, there would be additional need for the BLM and other fire organizations to respond to suppress these fires, resulting in an increase in fire suppression costs. Disturbance of native vegetation communities caused by construction of transmission lines and associated roads also could lead to an increase in the frequency of wildland fires. Any increase in wildland fire frequency could have a destabilizing effect on the local vegetative community and could lead to establishment of a plant community dominated by non-native, invasive, and fire-tolerant species that provide flash fuels and facilitate the spread of wildland fire.

Once operational, transmission lines present a potential for wildfires as a result of electrical discharges or extremely hot components of malfunctioning equipment (transformers, switches, capacitors, and the like) or ground faulting of energized conductors against their support poles, other energized conductors, vegetation, structures, or other ground obstacles in or near the transmission ROW. Although designs typically include some form of lightning protection, conductor support structures can attract lightning strikes and thus also represent a risk of wildfires. Smoke from nearby fires that envelops two energized conductors at different voltage can cause arcing and faulting that can lead to a fire because of the conductive nature of the particulates in the cloud.

Vegetation management plans for transmission lines passing through forested areas often require the elimination of trees to prevent ground faulting, allowing the transmission line ROW to act as a fire break should fires be initiated by other causes elsewhere within the forest.

5.4.3.2 Technology-Specific Impacts

During operation, all solar facilities present fire risks at various locations within their solar fields and power blocks as a result of electrical shorts or electrical equipment malfunctions. Such risks are minimized through proper design and maintenance of components involved in power distribution and transfer; the use of over-current protection devices; control of vegetation that could contribute fuel; posting of warning signs; and control of access to high electrical-hazard areas. For any solar technology, the greatest fire risks exist at the electrical substations, because the power they generate is modified with respect to voltage and current phase to be

compatible with conditions on the grid to which the facility is connected. Properly protected (grounded) electrical equipment, incorporation of circuit breakers or other over-current protection devices, routine inspections for leaks and deterioration, the use of nonflammable dielectric media where possible, engineered barriers to prevent access by unauthorized individuals or wildlife, and maintaining the substation in a vegetation-free condition are typical strategies for reducing fire risks from substations.

Parabolic trough and power tower facilities present fire risks as a result of extremely hot heat transfer fluids (HTFs), some of which is flammable, circulating between their solar fields and the heat exchanger (or molten salt storage tank) located at the power block, or from the operation of natural gas- or propane-fired boilers that are often integrated into the design of concentrating solar power (CSP) facilities to facilitate rapid morning start-ups. Facilities utilizing concentrating mirrors, such as parabolic trough facilities and solar dish engine facilities, can also present a fire risk as a result of misaligned mirrors focusing their concentrated solar energy on any vegetation present.

Solar dish engine facilities present unique fire risks because of their use of highly flammable hydrogen gas as a working fluid in the Stirling engine, with each such engine supported by its own compressed gas tank of hydrogen or, alternatively, with all engines supported by a centrally located hydrogen distribution facility. Electrical hazards also exist near the transformers that may be positioned at the base of each Stirling dish engine support tower. Finally, indirectly, any solar facility can create increased fire risk because of the operation of internal combustion vehicles and equipment in dry desert environments or because invasive species are allowed to become established within the facility's footprint from improper vegetation management.

5.4.3.3 Potentially Applicable Mitigation Measures

- In areas susceptible to wildland fires, coordination with the managing agency and local fire organizations should be required early in the project planning process to determine mitigation measures that would be incorporated into the design of the project to prevent an increase in wildland fire frequency.

- A vegetation plan designed to prevent the establishment of non-native, invasive species on the solar energy facility and along transmission line ROWs and roads should be developed and implemented to minimize the potential for increasing the frequency of wildland fires.

- The ROWs for solar facilities should be large enough to ensure there is a sufficient firebreak inside the ROW, so there would be no threat to facilities from either a wildland fire approaching from outside the ROW or a fire moving from inside to outside of the ROW. This distance should be determined through coordination with fire management staff, and actions, both active and passive (e.g., vegetation manipulation) should be undertaken

specifically to remove the need for protective responses, by the managing agency, state, and local fire organizations.

- The effectiveness of developing and adhering to a fire safety plan and providing worker training to reduce fire risks should be evaluated.

5.5 RECREATION

Recreation use would be excluded from all areas developed for solar energy facilities and could also have impacts on recreational use of lands located nearby, including lands not administered by BLM. The following subsections identify recreational uses that would be affected, common and technology-specific impacts from solar development, and potentially applicable mitigation measures.

5.5.1 Common Impacts

5.5.1.1 Construction and Operations

Utility-scale solar energy development is not compatible with recreation uses (e.g., hiking, biking, back country driving, hunting, bird watching, OHV use, and camping), and the direct impact of solar development is the exclusion of recreational use from areas developed for solar energy production. In addition, indirect effects on recreation use would occur primarily on lands near the solar facilities and would result from the change in the overall character of undeveloped BLM-administered lands to an industrialized, developed area, displacing people who are seeking more rural or primitive surroundings for recreation. Changes to the visual landscape, impacts on vegetation, development of roads, and displacement of wildlife species resulting in reduction in recreational opportunities could degrade the recreational experience near where solar development occurs. This reduction in recreation use could also occur on specially designated areas, as discussed in Section 5.3. The potential exists to sever informal access routes[2] if these routes pass through solar development areas and they are closed to public use. In addition to public lands, state and private lands also could be affected.

Many BLM field offices have completed planning activities to designate lands for OHV use. Areas open to application for solar energy development may be currently available for OHV use, and solar development in these areas would displace this use. ROW applications for solar facilities may include areas containing designated open OHV routes, thereby eliminating public access along those routes.

[2] This is in contrast to access routes with legal access, such as county roads or road ROWs granted by BLM, which would be prior existing rights.

5.5.1.2 Transmission Lines and Roads

Transmission line ROWs would cause less impact on recreation users than solar energy facilities. Access to the land in transmission ROWs would not be precluded; however, depending on the type of recreation, the overall recreational experience could be adversely affected by the visual disturbance to the landscape, potential noise impacts associated with overhead transmission lines, and increased traffic on service roads. Transmission line service roads may provide additional opportunity for backcountry driving and/or provide new or better access to some areas; conversely, the impacts of additional road access in areas without existing roads could also lead to degradation of these areas.

5.5.2 Technology-Specific Impacts

On the basis of the amount of land required for comparably rated facilities, power tower, dish engine, and PV technologies require about 80% more land area than parabolic trough technologies, resulting in larger areas being excluded from recreation use. In addition, because of the height of the structures, a power tower facility would be more visible over longer distances and would potentially affect recreation users over a larger area.

5.5.3 Potentially Applicable Mitigation Measures

- Public access through or around solar facilities should be retained to permit continued use of public lands and non-BLM administered lands.
- Solar facilities should not be placed in areas of unique or important recreation resources.
- Replacement of access lost for OHV use should be considered as part of the analysis of project-specific impacts. Any process for designating a replacement route would include the consideration of the designation criteria for routes as specified in 43 CFR 8342.1, and would be consistent with existing land use plans.

5.6 MILITARY AND CIVILIAN AVIATION

Developers of solar energy facilities would have to consider the needs of, and likely restrictions posed by, nearby military and civilian aviation facilities, installations, airspace, and activities. The following subsections identify military and civilian aviation and other considerations affecting solar development, common and technology-specific considerations, and potentially applicable mitigation measures.

5.6.1 Common Impacts

Development of utility-scale solar facilities has the potential to affect both military and civilian aircraft operations, radar use, and other operations. Numerous civilian airfields, military

training routes (MTRs), and special use airspace (SUA) areas are located within the six-state study area. The military airspace in the study area is intensively used and is important to maintaining overall training and readiness for all branches of the military. Many issues must be considered as part of the decision-making process in siting both utility-scale solar energy production facilities and transmission facilities, especially intrusion of facilities into low-level airspace in military training areas and near military and civilian airports. If the project site is in the proximity of a military or civilian airport or a common aircraft flight path, the potential for glint and glare from reflective surfaces to adversely affect pilot control of aircraft would have to be considered as potential aircraft hazards. Consideration of the effect of military overflights, especially supersonic flights, on solar facilities should be considered (e.g., the potential for solar field equipment damage) as part of project design and location.

In addition, effects on airborne and ground-based radars including weather radar must be understood. Also, potential effects on aircraft performance and on pilots, such as the creation of thermal plumes, glare, and light pollution in both the visible and infrared spectra, are poorly understood and require further study. Finally, many planned solar facilities use wireless-controlled aiming devices to focus reflected sunlight on collecting towers. The effects of airborne electronic jamming in nearby military operating areas are not understood and could conceivably cause the mirrors to point in an unintended direction, thereby creating a potential safety-of-flight or other concerns.

The potential for displacing sensitive species from solar energy development areas onto military reservations and/or simply increasing the significance of sensitive species on military reservations after disturbance of areas developed for solar energy production is also a consideration. Any potential for impact on the function of a military reservation because of an increase in the importance of sensitive species found on the reservation would be considered as part of the analysis of any solar energy development proposal.

The Federal Aviation Administration (FAA) will be involved in reviewing potential air space conflicts including any solar energy facility construction proposed in proximity to civilian airports. The Obstruction to Navigation Federal Regulation (49 CFR Part 77) requires FAA approval of any project higher than 200 ft (61 m) in height. An FAA finding of No Hazard to Air Navigation does not address all military airspace and other issues; coordination with the military command responsible for management of the training space (military operating areas [MOAs], MTRs, SUAs) is still required.

5.6.2 Technology-Specific Impacts

Solar power tower facilities with tall towers and all transmission lines or transmission towers associated with facilities using any of the solar technologies could pose a potential obstruction hazard to aircraft navigation. These structures have the greatest likelihood for conflict with military or civilian aviation. Because of the density and sensitivity of existing MTRs, almost any solar development in the six-state study area will require coordination with military users.

If power tower facilities are close to a civilian airport or are in the flight path of airplanes, then the height of the tower and the glare from the heliostat mirrors should be considered as potential hazards for low-flying aircrafts.

5.6.3 Potentially Applicable Mitigation Measures

- Decisions regarding the location of solar facilities and transmission facilities near or within MTRs or adjacent to military or civilian airports should be coordinated with military and civilian airspace managers very early in the processing of solar project applications, in order to identify and mitigate potential impacts on military and civilian airport and airspace use.

- The FAA shall be contacted early in the process of considering a solar energy project application to determine if there might be any potential impacts on aviation and if any mitigation might be required to protect military or civilian aviation use.

- As part of the evaluation of impacts from the development of solar energy facilities, their potential for impacting the operation of existing military installations, either because they displace species onto an installation or because they increase the significance of special status species populations on the installation, should be included as part of the environmental impact analysis of the solar energy project.

5.7 GEOLOGIC SETTING AND SOIL RESOURCES

Solar energy development would have a number of impacts on soils in and around project sites, most of which relate to the effects of ground-disturbing activities. Sections 5.7.1 and 5.7.2 identify the types of common and technology-specific impacts on soils from solar development. The types of geologic hazards that may be encountered by developments in the six state study area are described in Section 5.7.3. Potentially applicable mitigation measures to address soil impacts and geologic hazards are discussed in Section 5.7.4.

5.7.1 Common Impacts

Common impacts on soil resources encompass a range of impacts that would be expected to occur mainly as a result of ground-disturbing activities, especially during the construction phase of a solar energy project, regardless of the type of facility under development. Table 5.7-1 lists the types of potential soil impacts common to all solar energy projects and the project-related activities that could cause them. Common impacts include soil compaction, soil horizon mixing, soil erosion and deposition by wind, soil erosion by water and surface runoff, sedimentation, and soil contamination, as described below. Mitigation measures for avoiding or minimizing soil impacts are presented in Section 5.7.4. Implementing mitigation measures

TABLE 5.7-1 Potential Impacts on Soil Resources Common to All Solar Energy Projects

Soil Impact	Impacting Project Activities	Resources Affected by Soil Impact
Soil compaction	Vegetation clearing and grubbing	Vegetation
	Excavation and backfilling	Water resources (changes in natural flow systems due to increased surface runoff; degradation of surface water quality)
	Constructing project structures (met towers, solar collectors, cooling systems)	
	Constructing ancillary facilities (central control building, concrete batching plant, sanitary facilities, and temporary offices)	Cultural
	Constructing infrastructure (roads, parking areas, fences, transmission lines)	
	Heavy truck and equipment traffic	
	Increased foot traffic	
Soil horizon mixing	Vegetation clearing and grubbing	Vegetation
	Excavation and backfilling	Cultural
	Trenching and backfilling	
	Drilling and backfilling	
Soil erosion and deposition by wind	Vegetation clearing and grubbing	Vegetation
	Excavation and backfilling	Wildlife (including sand dune habitats)
	Stockpiling soils	Air quality (due to fugitive dust)
	Heavy truck and equipment traffic (especially on unpaved roads and surfaces)	Water resources (surface water quality)
		Cultural

TABLE 5.7-1 (Cont.)

Soil Impact	Impacting Project Activities	Resources Affected by Soil Impact
Soil erosion by water and surface runoff	Vegetation clearing and grubbing	Vegetation
	Excavation and backfilling	Wildlife
	Stockpiling soils	Water resources (changes in natural flow systems and surface water quality)
	Constructing road beds	
	Crossing drainages and wetlands	Cultural
	Heavy truck and equipment traffic (especially on unpaved roads and surfaces)	
Sedimentation	Vegetation clearing and grubbing	Vegetation
	Excavation and backfilling	Wildlife
	Stockpiling soils	Water resources (surface water quality)
	Constructing road beds	
	Crossing drainages and wetlands	
	Heavy truck and equipment traffic (especially on unpaved roads and surfaces)	
Soil contamination	Fluid releases related to truck and mechanical equipment use (fuels, lubricating oils, hydraulic fluids, coolants, and battery acid)	Vegetation
		Wildlife
	Accidental releases (spills, leaks, and fires) of hazardous materials (see Section 5.20.1)	Water resources (surface water and groundwater quality)
	Herbicide applications for weed control	
	Chemical stabilizer applications for erosion (fugitive dust) control	
	Toxic metal releases if solar cells were to break during dismantling	

to preserve the health and functioning of soils at the project site would reduce the likelihood of soil impacts becoming impacting factors on other resources, such as air, water, vegetation, and wildlife and would contribute to the success of future reclamation efforts.

- *Soil compaction.* Soil compaction occurs when soil particles are compressed, increasing their density by reducing the pore spaces between them (USDA 2004). It is both an intentional engineering practice that uses mechanical methods to increase the load-bearing capacity of soils underlying roads and site structures and an unintentional consequence of activities occurring in all phases of project development. Unintentional soil compaction is usually caused by vehicular (wheel) traffic on unpaved surfaces but can also result from animal and human foot traffic. Soils are more susceptible to compaction when they are moist or wet. Other factors, such as low organic content and poor aggregate stability, also increase the likelihood that compaction will occur. Soil compaction can directly affect vegetation by inhibiting plant growth because reduced pore spaces restrict the movement of nutrients and plant roots through the soil. Reduced pore spaces can also alter the natural flow of hydrological systems by causing excessive surface runoff, which in turn may increase soil erosion and degrade the quality of nearby surface water. Because soil compaction is difficult to correct once it occurs (USDA 2004), the best mitigation is prevention to the extent possible.

- *Soil horizon mixing.* Soil horizon mixing is another form of soil damage that occurs as a result of construction activities like excavation and backfilling that displace topsoil and disturb the existing soil profile. When topsoil is removed, stabilizing matrices, such as biological crusts and desert pavement, are destroyed, increasing the susceptibility of soils to erosion by both wind and water. Such disturbances also directly affect vegetation by disrupting indigenous plant communities and facilitating the growth of invasive plant species.

- *Soil erosion and deposition by wind.* Exposed soils are susceptible to wind erosion. Wind erosion is a natural process in which the shear force of wind is the dominant eroding agent, resulting in significant soil loss across much of the exposed area. Wind erosion and deposition are important processes in desert environments, and their effects can readily be seen in the alluvial valleys where many of the proposed SEZs are located—as dust clouds and storms and eolian landforms such as yardangs and sand dunes. Project-related activities such as vegetation clearing, excavating, stockpiling soils, and truck and equipment traffic (especially on unpaved roads and surfaces) can significantly increase the susceptibility of desert soils to wind erosion. It is not currently known whether these activities, as well as those taken to stabilize soils to control wind erosion, could also affect the erosional and depositional processes that maintain sand dunes close to the proposed solar energy zones (SEZs). In its soil surveys, the Natural Resources Conservation Service (NRCS) rates the susceptibility of soils to wind erosion by assigning them

to wind erodibility groups based on soil texture, organic matter content, effervescence of carbonates, rock fragment content, and mineralogy (NRCS 2010). The rating also takes into account factors such as soil moisture, surface cover, soil surface roughness, wind direction and speed, and length of uncovered distance (USDA 2004). Because wind dispersion and deposition of eroded soils can be geographically widespread in desert environments, this process is an important impacting factor for air quality, water quality, vegetation, and all wildlife. State and local governments may also have specific air permitting requirements regarding the control of fugitive dust and windborne particulates. Wind erosion and wind erodibility group designations for the soils found at the proposed SEZs are identified in later chapters.

- *Soil erosion by water and surface runoff.* Exposed soils are also susceptible to erosion by water. Water erosion is a natural process in which water (in the form of raindrops, ephemeral washes, sheets, and rills) is the dominant eroding agent. The degree of erosion by water is generally determined by the amount and intensity of rainfall, but is also affected by the cohesiveness of the soil (which increases with organic content), its capacity for infiltration, vegetation cover, and slope gradient and length (USDA 2004). The proposed SEZs are located in desert environments where rainfall is rare but intense, occurring often as violent thunderstorms that cause sudden runoff. Activities such as vegetation clearing, excavating, and stockpiling soils significantly increase the susceptibility of soils to runoff and erosion, especially during heavy rainfall events. Surface runoff caused by soil compaction also increases the likelihood of erosion. Soil erosion by surface runoff is an important impacting factor for the natural flow of hydrological systems, surface water quality (due to increased sediment loads), and all wildlife. State and local governments may also have specific flood control requirements that directly affect what surface runoff is allowed and how it should be controlled. Surface runoff potential and water erosion potential for the soils found at the proposed SEZs are identified in later chapters.

- *Sedimentation.* Soil loss during construction (by wind or water erosion) is a major source of sediment that ultimately makes its way to surface water bodies such as reservoirs, irrigation canals, rivers, lakes, streams, and wetlands. When sediment settles out of water (a process called sedimentation), it can clog drainages and block navigation channels, increasing the need for dredging. By raising streambeds and filling in streamside wetlands, sedimentation increases the probability and severity of floods. Sediment that remains suspended in surface water can degrade water quality, damaging aquatic wildlife habitat and commercial and recreational fisheries. Sediment in water also increases the cost of water treatment for municipal and industrial users (USDA 2004).

- *Soil contamination.* Soil contamination in the project area could result from the general use of trucks and mechanical equipment (fuels, oils, and the like) during all project phases. Facility-specific operations involve the use of hazardous materials such as dielectric fluids and cleaning solvents and would likely generate waste streams such as sanitary wastewater. Improper storage and handling of hazardous materials could result in accidental spills, leaks, and fires (Section 5.20.1). Maintenance-related activities could also contaminant soils in the project area. These activities include the applications of herbicides (for weed control) and chemical stabilizers (for dust control) to the soil surface. Contaminated soil can become a source of contamination for other resources, including vegetation (through uptake), wildlife (through inhalation and ingestion), and water quality (surface water through deposition and groundwater through leaching and infiltration).

5.7.1.1 Site Characterization

Site characterization would involve little or no ground disturbance (Section 3.2.1); therefore, activities during this project phase would result in only small or negligible impacts on soil resources. However, some ground-disturbing activities, such as drilling deep soil cores, installing monitoring wells, clearing and excavating areas to create surface impoundments for drilling fluids, and building access roads (in remote locations), would occur and could result in impacts on soil resources. Direct adverse impacts from these activities relate mainly to the increased potential for soil compaction, soil horizon mixing, soil erosion and deposition by wind, and soil erosion by water and surface runoff, and sedimentation of nearby surface water bodies (Table 5.7-1). The degree of impact would depend on the size and design of the project (i.e., the extent of ground-disturbing activities) and on site-specific factors such as soil properties, slope, vegetation cover, weather conditions (i.e., precipitation rate and intensity; prevailing wind direction and speed), and distance to surface water bodies. Implementing good industry practices and mitigation measures (Section 5.7.4) would reduce the level of adverse impacts associated with these activities.

5.7.1.2 Site Preparation and Construction

Construction of a solar facility could result in significant impacts on soil resources over an area equivalent to the sum of the footprints of all structures (e.g., solar collectors, cooling systems, and thermal energy storage [TES]) and related infrastructure (e.g., on-site roads, access roads, parking areas, and fencing) (Section 3.2.2). Soil-related impacts during the site preparation and construction phase may extend beyond the site boundary as a result of increased erosion by wind or water. Ground-disturbing activities would include vegetation clearing and grubbing; excavating for foundations, footings, and trenches for buried piping and electrical connections; pile driving (foundations); stockpiling excavated material for backfilling; drilling rock to set foundations and footings; drilling and installing groundwater supply wells; grading for roads and staging and laydown areas; and installing surface impoundments (e.g., evaporation ponds). The construction of other facilities, such as the central control building, electrical

substations, meteorological towers (if not done during site characterization), concrete batching plant, sanitary facilities and temporary offices, and an area for minor maintenance and storage of equipment and parts, also would have the potential to result in adverse impacts on soil resources, because they involve some degree of ground disturbance.

Direct adverse impacts of site preparation and construction activities relate mainly to the increased potential for soil compaction, soil horizon mixing, soil erosion and deposition by wind, and soil erosion by water and surface runoff, and sedimentation of nearby surface water bodies (Table 5.7-1). Soil contamination could also result from the release of contaminants related to the use of trucks and mechanical equipment or improper storage and handling and from the application of chemical stabilizers to control fugitive dust emissions. The degree of impact would depend on the size and design of the project (i.e., the extent of ground-disturbing activities) and on site-specific factors, such as soil properties, slope (e.g., along gullies and on alluvial fan surfaces), vegetation, weather, and distance to surface water. Implementing good industry practices and mitigation measures (Section 5.7.4) would reduce the level of adverse impacts associated with these activities.

5.7.1.3 Operations

Direct adverse impacts of operations are expected to be small, because project activities (e.g., monitoring controls and inspecting equipment, maintenance, and mirror washing) would not involve extensive ground disturbances (beyond that which has already occurred during construction) that increase the potential for soil compaction, soil horizon mixing, soil erosion and deposition by wind, soil erosion by water and surface runoff, and sedimentation of nearby surface water bodies (Section 3.2.3). Soil erosion would still occur during the operations phase, however, because soil surfaces exposed by vegetation clearing, grading, and excavation during the site preparation and construction phase would continue to be exposed throughout the life of the project. The risk of erosion would be greatest when exposed soils are subjected to high wind conditions or intense rainfall and surface runoff along roads is channeled into natural drainages. Soil compaction could also occur but would not be significant because most routine vehicle traffic would be limited to paved or graveled roads. Soil contamination could result from the release of contaminants related to the use of trucks and mechanical equipment or improper storage and handling and through the sustained applications of herbicides and chemical stabilizers to control vegetation and fugitive dust emissions. Implementing good industry practices and mitigation measures (Section 5.7.4) would reduce the level of adverse impacts associated with these activities.

5.7.1.4 Decommissioning/Reclamation

Project activities during the decommissioning/reclamation phase could result in significant impacts on soil resources, because they would involve ground disturbances that increase the potential for soil compaction, soil horizon mixing, soil erosion and deposition by wind, soil erosion by water and surface runoff, and sedimentation of nearby surface water bodies. Ground-disturbing activities would include removal of most if not all equipment,

removal of permanent structures and improvements (including on-site and access roads), and closure of on-site wells (belowground cables would be left in place) (Section 3.2.4). Direct adverse impacts would be smaller than during construction, because the objective of this project phase is to return the site to its native condition (e.g., by re-establishing native vegetative communities) and the use of existing access roads would reduce impacts such as compaction and erosion (e.g., fugitive dust generation). However, given the long time frame needed to re-establish desert vegetation, soils would remain susceptible to erosion throughout the decommissioning/reclamation phase and beyond, especially if subjected to high wind conditions or intense rainfall. Soil contamination is less likely during this phase but could result from fuel and oil releases related to the use of trucks and mechanical equipment and toxic metal releases if solar cells are broken during facility dismantling. Implementing good industry practices and mitigation measures (Section 5.7.4) would reduce the level of adverse impacts associated with these activities.

5.7.1.5 Transmission Lines and Roads

The construction of transmission lines within designated ROWs to connect new solar projects to regional utilities would result in soil impacts over an area equivalent to the sum of the footprint areas for all the tower foundations, access roads, and staging and laydown areas. Transmission line upgrades could also result in substantial soil disturbance. Construction would involve ground-disturbing activities such as vegetation clearing and grubbing; excavating for foundations and footings; stockpiling excavated material for backfilling; drilling rock to set foundations and footings; and grading for access roads and staging and laydown areas (Section 3.2.5 and Appendix F). Direct adverse impacts of these activities relate mainly to the increased potential for soil compaction, soil erosion by water and surface runoff, and sedimentation of nearby surface water bodies. The degree of impact would also depend on site-specific factors, such as soil properties, slope (e.g., along gullies and on alluvial fan surfaces), vegetation, weather, and distance to surface water. Some disturbed areas (e.g., assembly and laydown areas and temporary roads) would be reclaimed at the end of the construction period. Implementing good industry practices and mitigation measures (Section 5.7.4) would reduce the level of adverse impacts associated with these activities.

Direct adverse impacts of operations are expected to be small because activities would mainly entail periodic inspections and maintenance that would not increase the potential for soil compaction, soil erosion by water and surface runoff, or sedimentation of nearby surface water bodies. Soil erosion could still occur, however, on exposed surfaces under high wind conditions or intense rainfall and along roads as surface runoff is channeled into natural drainages. Soil compaction could also occur but would not be significant because most routine vehicle traffic would be limited to paved or graveled roads. Implementing good industry practices and mitigation measures (Section 5.7.4) would reduce the level of adverse impacts associated with these activities.

As during the site preparation and construction phase, decommissioning of transmission lines would involve ground-disturbing activities (e.g., removal of all equipment and permanent structures and remediation of all spills or leaks of chemicals) that could increase the potential

for soil compaction, soil erosion by water and surface runoff, and sedimentation of nearby surface water bodies. Impacts would be smaller than during site preparation and construction, because the objective of this project phase is to return the site to its native condition (e.g., by re-establishing native vegetative communities) and the use of existing access roads would reduce impacts such as compaction and erosion (e.g., fugitive dust generation). Implementing good industry practices and mitigation measures (Section 5.7.4) would also reduce the level of adverse impacts associated with these activities.

5.7.2 Technology-Specific Impacts

Impacts on soil resources result from ground-disturbing activities in the project area, particularly during the site preparation and construction phase (Section 5.7.1). Therefore, soil impacts are roughly proportional to the size of a given solar facility, with larger areas of disturbed soil having a greater potential for impacts than smaller areas. The magnitude of soil impacts would also depend on the types of components built for a given facility, since some components, such as power blocks, cooling systems, thermal storage facilities, support buildings, and septic systems, would involve disturbance (e.g., foundation excavation) beyond the initial vegetation clearing and grading to prepare the site and would take place over a longer time frame.

Based on the assumptions presented in Section 3.1, dish engine and PV solar facilities would typically cover larger areas of ground than parabolic trough and power tower facilities. However, constructing their major components (solar fields with pile-driven foundations expected for individual dish engines) would involve less extensive disturbance than constructing the components of parabolic trough and power tower facilities (power blocks, cooling systems, and septic systems), and construction would likely take place over a shorter time frame. Based on these assumptions, small dish engine and PV solar facilities would be expected to have smaller impacts on soil resources than large dish engine and PV facilities; and dish engine and PV facilities in general would be expected to have smaller soil impacts than parabolic trough and power tower facilities. Note that in addition to the type of solar facility built, site-specific conditions, such as soil texture, prevailing wind direction and speed, and natural patterns of surface water runoff, are important factors in characterizing the relative impacts on soil resources among the proposed SEZs.

5.7.3 Geologic Hazards

The following are the types of geologic hazards that could potentially occur at solar project sites in the six-state study area:

- *Seismic ground shaking.* Ground shaking occurs as seismic waves, which are propagated by a fault rupture, travel outward in all directions from the initial point of rupture (focus). Ground motion is calculated as “acceleration” and expressed as a fraction of gravity. There are both vertical and horizontal components to the ground motion; however, it is the horizontal movement that

causes the most damage to structures. The pattern of motion depends on the magnitude of the earthquake, distance from the epicenter, and the thickness and composition of surface and near-surface sediments. For example, areas underlain by unconsolidated alluvium or basin fill amplify the intensity and duration of strong ground motion. Ground shaking has the potential to trigger soil liquefaction, landslides, and other land failures, which can cause damage and collapse (Christensen 1994). For proposed project sites within seismic zones, a seismic study would be needed to determine the probability of a seismic event and the design basis for structures built at the site.

- *Ground rupture.* Ground rupture refers to the break and slip that occurs along a fault plane, which can cause damage to nearby structures. Ground rupture is most often associated with earthquakes; however, fissures along the ground surface also occur as a result of subsidence caused by high rates of groundwater withdrawal, which cause differential settling and compaction of the underlying aquifer.

- *Liquefaction.* Liquefaction is a soil condition in which soil loses its shear strength and behaves like a liquid when shaken by an earthquake. Liquefaction potential is highest in earthquake-prone areas where loose, granular soils and shallow groundwater are present. Liquefaction can cause settlement of the ground surface in uneven patterns that can damage buildings, roads, and other infrastructure (USGS 2008a).

- *Volcanic activity.* The types of hazards associated with volcanism relate to the composition of material erupted and the style of eruption. For example, large, silic central-vent volcanoes like Mount Shasta and Lassen Peak (California) are expected to erupt more frequently and explosively than vents within mafic volcanic fields, because they are located above large, shallow chambers of viscous, gas-rich magma. Volcanic hazards include flowage phenomena, such as directed blasts, pyroclastic flows and surges, lava flows and domes, landslides and debris flows (lahars), and floods; eruption of tephra, consisting of solidified lava, pumice, ash, and rock fragments ejected high into the air that fall back to earth on and downwind from the source vent; emissions of volcanic gases, consisting mainly of steam but also carbon dioxide; and compounds of sulfur and chlorine distributed by wind (Miller 1989; USGS 2010b).

- *Slope instability.* Slope instability is not likely to be a significant hazard for solar projects, because projects would be located in areas with slopes of less than 5%. However, excavation and blasting activities to create roads or other infrastructure could result in hill cuts that add to the instability of nearby slopes. This potential hazard is generally mitigated by siting roads and other infrastructure along natural topographic contours and avoiding hill-cutting to the extent possible. A site reconnaissance prior to construction would identify natural areas of active or inactive landslides to be avoided.

- *Subsidence and settlement.* Ground subsidence and settlement can pose significant hazards to project sites from a variety of causes, both natural and man-made. Natural causes include seismic activity (and soil liquefaction), karst features (underground solution cavities), lava tubes, and hydrocompaction. Human activities, such as the withdrawal of groundwater or hydrocarbons and underground mining, may also cause subsidence and settlement (Cowart 2003). A geotechnical investigation would determine the subsidence potential for solar project sites and recommend appropriate improvements during construction (including over-excavation and recompaction) to reduce the risk of subsidence and settlement (Kleinfelder, Inc. 2006).

- *Expansive soils.* Expansive soils are naturally occurring fine-grained soils (e.g., loess and sands and silts with soluble cement) with the potential to shrink and swell in response to changes in moisture. These soils expand as they are wetted (by rainfall or watering) and contract as they dry, leaving small fissures and cracks in the soil matrix. Excessive wetting and drying can weaken soils and cause differential settlement, which is damaging to structures built on them. Appropriate site improvement during construction (including over-excavation and recompaction) can reduce the soil expansion potential at project sites (Kleinfelder, Inc. 2006).

- *Flooding and debris flows.* Sites with flooding potential should be mapped to determine the location of the 100-year floodplain (an area with a flood elevation that has a 1% or greater probability of being equaled or exceeded in any given year [FEMA 2008]). For project sites falling within the 100-year floodplain, project structures would need to meet the development criteria for building in a floodplain (e.g., inhabitable structures would have to be built above flood elevation). High-velocity floods and debris flows are also known to occur on alluvial fan surfaces along mountain fronts at the margins of the alluvial valleys where many of the proposed SEZs are located, especially during periods of intense and prolonged rainfall. Runoff from these events can be controlled through the use of engineered structures such as levees or diversion dikes, as was done in the area of the proposed Riverside East SEZ in California (Section 7.4.7). Because floodplains are areas of high erosion potential, the best mitigation measure is avoidance.

5.7.4 Potentially Applicable Mitigation Measures

5.7.4.1 Soil Resources

The main objective of the mitigation measures for soil resources is to preserve the health and functioning of project area soils by reducing or controlling the ground-disturbing activities that cause the soil impacts described in Section 5.7.1. Preserving the health and functioning of

project area soils is an essential step in reducing impacts on other important resources (Table 5.7-1). Erosion control measures would be based on an assessment of site-specific conditions and would include minimizing the extent of disturbed areas, stabilizing disturbed areas, and protecting slopes and channels in the project area. Measures to control sedimentation would focus on retaining sediment on-site and implementing controls along the project site perimeter (CASQA 2004).

Developers would conduct (as necessary) geotechnical engineering and hydrology studies to characterize site conditions related to drainage patterns, soils, vegetation, surface water bodies, land subsidence, and steep or unstable slopes. The results of such studies would be compiled into reports to aid in the permitting, design, and construction of a proposed solar energy project. In the geotechnical engineering report, factors such as soil properties, engineering constraints, the corrosive potential of construction materials, stability, and facility design criteria would be identified. The hydrology report would present data on local water bodies, surface water drainage patterns, floodplains, rainfall, and expected runon and runoff volumes and flow rates. Many of the mitigation measures listed below would be components of the various plans required to mitigate the impacts of solar energy facilities, particularly the Drainage, Erosion, and Sedimentation Control Plan, Wind Erosion Management Plan, Access Road Siting and Management Plan, Dust Abatement Plan, Integrated Vegetation Management Plan, Ecological Resource Mitigation and Monitoring Plan, Habitat Restoration and Management Plan, Spill Prevention and Emergency Response Plan, and Stormwater Management Plan. Plans would be revised or amended as necessary to account for changes in site conditions as a project proceeds from construction through decommissioning. Applicants must obtain and meet the requirements of all applicable federal, state, and county permits and building codes.

Studies may also be needed to determine whether construction and operation of a solar facility within a proposed SEZ would affect the eolian processes that maintain nearby sand dunes (e.g., Big Dune in Amargosa Valley in Nevada). The need for such studies would be evaluated on a case-by-case basis.

The following subsections identify potentially applicable mitigation measures for solar energy facilities, grouped by phase of development. These measures address a range of site conditions and may not be applicable to every solar project. However, they should be implemented by projects if they are applicable. The mitigations measures listed here have been adapted from those outlined in reports such as DOI and USDA (2006), BLM (2010a), State of California Department of Transportation (2003), USFS (2000), and Desert Managers Group (2010). Project developers should implement these measures, as applicable, and develop others that address unique site conditions not anticipated here. Routine site inspections should be conducted to identify and correct improperly installed, damaged, or ineffective measures. Inspections should be made more frequently during the rainy season and during and following intense rainfall events to ensure the timeliness of corrective actions.

5.7.4.1.1 Siting and Design.

- The footprint of disturbed areas, including the number and size/length of roads, fences, borrow areas, and laydown and staging areas, should be minimized. The boundaries of disturbed area footprints should be clearly delineated on the ground (e.g., through the use of construction fencing).

- Project structures and facilities should be sited to avoid disturbance in areas with existing biological soil crusts to the extent possible.

- Project areas should be replanted with native vegetation at spaced intervals to the extent possible to break up areas of exposed soil and reduce soil loss by wind erosion (see also Section 5.10.5).

- Land disturbance (including crossings) in natural drainage systems and groundwater recharge zones, specifically ephemeral washes and dry lake beds, should be avoided. Any structures crossing drainages should be located and constructed so that they do not decrease channel stability or increase water volume or velocity. Developers should obtain all applicable federal and state permits.

- Solar facilities or components (e.g., heliostats, panels, dishes, and troughs) should not be placed in natural drainage ways.

- Adequate space (i.e., setbacks) between solar facilities and natural washes should be maintained to preserve their hydrological function and provide a buffer for flood control.

- Existing roads, disturbed areas, and borrow pits should be used. In addition, all borrow pits shall be identified beforehand, and included in the NEPA direct and indirect analyses. If new roads are necessary, they should be designed and constructed to the appropriate road design standards, such as those described in *BLM Manual 9113* (BLM 1985) and BLM (2007). The specifications and codes developed by the U.S. Department of Transportation (DOT) should also be taken into account.

- New roads should be designed to follow natural land contours and avoid or minimize hill cuts in the project area and avoid existing desert washes. Siting of new roads and walking trails (if any) should be consistent with the designation criteria specified by the BLM in 43 CFR 8342.1.

- Ground-disturbing geotechnical studies (e.g., geotechnical drilling) should adhere to the permitting requirements specified by the BLM in 43 CFR 2920.

- Roads should be designed on the basis of local meteorological conditions, soil moisture, and erosion potential in order to avoid erosion and changes in surface water runoff.

- Temporary roads should be designed with eventual reclamation in mind.

- Areas with unstable slopes should be avoided, and local factors that can cause slope instability (e.g., groundwater conditions, precipitation, earthquake activity, slope angles, and the dip angles of geologic strata) should be identified.

- Excessive grades should be avoided on roads, road embankments, ditches, and drainages, especially in areas with erodible soils.

- The creation of excessive slopes should be avoided during site preparation and construction. Special construction techniques should be used, where applicable, in areas of steep slopes, erodible soil, and drainage ways.

- Construction should be conducted in stages to limit the areas of exposed soil at any given time. For example, only land that will be actively under construction in the near term (e.g., within the next 6 to 12 months) should be cleared of vegetation.

5.7.4.1.2 General Multiphase Measures.

- Potential soil erosion should be controlled at culvert outlets with appropriate structures.

- Catch basins, roadway ditches, and culverts should be cleaned and maintained regularly.

- Abandoned roads and roads no longer needed should be subsoiled to increase infiltration and reduce soil compaction, then recontoured and revegetated.

- Ground-disturbing activities should be minimized, especially during the rainy season.

- Originally excavated materials should be stockpiled and used for backfill.

- The speed of vehicles and equipment on unpaved surfaces should be controlled to reduce dust emissions.

- Runoff from slope tops should be controlled and directed to settling or rapid infiltration basins (temporarily) until disturbed slopes are stabilized. Disturbed slopes should be stabilized as quickly as possible.

- Drainage crossings should be stabilized as quickly as possible, and channel erosion from runoff caused by the project should be prevented.

- Sediment-laden waters from disturbed, active areas within the project site should be retained through the use of barriers and sedimentation devices (e.g., berms, straw bales, sandbags, jute netting, or silt fences). Such barriers and devices should not be installed in wildlife crossing areas.

- Barriers and sedimentation devices should be placed around drainages and wetlands to prevent contamination by sediment-laden water.

- Sediment from barriers and sedimentation devices should be removed to restore sediment control capacity.

- Routine site inspections should be conducted to assess the effectiveness and maintenance requirements for erosion and sediment control systems.

- Barriers and sedimentation devices should be maintained, repaired, or replaced as necessary to ensure optimum control.

- A spill prevention plan to identify sources, locations, and quantities of potential chemical releases (through spills, leaks, or fires) and to define response measures and notification requirements should be developed and followed to reduce the potential for soil contamination. The plan should also identify individuals and their responsibilities for implementing the plan.

5.7.4.1.3 Site Characterization and Construction.

- Construction activities should take place over as short a timeframe as possible once ground disturbance has occurred. If an activity requires an extended schedule, measures to limit wind and water erosion should be employed during the activity (rather than after the activity), to the extent possible.

- Construction traffic should avoid unpaved surfaces (to reduce the risk of compaction) and reduce speed to lessen fugitive dust emissions.

- The clearing and disturbing of sensitive areas (e.g., steep slopes and natural drainages) and other areas should be avoided outside the construction zone. The construction zone boundaries should be clearly delineated on the ground (e.g., through the use of construction fencing).

- Ground disturbance from construction-related activities, such as vehicle and foot traffic, should avoid areas with intact biological soil crusts to the extent possible. For cases in which impacts cannot be avoided, soil crusts should be

salvaged and restored, on the basis of recommendations by BLM, once construction has been completed.

- The creation of excessive slopes should be avoided during site preparation and construction (e.g., during excavation).Special construction techniques should be used, where applicable, in areas of steep slopes, erodible soil, and stream channel crossings.

- Electrical lines from solar collectors should be buried along existing features (e.g., roads or other paths of disturbance) to minimize the overall area of surface disturbance whenever possible.

- Borrow materials should be obtained only from authorized and permitted sites.

- Construction grading should be conducted in compliance with good industry practice (e.g., the American Society for Testing and Materials [ASTM] international standard methods) and other requirements (e.g., BLM and/or local grading and construction permits), as they apply.

- Erosion control structures (e.g., rock lining or apron) should be added at culvert outlets to reduce flow velocity and minimize the potential for scouring.

- Temporary stabilization of disturbed areas that are not actively under construction should occur throughout the construction phase. Soil stabilization methods such as erosion matting (organic or synthetic mats or blankets) or soil aggregation (binding) are examples of measures that should be used to limit wind erosion and dust emissions, as site conditions warrant.

- Permanent stabilization of disturbed areas should occur during final grading and landscaping of the site.

- Water or other stabilizing agents should be used to wet roads in active construction areas and laydown areas in order to minimize the windblown erosion of soil.

- Topsoil from all excavation and construction activities should be salvaged so it can be reapplied to the disturbed area once construction is completed.

- Native plant communities in disturbed areas should be restored by natural revegetation or by seeding and transplanting (using weed-free native grasses, forbs, and shrubs), on the basis of BLM recommendations, as early as possible once construction is completed (see also Sections 5.10.1 and 5.10.5).

- Construction on wet soils should be avoided.

5.7.4.1.4 Operations.

- All appropriate mitigation measures developed for the construction phase should be applied to similar activities during the operations phase.

- The area disturbed by operation of a solar energy project should be minimized (e.g., by using existing roads).

5.7.4.1.5 Decommissioning/Reclamation.

- All mitigation measures developed for the construction phase should be applied to similar activities during the decommissioning/reclamation phase.

- The original grade and drainage pattern should be re-established.

- Native plant communities in disturbed areas should be restored by natural revegetation or by seeding and transplanting (using weed-free native grasses, forbs, and shrubs), on the basis of BLM recommendations, as early as possible once decommissioning is completed (see also Sections 5.10.1 and 5.10.5).

5.7.4.2 Geologic Hazards

The potential geologic hazards that could be significant at solar project sites in the six-state study area include seismic ground shaking, ground rupture, liquefaction, volcanic activity, slope instability, subsidence (collapse) and settlement, expansive soils, and flooding and debris flows.). Solar project developers should conduct geotechnical studies (as needed) to identify and assess these hazards and to propose facility design criteria and site-specific mitigation measures. The mitigation measure to address geologic hazards therefore would be to build project structures in accordance with the design basis recommendations specified in the project-specific geotechnical investigation report. Structure designs must meet the requirements of all applicable federal, state, and county permits and building codes.

In areas of high seismic activity (especially those having soils with a high liquefaction potential) or in areas that encompass 100-year floodplains, the most effective mitigation measure is to alter the location or scope of the proposed project.

5.8 MINERALS (FLUIDS, SOLIDS, AND GEOTHERMAL RESOURCES)

Solar energy development could affect the development of minerals or geothermal resources in the areas where it occurs. The following subsections discuss the common and technology-specific impacts from solar development on these resources and potentially applicable mitigation measures.

5.8.1 Common Impacts

5.8.1.1 Construction and Operations

A significant portion of the BLM-administered land within the six-state study area is undergoing mineral development, particularly the development of oil and gas resources. Interest in development of geothermal energy resources also is present in some areas. Hard rock mineral development, leasable mineral development, and the development of common variety minerals, such as sand and gravel, also occur on public lands. Utility-scale solar energy development would be incompatible with most mineral development activities and would preclude these activities within developed areas once solar energy facilities are constructed. An exception to this could occur if oil and gas or geothermal resources could be accessed under a solar energy facility utilizing offset drilling technologies. Existing valid mining claims, oil and gas leases, or other types of mineral leases would preclude or affect solar energy development. The impact on future mineral development must be determined at the site-specific level.

5.8.1.2 Transmission Lines and Roads

Valid mining claims, oil and gas leases, or other types of mineral leases would preclude or could affect the location of ROWs for transmission lines serving solar facilities, although in most instances it is likely that ROWs could be located to avoid areas of mineral development or in a manner consistent with planned mineral development. Authorized ROWs would result in constraints on new mineral development activities, assuming the ROW was issued before the valid mining claim was filed.

5.8.2 Technology-Specific Impacts

On the basis of the amount of land required for comparably rated facilities, power tower, dish engine, and PV technologies require about 80% more land area than parabolic trough technologies, resulting in larger areas being excluded from potential mineral development.

5.8.3 Potentially Applicable Mitigation Measures

- Where valid mining claims or leases exist, early coordination with claim or lease holders should be initiated to determine whether it would be possible to locate solar facilities in or near these areas in such a way as to avoid future adverse effects on mineral development activities.

- All solar energy development ROWs should contain the stipulation that BLM retains the right to issue oil and gas or geothermal leases with stipulation of no surface occupancy within the ROW area. Upon designation, SEZs should be

classified as no-surface-occupancy areas for oil and gas and geothermal leasing.

- Transmission lines should be located to avoid conflicts with mining activities in areas with active mineral development.

5.9 WATER RESOURCES

A utility-scale solar energy project can affect surface water and groundwater in several ways, including the use of water resources, modification of the natural surface water and groundwater flow systems, alteration of the interactions between groundwater and surface waters, contamination of aquifers, wastewater treatment either on- or off-site, and water quality degradation by runoff or excessive withdrawals, as well as from leaks and spills of chemicals used for the project. These potential impacts on water resources affect both water quantity and water quality. While some impacts on water resources (e.g., water use) are dependent upon the technologies used for solar energy production, impacts on water resources associated with land disturbance and construction activities are common impacts regardless of the type of solar energy technology used.

Water Management. The six-state study area is largely composed of arid landscapes; thus water use by solar energy technologies is a significant consideration for water resources impacts and also requires the analysis of water and land management practices. Acquiring reliable, long-term water supplies to support utility-scale solar facilities would entail either the acquisition of unallocated water supplies (depending on availability) or the conversion of existing water rights from current uses. Water could be obtained from either surface, groundwater, or recycled water, depending on the location of the development and the types of water supplies available. In many regions of the six-state study area, Native American water rights and management issues also need to be addressed. The need to secure water rights for solar energy development could compete with other uses of water in the region, which could reduce the amount of water available for agricultural, municipal, environmental, industrial, and ecological uses. Use of either surface water or groundwater could also affect vegetation and aquatic habitat for species of concern. Depending upon the local availability of water resources and management practices, solar energy development can lead to the conversion of land use practices in the region, such as agricultural lands being taken out of production as a result of the transfer of water rights.

Water rights and water management issues addressed by federal laws and policies are directed toward controlling floodplain development, water quality, and waste disposal. The primary federal law pertaining to the protection of water resources is the Clean Water Act (CWA). The CWA establishes the framework for federal and state collaboration in regulating direct and indirect discharges (including stormwater discharges) from construction and industrial activity and prohibits alteration to waters of the United States (including wetlands) unless a permit is obtained. Section 401 of the CWA requires a licensing or permitting process to take place for the construction or operation of facilities that may discharge to receiving waters to

ensure that water quality standards of the CWA are met. Section 402 of the CWA establishes the U.S. Environmental Protection Agency's (EPA's) National Pollution Discharge Elimination System (NPDES) to regulate discharges from both construction sites and industrial facilities (including stormwater and wastewater). Section 404 of the CWA pertains to the regulation of activities that involve the dredging or filling of jurisdictional water of the United States (can include ephemeral washes) and is administered jointly by the EPA and the U.S. Army Corps of Engineers (USACE). Executive Order (E.O.) 11988, "Floodplain Management" (*Federal Register*, Volume 42, page 26951, May 24, 1977), and E.O. 11990, "Protection of Wetlands" (*Federal Register*, Volume 42, page 26961, May 24, 1977), direct federal agencies to "avoid to the extent possible the long and short term impacts" of modifications to or the destruction of floodplains and wetlands, respectively. Additional regulation of water resources can be imposed by federal, state, and local agencies through various laws, water rights administration processes, court decisions, and international compacts pertaining to water resources. The myriad of applicable laws and agencies regulating water resources is complex and often needs to be assessed on a case-by-case basis.

5.9.1 Common Impacts

5.9.1.1 Site Characterization

Activities during site characterization related to water resources may include limited modification or construction of access roads to transport drilling equipment and a meteorological tower, groundwater exploration drilling and testing to evaluate water availability, and deep soil coring to gather information necessary for the design of substantial structure foundations. These activities would vary by site. Water also would be used for dust suppression and the workforce's potable supply, which would need to be trucked in from an off-site source or from a local source.

The impacts on water resources resulting from site characterization activities are considered minor, because they are limited in extent and duration. Access road modification and construction could require the modification of natural drainage systems, which could (1) increase sediment and dissolved solid loads in the water downstream from disturbed areas and (2) lead to flooding. Any alteration of a water of the United States would require a Section 404 permit (see Section 5.9 above). During investigation of groundwater and deep soil sampling for geotechnical purposes, water would likely be trucked in. Mud pits would be dug to contain drilling mud for reuse. Cuttings from drilling would be managed according to federal and state regulations on containment and disposal of waste. The extent of ground disturbance, which could cause soil erosion and degrade surface water quality in downstream waters, would likely be very small.

5.9.1.2 Construction

5.9.1.2.1 Use of Water Resources. Water would be needed for various activities in the construction phase, including concrete preparation for foundations of the support structures for

solar reflectors and PV panels and buildings, drinking water for site workers, vehicle washing, road construction, and dust control on roads and construction sites. For this analysis, it was assumed that the major water use activities during construction relate to fugitive dust control and workforce potable supply. The methodology for estimating the amounts of water needed by type of solar energy technology and by project size are presented in Appendix M. Water sources are likely to be local groundwater, surface water bodies, or recycled water depending upon availability of those resources. Water could be trucked in from off-site sources as well. Water used for making concrete would likely be derived from an off-site source. Water rights and permits would need to be obtained from applicable local, state, and/or regional water authorities before water use could occur.

In most areas, groundwater would likely be withdrawn from local aquifers to meet the project's water needs. Depending on project site locations, groundwater may be present in basin sediment aquifers or carbonate aquifers of the Basin and Range province and in other bedrock aquifers (see Figure 4.9-3). Withdrawal of groundwater could lower water levels of the source aquifer. In addition, the combined groundwater withdrawals for a solar energy facility and other withdrawals and uses in a basin could exceed the sustainable yield and dewater the aquifer to the degree that nearby water wells are adversely affected. Depending on site-specific geology, withdrawals exceeding the sustainable yield of the groundwater basin could cause permanent loss of storage capacity in the aquifer and also land subsidence. Impacts of reduced groundwater flow magnitude and timing of groundwater flows to streams, springs, seeps, and wetlands would depend upon the connectivity of surface water and groundwater in the region. These impacts include loss of obligate and facultative wetland vegetation species; habitat and forage for wildlife, wild horses, and livestock; and others.

If surface water were used, withdrawal of surface water from a stream would reduce its flow. Replenishment of aquifers that are hydraulically connected and recharged by the stream would also be reduced. Since streamflows in arid and semiarid environments fluctuate dramatically with seasons, the reduction of streamflows could have significant impacts, especially during low-flow seasons and drought conditions.

5.9.1.2.2 Streams: Perennial, Intermittent, and Ephemeral. Construction activities could affect natural surface water and groundwater flow systems by diverting and/or channelizing on-site and nearby streams to accommodate access road and facility construction. The level of impacts resulting from alterations of natural drainage patterns for elevated roadbeds would depend on road orientation, drainage structure, and the type of landscape that the roads cross. Hard structures, such as foundations, could increase erosion around such structures. In some cases upstream drainage would be altered such that flow would be routed around the site and through stormwater infrastructure. Excavation (trenching) or horizontal boring activities to bury pipes or wires might alter surface overland flow and allow subsurface flow to follow the filled trenches or borings. Construction activities could also damage or destroy desert pavement and biological crusts (if present), thus increasing the rate of soil erosion.

The modification of streams, washes, and drainages will alter surface runoff timing and drainage patterns and could increase peak flows and water flow velocities of downgradient

streams. All these processes could lead to increased erosion, sediment transport, and sediment deposition impacts. The discharge of wastewater and stormwater could also increase the flow rates of the receiving surface waters. Land disturbance impacts are expected to be greater in areas occupied by an alluvial fan or other landscape features with topography more so than in a flat regions. The modification of the natural drainage patterns of a potential development site affects more than just the surface runoff and erosion processes. Ephemeral streams, washes, and drainages often provide critical habitat for many plant and animal populations, as well as connect surface water and groundwater resources in desert environments. The modification of ephemeral water bodies could also result in some areas of the landscape receiving less water as the result of concentrating drainage patterns. The loss or modification of ephemeral water bodies either by erosion or drainage alterations could result in the loss of vegetation and landscape features that generate critical habitat for desert wildlife.

5.9.1.2.3 Floodplains, Wetlands, Playas, and Riparian Areas. Adverse effects on existing floodplains, wetlands, playas, and riparian areas could result from land disturbance activities. The land disturbance activities can alter the natural drainage patterns (described previously) that feed into these receiving areas. Land disturbance activities can affect floodplains, wetlands, and riparian areas on-site as well as downstream of the development site. Modification to these areas could cause flooding and erosion issues and could destroy critical habitats for plants and animals. Reductions to the connectivity of these areas with existing surface waters and groundwater could (1) affect wildlife corridors and (2) limit water availability and thus alter the ability of the area to support vegetation, resulting in impacts on aquatic habitat quality. Additionally, increases in water and sediment transport to floodplains, wetlands, and riparian areas could result in localized erosion and sedimentation that can have detrimental effects on the ecological and hydrological functioning of these habitats. Potential effects on habitat include inhibiting growth of vegetation, clogging groundwater recharge areas, and changing the overall stability of the natural landscape (see Section 5.10.1 for further discussion on impacts on wetland areas).

5.9.1.2.4 Degradation of Water Quality. Both groundwater and surface water quality could be affected by construction activities. These activities include land disturbance-related soil erosion and sedimentation; fuel and chemical spills; storage and potential treatment of wastewater; and the potential application of pesticides, herbicides, and dust suppressant chemicals. Surface water quality could be adversely affected in areas hydraulically downstream and downwind from disturbed areas, including staging areas, construction sites, access roads, soil piles, foundation excavation, trenching, and borrow pits. Sediments from these disturbed areas can be transported by wind or water to adjacent water bodies (including stream, lakes, playas, wetlands, and washes) and degrade water quality through the addition of sediments, dissolved solids, metals, and organics.

Improperly designed groundwater wells could create conduits for poor-quality groundwater, as well as contaminants, to move between aquifers. Chemical and fuel spills could infiltrate to groundwater and could spread by surface runoff to surface water features. Wastewater will most likely be contained in portable toilets, on-site sewage lagoons, or septic

tanks with leach fields. Leaky wastewater storage containers could degrade groundwater and surface water quality and introduce pathogens. Developers would have to follow applicable federal, state, and local regulations and potentially coordinate with local treatment facilities for wastewater storage, transport, and treatment either on-site (e.g., septic tank with leach field) or off-site. If pesticides or herbicides are used, the leaching or transport of undegraded pesticides and herbicides would negatively affect downstream waters or groundwater. Dust suppression by water or water mixed with dust suppression chemicals could degrade water quality by increasing total dissolved solids (TDS) concentrations in nearby water bodies and groundwater through evaporation or through the use of poor-quality groundwater or recycled water.

5.9.1.3 Operations

Potential impacts on water resources during the operations phase of a solar energy development include land disturbance-related issues, water use, wastewater generation, and potential chemical releases affecting water quality. Land disturbance activities include truck traffic, soil disturbance while servicing and cleaning mirrors/panels, and surface runoff and erosion resulting from the altered hydrology imposed by the solar facility structures. Impacts associated with land disturbance from truck traffic and maintenance are considered minor given the limited temporal and spatial extent over which these activities would occur during the operations phase. Impacts relating to the altered hydrology can be reduced through the implementation of mitigation measures and best management practices (BMPs) relating to site design, stormwater, and avoidance of critical landscapes (e.g., ephemeral washes and wetlands) discussed in Section 5.9.3.

Groundwater or surface water withdrawals would likely continue in the operations phase to meet project water needs once the solar facility was constructed, unless recycled water was available for use by the facility. The water needs would depend on the solar technologies and their associated structures and operational activities (see Section 5.9.2 for technology-specific water use estimations). Groundwater withdrawals cause a cone of depression around a pumping well to expand until groundwater inflow is balanced by the rate of water extraction. Reaching an equilibrium between groundwater inflow and water extraction may take more than a millennium to achieve depending upon the rate of extraction, distances to potential groundwater capture sources, other groundwater pumping operations in the basin, and the size and properties of the groundwater aquifer (Bredehoeft and Durbin 2009). Groundwater surface elevations in the region surrounding a pumping well or wells decrease during this pre-equilibrium phase, which can have adverse impacts on phreatic vegetation, other groundwater users, land subsidence, loss of groundwater storage capacity, and groundwater flow processes throughout the basin. If stream water were used, water withdrawal would lower streamflow downstream from water intake areas. Loss of streamflow could reduce groundwater recharge and floodplain interaction affecting riparian vegetation and could affect habitat (i.e., certain flow and sediment conditions) that fish rely on to survive.

Sanitary wastewater is generated by the solar facility workforce, and additional industrial wastewater can come from blowdown water for technologies that use wet cooling. It is likely that

Protecting Streams in a Desert Landscape

Federal, state, and local laws and agencies that focus on surface waters often have direct mechanisms for protecting streams that are perennial in nature (i.e., containing water year-round). However, in arid and semi-arid landscapes, streams are predominately intermittent or ephemeral in nature. Ephemeral streams flow in direct response to precipitation and have channels that are above the groundwater table, whereas intermittent streams typically flow continuously at certain times of the year as a result of snowmelt runoff or spring/groundwater sources (Levick et al. 2008). Intermittent and ephemeral streams provide significant hydrologic function and ecological value to desert landscapes by conveying rainfall and snowmelt that transports water, sediments, and solutes to downstream areas; shaping geomorphic features such as alluvial fans; providing groundwater recharge; supporting vegetation growth and diversity, generating critical habitat areas and connecting wildlife corridors; and providing water supply to desert animals. While the significance of intermittent and ephemeral streams is known, it is difficult to identify the location and extent of these features, as they are highly dynamic both spatially and temporally.

At the federal level, the primary mechanism for protecting natural waters is the Clean Water Act (CWA), which was established to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The most relevant part of the CWA for protecting intermittent and ephemeral streams is Section 404, which requires a permit with the U.S. Army Corps of Engineers (USACE) before any dredged or fill materials are placed into "jurisdictional waters" for the purpose of minimizing any adverse impacts. The difficulty in applying the permitting process of Section 404 is in the determination of what constitutes jurisdictional waters, which is the responsibility of both the USACE and the U.S. Environmental Protection Agency (EPA). Jurisdictional waters are defined as water bodies that are navigable, subject to interstate or foreign commerce, adjacent wetlands, or waters tributary to navigable waters or waters that support commerce. Recent U.S. Supreme Court decisions (Rapanos v. United States and Carabell v. United States) have complicated the process of identifying jurisdictional waters with respect to intermittent and ephemeral streams by requiring them to have a "significant nexus" to the more traditionally defined navigable waters (see EPA and USACE [2007] for further details regarding this distinction) in order to fall under jurisdiction of Section 404 of the CWA. Ultimately, this results in a situation where the applicability of Section 404 of the CWA for protecting intermittent and ephemeral streams needs to be determined on a case-by-case basis.

An indirect method for protecting intermittent and ephemeral streams exists in Executive Order 11988, Floodplain Management of 1977 (*Federal Register*, Volume 42, page 26951, May 24, 1977) that requires "Federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative." According to E.O. 11988, a floodplain is defined as an area that will be inundated by a flood of magnitude that has a 1% annual chance of being equaled or exceeded, which is referred to as the "100-year floodplain." The primary intent for E.O. 11988 is to avoid development in floodplains in order to minimize flood hazards, but this indirectly protects water courses and surrounding floodplain areas in the process. The Federal Emergency Management Agency (FEMA) analyzes flood hazards and delineates the approximate boundaries of 100-year floodplains in their Flood Insurance Rate Maps (FIRMs) under the National Flood Insurance Program; however, many regions in the southwestern United States do not have FIRM delineations available. Detailed hydrologic analysis and modeling is needed to produce accurate delineations of floodplains, which is work that is still needed for a majority of the desert areas in the southwestern United States.

The protection of intermittent and ephemeral streams in desert landscapes is primarily determined by hydrologic analyses to identify jurisdictional waters and 100-year floodplains. This approach assumes that critical hydrologic functions and ecological processes that intermittent and ephemeral streams provide either occur in reaches that are subject to the definition of jurisdictional waters or are prone to flooding. Additional protections of intermittent and ephemeral streams may be given to streams located within specially designated areas (see Section 5.3) or in critical habitat areas (see Section 5.10). State and local governments may have additional mechanisms for protecting intermittent and ephemeral streams. An example is the Lake and Streambed Alteration (LSA) program in California (http://www.dfg.ca.gov/habcon/1600/), which is similar in nature to Section 404 of the CWA in requiring a permit process involving the California Department of Fish and Game for any alterations to a river, stream, or lake. The main difference is that the LSA applies to all intermittent and ephemeral water features.

these two sources of wastewater would be contained or treated separately and would comply with federal, state, and local regulations regarding wastewater. As mentioned in Section 5.9.1.2 for the construction phase, wastewater generated during the operations phase could be contained in portable toilets for smaller facilities not generating blowdown water, on-site sewage lagoons, or septic tanks with leach fields. On-site treatment of wastewater may be accomplished by using evaporation ponds (industrial wastewater only) or septic tank-leach fields. Additionally, any wastewater or treated effluent from on-site wastewater treatment discharged to a surface water body would need NPDES permitting. Off-site treatment of wastewater would require managers to coordinate with local wastewater treatment facilities and comply with federal, state, and local regulations regarding the storage and transport of wastewater. Impacts from the storage and potential treatment of wastewater on-site are primarily associated with the leakage of wastewater from storage containers. Wastewaters could introduce organics, salts, metals, and pathogens to nearby surface waters and groundwater, resulting in degraded water quality and potential public health concerns.

Water quality could also be degraded during the operations phase as a result of the application of herbicides and pesticides used for controlling on-site vegetation. Additionally, accidental spills of chemicals from a solar energy facility such as HTFs, TES medium, and dielectric fluids could contaminate nearby surface waters and groundwater.

5.9.1.4 Decommissioning/Reclamation

Decommissioning activities would involve removal of all buildings, structures, access roads, and on-site roads. Disturbed land areas would likely be restored to their original grade and revegetated. During the removal of surface structures, the on-site water needs would be on the same order of magnitude as those for construction. Water would most likely be used to restore the vegetation on-site as well. Any groundwater wells no longer in use would be sealed and abandoned in place following practices established by the local and state regulations.

If water withdrawal from an aquifer were discontinued, groundwater surface elevations would start to recover if the capacity of the aquifer has not been lost due to excessive withdrawals in the basin. Aquifer recovery could take a much longer period of time than other decommissioning activities and is dependent upon many factors relating to the geology of the aquifer, other water extractions in the basin, and even climate conditions. The time lag for aquifer recovery could be substantial depending on the conditions of the aquifer and the extent and duration of the pumping. If withdrawals from a stream were discontinued, the streamflow would return to preconstruction levels. However, the potential impacts due to soil disturbance would largely be the same as those described for the construction phase.

5.9.1.5 Transmission Lines

Surface activities associated with the site characterization, construction, operation, and decommissioning/reclamation for transmission lines, and those associated with line upgrades, could adversely affect the quality of surface water in a way similar to that described for solar

facilities in Sections 5.9.1.1 through 5.9.1.4. However, the water needs for transmission lines would be substantially less than those for solar facilities and include potable needs and water for vehicle washing and dust suppression. The surface activities common to transmission lines include construction of transmission line supports and new access roads, modification of existing access roads, and heavy equipment traffic. Increases of surface runoff as a result of new and modified access roads and drainage systems could affect sediment and dissolved solid loads in the receiving water. Contaminants from surface spills and improperly stored materials, as well as the application of herbicides to control vegetation growth, could potentially enter nearby surface waters and groundwater and adversely affect water quality.

5.9.2 Technology-Specific Impacts

The technology-specific impacts on water resources are related to the materials used in utility-scale solar energy development, site selection, project layout, site preparation practices, water needs during construction and operation, and the production and disposal of wastewater among the different technologies. The assumptions and methods used to estimate water use by the various solar energy technologies are presented in Appendix M, and estimates of water use by example facilities are presented in Table 5.9-1. While new technologies continue to be developed to reduce water use in the thermoelectric industry (Feeley et al. 2006), in order to provide a conservative assessment of potential impacts, the analysis of water needs in this PEIS does not assume decreased water use over time.

5.9.2.1 Parabolic Trough and Power Towers

Parabolic trough or power tower facilities contain a power plant system to generate electrical power. Water is used to make steam in a Rankine Cycle steam turbine generator (STG) to produce electricity. The steam leaving the STG is cooled, condensed, and recycled. Cooling the steam by water, air (dry cooling), or hybrid systems creates different levels of water demand in parabolic trough and power tower facilities. A small portion of the recycled water, which is removed periodically as blowdown water, needs to be replenished to control water quality. Based on information provided in Section 3.1.5, for a parabolic trough or a power tower facility with wet cooling, the water demand is estimated to range from 4.5 to 14.5 ac-ft/yr/MW (5,550 to 17,885 m^3/yr/MW). An additional 0.5 ac-ft/yr/MW (617 m^3/yr/MW) is estimated to be used for mirror washing. Dry cooling generally demands about 10% of the water used in wet cooling, and hybrid cooling systems use about 20% of the water used in wet cooling (DOE 2009). Table 5.9-1 lists the water demands for different solar power plant configurations. The size of a parabolic trough facility is assumed to be between 100 and 400 MW. The water demands for a 100-MW and 400-MW parabolic trough or power tower facility are estimated to be 500 to 1,500 ac-ft/yr (0.6 to 1.9 million m^3/yr) and 2,000 to 6,000 ac-ft/yr (2.5 million to 7.4 million m^3/yr), respectively, using wet cooling.

In parabolic trough technologies, common HTFs are synthetic oils. Other potential HTFs are organic salts, mixtures of glycol and water, mineral oils, silicone oils, and mixtures of inorganic nitrate salts. Decomposition of synthetic oil can produce hydrogen, benzene, and

TABLE 5.9-1 Estimates of Water Requirements for Various Solar Power Plant Configurations[a] (ac-ft/yr[b])

Technology	Cooling and Other Uses	Low	High
Parabolic trough (including CLFR[c]) or power tower	Wet cooling and washing 100-MW facility	500	1,500
	Wet cooling and washing 400-MW facility	2,000	6,000
	Dry cooling and washing 100-MW facility	70	150
	Dry cooling and washing 400-MW facility	280	600
Dish engine	Mirror washing 10-MW facility	5	5
	Mirror washing 400-MW facility	200	200
PV	Panel washing 10-MW facility	0.5	0.5
	Panel washing 400-MW facility	20	20

[a] Potable water use is estimated to be between 0.2 and 0.6 ac-ft/year.

[b] Conversion from gal/h/MW to ac-ft/yr/MW assumes 1 gal = ~ 0.0000031 ac-ft (or 1 ac-ft = 325,900 gal).

[c] CLFR = compact linear Fresnel reflector.

Source: Table 3.1.5-1 (based on data from DOE [2009]).

dibenzofuran. In parabolic trough and power tower technologies, molten salts (mixtures of sodium nitrate, potassium nitrate, and calcium nitrate) may be used as TES media. They are solid under normal temperatures and could be easily confined and removed if accidentally released to the arid environment. However, they also are highly soluble and could be released to water if exposed to precipitation. Additionally, diesel fuel would be located at the site to fuel backup generators. The accidental release of these chemicals to the environment could contaminate nearby surface waters and groundwater.

The reflectors in parabolic trough and power tower technologies are in specific alignment patterns. The specific alignment pattern of solar reflectors helps reduce solar shadows, better capture insolation, simplify engineering design, and reduce the construction cost of a solar power plant. This issue of having an aligned reflector configuration is more important in parabolic trough, power tower, or compact linear Fresnel reflector (CLFR) facilities than for other solar energy technologies To fit the alignment pattern, natural land slopes and potentially natural drainages in the solar field may need modification. Such modifications may alter the natural drainage system in the vicinity of the plant. Drainage and wash channel migrations and water quality degradation could result from expedited soil erosion, as well as impacts on vegetation and animal habitats.

5.9.2.2 Dish Engine

For solar dish engine facilities, a steam power plant system is not needed. The water demand is therefore substantially less than that for the parabolic trough or power tower solar

facilities. As shown in Table 5.9-1, the estimated water demand, about 5 ac-ft/yr (6,165 m^3/yr) for a 10-MW dish engine facility, is for mirror washing. If the size of a facility is assumed to be 400 MW, 200 ac-ft/yr (247,000 m^3/yr) of water is estimated to be needed for mirror washing. Depending upon the design of the dish engine facility, an additional water demand may be needed for in situ hydrogen gas production by electrolysis, but the amount of water needed would be typically much less than 1 ac-ft/yr (1,234 m^3/yr) (see Section 3.5.2 for further details).

Petroleum-based lubricating oils and glycol-based aqueous coolants are also present in each dish engine, in limited quantities. Leaks and spills of these liquids could adversely affect the environment if not responded to properly and promptly. In addition, wastewater would be generated during engine cleaning in preparation for engine repairs.

5.9.2.3 PV Systems

For PV systems, a steam power plant system is not needed. The water needs of a PV facility are lower than those of a solar dish engine facility, because less water is needed to clean PV panels than reflecting mirrors. As shown in Table 5.9-1, the water demand for a 10-MW PV facility is estimated to be about 0.5 ac-ft/yr (617 m^3/yr) for panel washing. For a 400-MW PV facility, it is estimated that 20 ac-ft/yr (24,700 m^3/yr) of water would be needed. No HTF is needed in PV facilities. Therefore, the risk of leaks or spills of HTFs does not exist.

5.9.3 Potentially Applicable Mitigation Measures

The main objectives of the mitigation measures for water resources are (1) to promote the sustainable use of water resources through appropriate technology selection and conservation practices and (2) to protect the quality of natural water bodies (including streams, wetlands, ephemeral washes, and floodplains, as well as groundwater aquifers) in and around solar energy facilities. An important aspect of implementing these measures is coordination with federal, state, and local agencies that regulate the use of water resources to meet the requirements of permits and approvals needed (1) to obtain water for development and (2) to alter the land surface. In the following subsections, potentially applicable mitigation measures for solar energy facilities are given, grouped by phase of development.

5.9.3.1 Siting and Design

In the very early stages of the development of siting and design plans, project developers would coordinate with appropriate federal, state, and local agencies that regulate activities that affect land and water resources to determine what permits or approvals may be needed for construction and operation of a solar facility. This coordination would facilitate the following activities and objectives:

- All structures related to the solar energy facility should be sited in locations that minimize impacts on surface water bodies, ephemeral washes, playas, and natural drainage areas (including groundwater recharge areas).

- Project developers should plan to implement water conservation measures related to solar energy technology water needs in order to reduce project water requirements. Developers would minimize the consumptive use of fresh water for power plant cooling by, for example, using dry cooling, using recycled or impaired water, or selecting solar energy technologies that do not require cooling water.

- Project developers should conduct a preliminary hydrologic study demonstrating a clear understanding of the local surface water and groundwater hydrology. The primary purpose of this preliminary hydrologic study is to identify surface watersheds and groundwater basins directly affected and connected to the location of the project site, and the study will include the following information:

  – The relationship of the project site hydrologic basin to the basins in the region;

  – Identification of all surface water bodies (including rivers, streams, ephemeral washes/drainages, lakes, wetlands, playas and floodplains);

  – Identification of all applicable groundwater aquifers; and

  – Preliminary estimates of the physical characteristics of surface water features and groundwater aquifers, the connectivity of surface water and groundwater, and the regional climate (seasonal and long term).

- Project developers should plan to avoid impacts on existing surface water features, including streams, lakes, wetlands, floodplains, intermittent streams, playas, and ephemeral washes/drainages (any unavoidable impacts would be minimized), in the development and in nearby regions according to:

  – All sections of the CWA, including Sections 401, 402, and 404 addressing licensing and permitting issues;

  – E.O. 11988 and E.O. 11990 of May 24, 1977, regarding floodplain and wetland management: E.O. 11988, “Floodplain Management” (*Federal Register*, Volume 42, page 26951 [42 FR 26951]), and E.O. 11990, “Protection of Wetlands” (42 FR 26961);

  – EPA stormwater management guidelines (EPA 2009a) and applicable state and local stormwater management guidelines;

- National Wild and Scenic Rivers System (Public Law 90-542; 16 United States Code [U.S.C.] 1271 et seq.); and

- Identification of impaired surface water bodies in accordance with Section 303(d) of the CWA.

- Project developers should plan to minimize impacts on groundwater aquifers.

  - Impacts on sole-source aquifers should be avoided according to EPA guidelines.

- Project developers should avoid impacts on local surface water and groundwater drinking water supplies (amounts and water quality) and develop mitigation plans in the event that local drinking water sources are contaminated or depleted by project activities.

As project developers formulate final siting and design plans for solar energy facilities, the following activities and objectives should be considered in order to minimize impacts on water resources. They should be done in coordination with the appropriate local, state, and federal regulating agencies. The following items relate to quantification and characterization of the existing hydrology, land alteration issues, water rights, and water quality.

- Mitigation plans should be developed as described in Section 5.1.

- A Drainage, Erosion, and Sedimentation Control Plan should be developed that ensures protection of water quality and soil resources, demonstrates no increase in off-site flooding potential, and includes provisions for stormwater and sediment retention on the project site. The plan would identify site surface water runoff patterns and develop mitigation measures that prevent excessive and unnatural soil deposition and erosion throughout and downslope of the project site and project-related construction areas. The plan would achieve the following:

  - Runoff from parking lots, roofs, or other impervious surfaces would be directed to retention basins prior to being released downgradient of the site;

  - Any landscaping used for stormwater treatment would require little or no irrigation and would be recessed to create retention basins/areas used to capture runoff;

  - The amount of area covered by impervious surfaces would be reduced through the use of permeable pavement or other pervious surfaces; and

  - Natural drainages and a pre-project hydrograph would be maintained for the area.

- A Stormwater Management Plan should be developed for the site to ensure compliance with applicable regulations and prevent off-site migration of contaminated stormwater, changes in pre-project storm hydrographs, or increased soil erosion.

  - Siting in identified 100-yr floodplains should not be allowed within the development.

  - Project developers should maintain the pre-development flood hydrograph for all storms up to and including the 100-yr rainfall event. All stormwater retention and/or infiltration and treatment systems should also be designed for all storms up to and including the 100-yr storm event.

- As part of a Spill Prevention and Emergency Response Plan, measures to prevent potential groundwater and surface water contamination should be identified.

- Developers should be required to conduct a detailed hydrologic study that demonstrates their clear understanding of the local surface water and groundwater hydrology. At a minimum this hydrologic study should include:

  - Quantification of physical characteristics describing surface water features, such as streamflow rates, stream cross-sections, channel routings, seasonal flow rates (intermittent streams), peak flow rates (ephemeral washes/drainages), sediment characteristics and transport rates, lake depths, and surface areas of lakes, wetlands, and floodplains;

  - Hydrologic analysis and modeling to define the 100-yr, 24-hour rainfall event for the project area and calculation of projected runoff from this storm at site;

  - Hydrologic analysis and modeling to identify 100-yr floodplain boundaries of any surface water feature on the site;

  - Quantification of physical characteristics describing the groundwater aquifer, such as physical dimensions of the aquifer, sediment characteristics, confined/unconfined conditions, hydraulic conductivity and transmissivity distribution of the aquifer, groundwater surface elevations, and groundwater flow processes (direction, recharge/discharge, surface current basin extractions, surface water/groundwater connectivity, and lag times between groundwater withdrawals and surface water depletions);

  - Quantification of the regional climate, including seasonal and long-term information on temperatures, precipitation, evaporation, and evapotranspiration; and

  - Quantification of the sustainable yield of surface waters and groundwater available to the project. Project developers should evaluate the water sources in terms of existing water rights and management plans for adequacy with regard to serving project demands while maintaining aquatic, riparian, and other water-dependent resources.

- Project developers should quantify water use requirements for project construction, operation, and decommissioning.

- Water sources used for potable water supply must meet federal, state, and local water quality standards (e.g., Sections 303 and 304 of the CWA).

- Developers should identify wastewater treatment measures and new or expanded facilities, if any, to be included as part of the facility's NPDES permit.

- Developers should coordinate with state/local regulatory agencies regarding the issuance of permits or "will-serve" agreements for the development and use of water and/or the operation of on-site wastewater treatment systems.

- Project developers should coordinate with appropriate water rights agencies for securing water rights.

- Project developers should choose appropriate water sources with respect to available water rights and management practices and with respect to maintaining aquatic, riparian, and other water-dependent sources (that may vary in water requirements on a temporal basis).

- Project developers who plan to use groundwater should develop and implement a groundwater Water Resources Monitoring and Mitigation Plan, which includes monitoring the effects of groundwater withdrawal for project uses, of vegetation restoration and dust control uses during decommissioning, and of aquifer recovery after project decommissioning. Monitoring frequency should be decided on a site-specific basis and in coordination with federal, state, and local agencies that manage the groundwater resources of the region.

- If groundwater use is proposed, project developers should ensure that a comprehensive analysis of the groundwater basin is provided and that the following potential significant impacts are evaluated:

  - Creation or exacerbation of overdraft conditions and their potential to cause subsidence and loss of aquifer storage capacity;

  - Use that cause injury to other water rights claims in the basin;

  - Estimates of the total cone of depression considering cumulative drawdown from all potential pumping in the basin, including the project, for the life of the project through the decommissioning phase;
  -
  - Changes in water quality that affect other beneficial use; and
  - Effects on surface water resources such as streams, springs, seeps, and wetlands that provide water and associated habitat for plants and animals.

- Project developers who plan to use surface water sources should develop a Water Resources Monitoring and Mitigation Plan that includes monitoring changes in flows, volumes, and water quality during construction and operations as well as their recovery during decommissioning. Monitoring frequency should be decided on a site-specific basis and in coordination with federal, state, and local agencies that manage the surface water resources of the region.

- If surface water use is proposed, project developers should ensure that a comprehensive analysis of the supply is provided and that the following potential significant impacts are evaluated:

  - Effects on other users;
  - Effects on water quality;
  - Effects on other water resources;
  - Effects on other environmental resources, including plants and animals, that directly or indirectly depend on those water sources;
  -
  - Effects on the natural hydrograph of the supply; and
  - Effects on the reliability of the supply.

5.9.3.2 Site Characterization and Construction

- The facility should obtain and comply with a construction stormwater permit through the EPA or state-run NPDES program (whichever applies within the state). In addition, the EPA requires that any development larger than 20 acres (0/08 km^2) and begun after August 2011 must comply with a requirement to monitor construction discharges for turbidity concentrations (EPA 2009c).

- Groundwater wells constructed during any stage of the project would conform to state and local standards and records should include:

  - Legal description (township, range, section, and quarter section);
  - Project map with proposed and existing well locations;
  - Well design characteristics: casing diameter, screened interval(s), well depth, and static water level;
  - Results of groundwater pumping tests or other tests done in the well;
  - Anticipated pumping capacity and peak pumping rates;
  - Identification of the groundwater aquifer and its hydrogeologic characteristics;
  - Estimation of the potential cone of depression that might be produced by the proposed pumping throughout the lifetime of a project by using an analytical or numerical model; and
  - Estimate of the total cone of depression considering cumulative drawdown from all potential pumping in the basin, including the project, for the life of the project through the decommissioning phase (also using an analytical or numerical model).

- Construction activities should avoid land disturbance in ephemeral washes and dry lakebeds; any unavoidable disturbance would be minimized. Stormwater facilities would be designed to route flow around the facility and maintain pre-project hydrographs.
- When stream or wash crossings are constructed, culverts or water conveyances for temporary and permanent roads should be designed to comply with county standards or to accommodate the runoff of a 100-year storm, whichever is larger.
- Geotextile mats should be used to stabilize disturbed channels and stream banks (CASQA 2003).
- Earth dikes, swales, and lined ditches should be used to divert work-site runoff that would otherwise enter a disturbed stream (CASQA 2003).
- Certified weed-free straw bale barriers should be installed to control sediment in runoff water; straw bale barriers should be installed only where sediment-laden water can pond, thus allowing the sediment to settle out (CASQA 2003).
- Check dams (i.e., small barriers constructed of rock, gravel bags, sandbags, fiber rolls, or reusable products) should be placed across a constructed swale

or drainage ditch to reduce the velocity of flowing water, thus allowing sediment to settle and reducing erosion (CASQA 2003).

- Special construction techniques should be used, where applicable, in areas of erodible soil, alluvial fans, and stream channel/wash crossings.

- Disturbed soils should be reclaimed as quickly as possible, or protective covers should be applied.

- Topsoil removed during construction should be reused for reclamation.

- Foundations and trenches should be backfilled with originally excavated material as much as possible; excess excavated material should be disposed of according to state and federal laws.

- If drilling activities are required as part of site characterization, any drilling fluids or cuttings should be maintained so that cuttings, fluids, or runoff from storage areas will not come in contact with aquatic habitats. Temporary impoundments for storing drilling fluids and cuttings should be lined to minimize the infiltration of runoff into groundwater or surface water.

- Washing equipment or vehicles in streams and wetlands should be avoided, because doing so increases their sediment loads.

- Entry and exit pits should be constructed in work areas to trap sediments from vehicles so that they do not enter into streams at stream crossings. Prerequisites to excavating the entry and exit pits should include:

  - Locating the entry and exit pits far enough from stream banks and at a sufficient elevation to avoid inundation by storm flow stream levels and to minimize excessive migration of groundwater into the entry or exit pits;
  -
  - Isolating the excavation for the entry and exit pits from the surface water by using silt fencing to avoid sediment transport by stormwater; and

  - Isolating the spoils storage resulting from excavation of the entry and exit pits by using silt fencing to avoid sediment transport by stormwater.

- Good waste management practices should be adopted for handling, storing, and disposing of wastes generated by a construction project to prevent the release of waste materials into stormwater discharges. Waste management includes the following: spill prevention and control, construction debris and litter management, concrete waste management, and liquid waste management.

- Any wastewater generated in association with temporary, portable sanitary facilities should be periodically removed by a licensed hauler and introduced into an existing municipal sewage treatment facility. Portable sanitary facilities provided for construction crews should be adequate to support expected on-site personnel.

- The creation of hydrologic conduits between two aquifers should be avoided during foundation excavation and other activities.

- If chemical dust palliatives (suppressants) are used, they should be selected and applied in accordance with considerations stated in Section 5.11.1.3.

- When an herbicide/pesticide is used to control vegetation, the climate, soil type, slope, and vegetation type should be considered in determining the risk of herbicide/pesticide contamination (BLM 2006a). In addition, a Nuisance Animal and Pest Control Plan and an Integrated Vegetation Management Plan should be developed to ensure that applications are conducted within the framework of BLM and U.S. Department of the Interior (DOI) policies and standard operating procedures and will entail only the use of EPA-registered pesticides/herbicides that also comply with state and local regulations.

- All hazardous materials and vehicle/equipment fuels should be transported, stored, managed, and disposed of in accordance with accepted BMPs and in compliance with all applicable regulations and the requirements of approved plans, including, where applicable, a Stormwater Management Plan, Spill Prevention and Emergency Response Plan, and Hazardous Materials and Waste Management Plan (see Section 5.21 for further details).

- Project developers should avoid or minimize and mitigate the degradation of water quality (e.g., chemical contamination, increased salinity, increased temperature, decreased dissolved oxygen, and increased sediment loads) that could result from construction activities. Water quality in areas adjacent to or downstream from development areas should be monitored during the life of the project to ensure that water quality is protected.

5.9.3.3 Operations

- The use of water should not contribute to the significant long-term decline of groundwater levels or surface water flows and volumes. Any project-related water use should not contribute to withdrawals that exceed the sustainable yield of the surface water or groundwater source.

- Water use should be minimized by implementing conservation practices, such as treating spent wash water and storing it for reuse.

- The treatment of sanitary and industrial wastewater either on-site or off-site would comply with federal, state, and local regulations. Any discharges to surface waters would require NPDES permitting. Any storage or treatment of wastewater on-site should have proper lining of holding ponds and tanks to prevent leaks.

- Berms and other controls should be used at facilities to prevent off-site migration of any leaked or spilled HTF, TES fluids, or any other chemicals stored or used at the site.

- Project developers should avoid or minimize and mitigate the degradation of water quality (e.g., chemical contamination, increased salinity, increased temperature, decreased dissolved oxygen, and increased sediment loads) that could result from operations. Water quality in areas adjacent to or downstream from development areas should be monitored during the life of the project to ensure that water quality is protected.

5.9.3.4 Decommissioning/Reclamation

- All management plans, mitigation measures, and stipulations developed for the construction phase should be applied to similar activities during the decommissioning/reclamation phase.

- Topsoil removed during construction should be reused during reclamation.

- Groundwater- and/or surface water-monitoring activities should be as outlined in the established groundwater monitoring plan for the site (discussed above).

5.10 ECOLOGICAL RESOURCES

Solar energy development could affect a wide variety of ecological resources in the areas where it occurs. The following subsections discuss the common and technology-specific impacts on vegetation, wildlife, aquatic biota, and special status species that could occur from solar development, as well as potentially applicable mitigation measures for such impacts. Information on the ecological resources present in the six state study area is given in Section 4.9.

5.10.1 Vegetation (Plant Communities and Habitats)

5.10.1.1 Common Impacts

Potential impacts on terrestrial and wetland plant communities and habitats from the development of utility-scale solar energy projects would include direct impacts from habitat

TABLE 5.10-1 Potential Impacts on Plant Communities Associated with Utility-Scale Solar Energy Facilities, Including Associated Access Roads and Transmission Line Corridors

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Plant Communities[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
Individual Impacting Factor[d]							
Alteration of topography and drainage patterns	Construction, operations	Changes in surface temperature, soil moisture, and hydrologic regimes, and distribution and extent of aquatic, wetland, and riparian habitats; erosion; changes in groundwater recharge; spread of invasive species; decrease in pollinators, changes in community structure and function.	None	None	Terrestrial	Aquatic, wetland, and riparian	Can be mitigated by avoiding development of drainages and using appropriate stormwater management strategies.
Erosion	Construction operations, decommissioning	Habitat degradation; loss of plants; sedimentation of adjacent areas especially aquatic, wetland, and riparian habitats, loss of productivity; spread of invasive species; changes in community structure and function.	None	Terrestrial	Aquatic, wetland, and riparian	None	Easily mitigated with standard erosion control practices.
Fugitive dust	Site characterization, construction, operations, decommissioning	Decrease in photosynthesis, reduction in productivity, increase in turbidity and sedimentation in aquatic habitat, spread of invasive species, decrease in pollinators, changes in community structure and function.	None	None	All plant communities	None	Can be mitigated by retaining vegetative cover, soil covers, or soil-stabilizing agents.

TABLE 5.10-1 (Cont.)

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Plant Communities[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
Individual Impacting Factor[d] (Cont.)							
Groundwater withdrawal	Construction, operations	Change in hydrologic regime, reduction in surface water, reduction in soil moisture, reduction in productivity, decrease in pollinators, changes in community structure and function.	None	Terrestrial (other than phreatophytic)	Aquatic, wetland, riparian, and phreatophytic	None	Can be mitigated by reducing water consumption requirements. May be difficult to mitigate for all but PV systems.
Habitat fragmentation	Construction, operations	Genetic isolation, loss of access to important habitats, reduction in diversity, spread of invasive species, decrease in pollinators, changes in community structure and function.	None	None	All plant communities	None	Difficult to mitigate; requires minimizing disruption of intact communities, especially by linear features such as transmission lines and roads.
Increased human access	Construction, operations	Collection, mortality.	None	All plant communities	None	None	Can be mitigated by reducing the number of new transmission lines and roads in important habitats.
Oil and contaminant spills	Site characterization, construction, operations, decommissioning	Death of directly affected individuals, uptake of toxic materials, reproductive impairment, decrease in pollinators, changes in community structure and function.	None	None	Terrestrial	Aquatic, wetland, and riparian	Can be mitigated by using project mitigation measures (e.g., pipeline check valves) and spill prevention and response planning.

TABLE 5.10-1 (Cont.)

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Plant Communities[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
Individual Impacting Factor[d] (Cont.)							
Restoration of topography and drainage patterns	Decommissioning	Beneficial changes in temperature, soil moisture, and hydrologic regimes; changes in community structure and function.	None	None	All plant communities	None	Mostly beneficial; adverse impacts can be mitigated by using standard erosion and runoff control measures.
Restoration of topsoil	Decommissioning	Beneficial changes in soil moisture, increased productivity, changes in community structure and function.	None	None	All plant communities	None	Mostly beneficial; adverse impacts can be mitigated by using standard erosion and runoff control measures.
Restoration of native vegetation	Decommissioning	Beneficial changes in soil moisture, increased productivity, increased diversity, increase in pollinators, changes in community structure and function.	None	None	All plant communities	None	Mostly beneficial; adverse impacts can be mitigated by ensuring species mix used includes a diverse weed-free mix of hardy native species.
Soil compaction	Site characterization, construction, operations, decommissioning	Reduction in productivity, reduction in diversity, increased runoff and erosion, spread of invasive species, changes in community structure and function.	None	All plant communities	None	None	Easily mitigated by aerating soil after being compacted.
Topsoil removal	Construction, operations	Reduction in productivity, reduction in diversity, direct mortality of individuals, increased sedimentation in aquatic habitat, spread of invasive species, decrease in pollinators, changes in community structure and function.	None	None	All plant communities	None	Readily mitigated by stockpiling soils to maintain seed viability, vegetating to reduce erosion, and replacing at appropriate depths when other site activities are complete.

TABLE 5.10-1 (Cont.)

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Plant Communities[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
Individual Impacting Factor[d] (Cont.)							
Vegetation clearing	Construction, operations	Elimination of habitat, habitat fragmentation, direct mortality of individuals, changes in temperature and moisture regimes, erosion, increased fugitive dust emissions, reduction in productivity, reduction in diversity, spread of invasive species, decrease in pollinators, changes in community structure and function.	None	None	None	All plant communities	Difficult to mitigate; most project areas are likely to require clearing. Restoration of a vegetative cover consistent with the intended land use would reduce some impacts.
Vegetation maintenance	Operations	Reduction in vegetation cover or vegetation maintained in early successional stage or low-stature, habitat fragmentation, direct mortality of individuals, reduction in diversity, spread of invasive species, decrease in pollinators, changes in community structure and function.	None	None	All plant communities	None	Can be mitigated by managing for low-maintenance vegetation (e.g., native shrubs, grasses, and forbs), invasive species control, minimizing the use of herbicides near sensitive habitats (e.g., aquatic and wetland habitats), and using only approved herbicides consistent with safe application guidelines.
Vehicle and equipment emissions	Construction, operations	Reduced productivity.	None	All plant communities	None	None	Readily mitigated by maintaining equipment in proper operating condition.

TABLE 5.10-1 (Cont.)

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Plant Communities[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
Individual Impacting Factor[d] (Cont.)							
Vehicle and foot traffic	Site characterization, construction, operations, decommissioning	Direct mortality of individuals through crushing, soil compaction, increased fugitive dust emissions.	None	All plant communities	None	None	Can be mitigated by using worker education programs, signage, and traffic restrictions.
All Impacting Factors Combined							
	Site characterization	Direct mortality of individuals, habitat loss, soil compaction, increased fugitive dust emissions, increased runoff and erosion, spread of invasive species, changes in community structure and function.	None	All plant communities	None	None	Relatively easy.
	Construction	Direct mortality of individuals, habitat loss, reduced productivity and diversity, habitat fragmentation, soil compaction, increased fugitive dust emissions, spread of invasive species, changes in temperature and moisture regimes, increased sedimentation in aquatic habitat, increased runoff and erosion, changes in groundwater recharge, changes in community structure and function.	None	None	None	All plant communities	Relatively difficult; residual impact mostly dependent on the size of area developed.

TABLE 5.10-1 (Cont.)

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Plant Communities[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
All Impacting Factors Combined (Cont.)							
	Operations	Direct mortality of individuals, habitat loss, reduction in vegetation cover or vegetation maintained in early successional stage or low-stature, reduced productivity and diversity, habitat fragmentation, soil compaction, increased fugitive dust emissions, changes in temperature and moisture regimes, increased sedimentation in aquatic habitat, increased runoff and erosion, changes in groundwater recharge, changes in community structure and function.	None	None	None	All plant communities	Relatively difficult; residual impact mostly dependent on the size of area developed.
	Decommissioning	Beneficial changes in soil moisture, temperature, and hydrologic regimes, increased productivity, increased diversity, direct mortality of individuals, habitat loss, soil compaction, increased fugitive dust emissions, changes in community structure and function.	None	None	All plant communities (benefits)	None	Relatively easy to mitigate adverse impacts of decommissioning. May be difficult to achieve restoration objectives.

TABLE 5.10-1 (Cont.)

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Plant Communities[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
All Impacting Factors Combined (Cont.)							
	Overall project	Direct mortality of individuals, habitat loss, reduced productivity and diversity, habitat fragmentation, soil compaction, increased fugitive dust emissions, changes in temperature and moisture regimes, increased sedimentation in aquatic habitat, increased runoff and erosion, changes in groundwater recharge, changes in community structure and function.	None	None	None	All plant communities	Relatively difficult; residual impact mostly dependent on the size of area developed and the success of restoration activities.

[a] Relative impact magnitude categories were based on professional judgment utilizing CEQ regulations for implementing NEPA (40 CFR 1508.27) by defining significance of impacts based on context and intensity. Similar impact magnitude categories and definitions were used in BLM (2008a,b) and assume no mitigation. Impact categories were as follows: (1) none—no impact would occur; (2) *small*—effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource (e.g., <1% of a population or community would be lost in the region); (3) *moderate*—effects are sufficient to alter noticeably but not to destabilize important attributes of the resource (e.g., >1 but <10% of a population or community would be lost in the region); and (4) *large*—effects are clearly noticeable and are sufficient to destabilize important attributes of the resource (e.g., >10% of a population or community would be lost in the region). Actual impact magnitudes on plant communities would depend on the location of projects, project-specific design, application of mitigation measures (including avoidance, minimization, and compensation) and the status of communities in project areas.

[b] Plant communities are placed into groups based on ecological system (aquatic, wetland, riparian, and terrestrial) when the category is relevant to impact magnitude.

[c] Actual ability to mitigate impacts will depend on site-specific conditions and the communities present in the project area. Recommended mitigation measures are presented in Section 5.10.5.

[d] Impacting factors are presented in alphabetical order.

removal as well as a wide variety of indirect impacts (Table 5.10-1). Impacts would be incurred during initial site preparation and would continue throughout the operational life of the facility, typically extending over several decades. Plant communities and habitats affected by direct or indirect impacts from project activities could incur short- or long-term changes in species composition, abundance, and distribution. Some impacts may also continue after the decommissioning of a solar energy project.

Land areas available for solar energy development support a wide variety of plant communities and habitats. The evaluation of impacts on these resources from the construction, operation, and decommissioning of a solar energy facility is based on the Level III ecoregions within the six-state study area (EPA 2007). Habitat types associated with the ecoregions occurring in these states are described in Appendix I.

Figure 5.10-1 shows the solar resources in relation to the ecoregions. More than half of the areas with the greatest potential for solar energy development are located in the basin areas of the Central Basin and Range, Mojave Basin and Range, and Sonoran Basin and Range ecoregions, as well as the Chihuahuan Deserts ecoregion. The basins support extensive arid and semiarid desert-scrub and shrubland habitats, such as Great Basin sagebrush, saltbush, greasewood, creosotebush, shadscale, or palo verde-cactus habitats. The Arizona/New Mexico Plateau and Colorado Plateau ecoregions also have high potential for solar development and support desert-scrub, shrub steppe, and grassland habitats. These habitat types would be the most likely to be affected by solar energy development. The plant communities that could be affected by project development and the nature and magnitude of impacts that could occur would depend on the specific locations of the projects, as well as on the specific project design and the mitigation measures implemented to address impacts. These impacts would be considered in project-specific NEPA analyses that would be conducted at the development phases of the projects.

5.10.1.1.1 Site Characterization. Direct impacts on plant communities during site characterization could occur from the operation of vehicles transporting equipment to off-road locations. Damage to plants (particularly shrubs), wetland soils, and biological soil crusts could result in long-term impacts and may require considerable periods of time for recovery to take place. Trampling from foot traffic would be expected to result in minor, short-term impacts. The construction of access roads would eliminate vegetation within the roadway footprint and could result in indirect impacts on nearby areas from altered drainage patterns, runoff, sedimentation, and increases in non-native, invasive plant species that could spread into adjacent wildlands. Soil borings and the installation of meteorological towers and groundwater wells could directly affect plant communities, potentially including sensitive habitats, remnant vegetation associations, or rare natural communities. Impacts could result from soil disturbance, the removal of vegetation, burial by drill cuttings, or the impoundment of drilling fluids. Erosion of exposed soils or cuttings or releases of drilling fluids could affect downstream habitats, such as wetlands, by sedimentation or the introduction of contaminants.

5.10.1.1.2 Construction. Direct impacts would primarily include the destruction of habitat during initial land clearing on the solar energy project site, as well as habitat losses

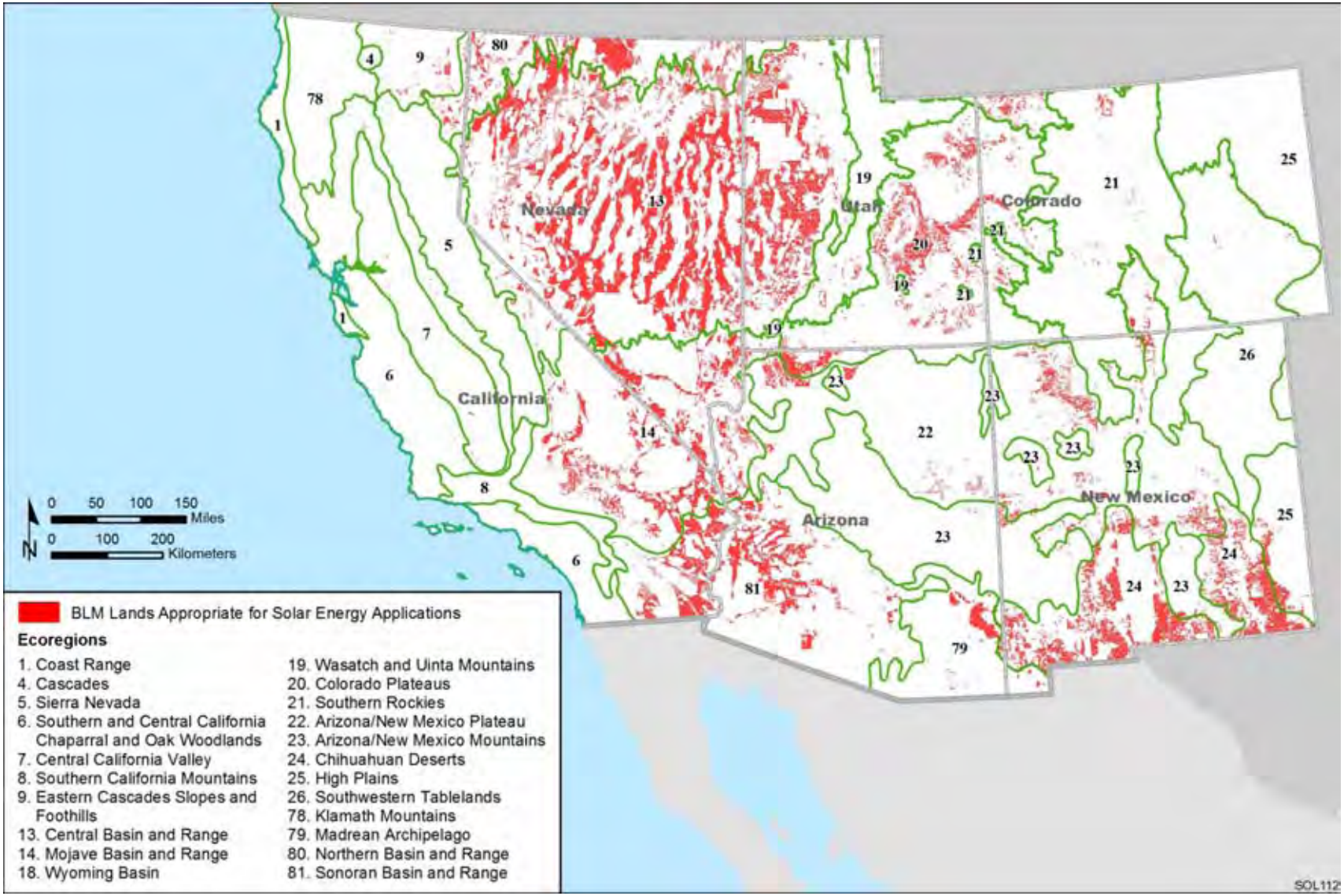

FIGURE 5.10-1 BLM-Administered Lands with Potential for Solar Energy Development and Associated Level III Ecoregions (Source: EPA 2007)

resulting from the construction of access roads, natural gas pipelines, and electric transmission lines. Site preparation activities may include the grading or excavation of soils to provide a level working area for equipment installation and, for some projects, excavation for equipment foundations. Land clearing on portions of the site would be required for construction of the solar array field, substation, maintenance buildings, and other structures (e.g., a power block, chemical storage tanks, TES, and cooling systems) that may be required, depending on the type of facility, and that may potentially result in considerable losses of habitat. For example, a 750-MW dish engine or PV facility may be approximately 6,750 acres (27.3 km^2) in size, assuming that 9 acres (0.04 km^2) are required per megawatt. Varying portions of land surface would be cleared during construction, depending on the technology used, avoidance of sensitive areas, and the balance struck between (1) clearing vegetation for solar array placement and access and for fire safety and (2) maintaining low-growing vegetation for soil stabilization, stormwater control, and provision of habitat. Additional areas may be cleared for construction laydown areas and staging areas. Damage to plants may also result from equipment operating near land-clearing and construction areas. However, as an upper-bound assumption for impact analyses, the entire project area was assumed to be cleared of all vegetation during site preparation. Assumptions regarding site clearing and vegetation management are discussed in Appendix M.

Native vegetation communities present in project areas would be destroyed and may include rare communities, remnant vegetation associations, endemic species, riparian areas, nonjurisdictional wetlands (such as isolated wetlands), or jurisdictional wetlands. In general, the vast majority of lands subject to solar energy development occurs within arid environments that often support unique species and ecosystems that are extremely sensitive to land disturbances and can take decades to recover. However, it is expected that direct impacts on sensitive habitats, many of which are water-dependent, located within a project site could be avoided. On May 24, 1977, the President signed E.O. 11990, “Protection of Wetlands” (*Federal Register*, Volume 42, page 26961, May 24, 1977), which requires all federal agencies to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands. Therefore, direct and indirect impacts on wetlands would be avoided or minimized. Compliance with CWA Section 404 would be required. Impacts on waters of the United States, including jurisdictional wetlands (those under the regulatory jurisdiction of the CWA, Section 404) on or near the project site or near the locations of ancillary facilities would be avoided or minimized and mitigated as required by Section 404. Preconstruction surveys would identify wetland locations and boundaries, and the permitting process would be initiated with the USACE for unavoidable impacts. Under the “no net loss” wetland policy, wetlands destroyed are compensated for by the development of new wetland areas, generally located off-site, and compensatory mitigation may be required for unavoidable impacts of solar project development. State regulations may also require avoidance or mitigation of wetland impacts, and riparian policies of BLM state offices would need to be followed.

While land surfaces over most of the project site may be kept free of vegetation, the restoration of some areas affected by temporary disturbances, such as construction staging areas or ROWs for electric transmission lines, water supply lines, or natural gas pipelines, would include the re-establishment of vegetation. Along with natural regeneration of native species that may occur, exposed soils in these areas would be seeded as directed under applicable BLM requirements. While restoration would focus on the planting of native species to restore locally

native plant communities, in some areas, restoration may potentially include species that are not locally native. Although the replanting of disturbed soils may successfully establish vegetation in some locations (i.e., with a biomass and species richness similar to those of local native communities), the resulting plant community may be somewhat different from native communities in terms of species composition and representation of particular vegetation types, such as shrubs (Newman and Redente 2001). The community composition of replanted areas would likely be greatly influenced by the species that are initially seeded, and colonization by species from nearby native communities may be slow (Paschke et al. 2005; Newman and Redente 2001). In addition, although the inclusion of invasive species would be prohibited, the planting of non-native species may result in the introduction of those species into nearby natural areas. The establishment of mature native plant communities may require decades, and some community types may never fully recover from disturbance. Successful re-establishment of some habitat types, such as some shrubland communities, may be difficult and may require considerably greater periods of time. Restoration of plant communities in areas with arid climates (e.g., averaging less than 9 in. [20 cm] of annual precipitation) would be especially difficult (Monsen et al. 2004) and may be unsuccessful in some areas. These would include such communities as the saltbush-greasewood communities of the Central Basin and Range ecoregion or the creosotebush communities, and unique habitat types, such as microphyll woodlands and desert washes of the Mojave Basin and Range and Sonoran basin and Range ecoregions. The loss of intact native plant communities could result in increased habitat fragmentation, even with the restoration of affected areas. However, the BLM is committed to the oversight of restoration efforts and ensuring that the Vegetation Management Plan for the site is followed. Assumptions regarding restoration of plant communities are discussed in Appendix M.

Indirect impacts on terrestrial and wetland habitats on or off the project site could result from land clearing and exposed soil; soil compaction; and changes in topography, surface drainage, and infiltration characteristics. Indirect impacts could include the degradation of habitat from construction activities occurring in adjacent areas or, in the case of wetlands, activities occurring within the watershed or groundwater recharge area.

In addition to habitat removal, the operation of heavy equipment on the project site or ROWs may result in loss or destruction of existing vegetation and biological (microbiological) soil crusts and the compaction and disturbance of soils (Belnap and Herrick 2006). Soil aeration, infiltration rates, moisture content, and erosion rates could be affected. Biological soil crusts occur in deserts and other sparsely vegetated arid habitats and are important for soil stability, nutrient cycling, and water infiltration; their disturbance may affect the development of plant communities (Fleischner 1994; Belnap et al. 2001; Gelbard and Belnap 2003). All these factors could affect the rate or success of vegetation re-establishment.

Habitats adjacent to a solar energy facility or ROW may become fragmented or isolated as a result of construction and increased access to the site by the public and non-project personnel. Biodiversity may subsequently be reduced in fragmented or isolated habitats. The fragmentation of large, undisturbed habitats of high quality by facility or ROW construction would be considered a greater impact than construction through previously disturbed or fragmented habitat. Fragmentation would be most significant for projects that effectively eliminate habitat corridors and connectivity.

The prevention of the spread or introduction of noxious weeds and invasive plant species is a high priority to federal, state, and county agencies. Ground disturbance from construction may make vegetation communities more susceptible to infestations of noxious weeds or invasive plants. These species are most prevalent in areas of surface disturbance, such as agricultural areas, roadsides, existing utility ROWs, and within the urban-wildland interface.

Legally, a noxious weed is any plant officially designated by a federal, state, or county government as injurious to public health, agriculture, recreation, wildlife, or property (Sheley and Petroff 1999). Under the Federal Plant Protection Act of 2000 (formerly the Noxious Weed Act of 1974 [7 USC 2801–2814]), a noxious weed is defined as "any plant or plant product that can directly or indirectly injure or cause damage to crops, livestock, poultry, or other interests of agriculture, irrigation, navigation, the natural resources of the United States, the public health, or the environment." Some of the worst wildland weeds may not be listed as noxious; for example, cheatgrass (*Bromus tectorum*), a highly invasive species, is not listed as noxious in states such as Colorado, where it occurs in large populations. Other species, such as buffelgrass (*Pennisetum ciliare*) are recognized as noxious too late to prevent widespread establishment, as in southern Arizona. Some species, such as crested wheatgrass (*Agropyron cristatum*), are found to be problematic after extensive planting. Noxious weeds are opportunistic plant species that readily flourish in disturbed areas, thereby preventing native plant species from establishing successive communities.

Invasive species are generally tolerant of disturbed conditions, and disturbed soils at project sites may provide an opportunity for the introduction and establishment of non-native invasive species. Seeds or other propagules of invasive species may be transported to a project site from infested areas by heavy equipment or other vehicles used at the site, or on recreational vehicles operated by the public and non-project personnel that can now access the area. Invasive species may also spread from established populations near a project site and colonize soils disturbed by project activities. The longer time periods required for the re-establishment of plant communities in arid regions may create an increased potential for the establishment and spread of invasive species. Invasive plant species typically develop high population densities and tend to exclude most other plant species, thereby reducing species diversity and potentially resulting in long-term effects. The establishment of invasive species may greatly reduce the success of native plant community restoration efforts in project areas and create a source of future colonization and degradation of adjacent undisturbed areas. The establishment of invasive grass species, particularly annual grasses, such as cheatgrass or buffelgrass, which produce large amounts of easily ignitable fuel over large contiguous areas, may also alter fire regimes. This situation may result in an increase in the frequency and intensity of wildfires, and in some areas, such as in some desert-scrub communities, an altered fire regime may become established where fire was previously infrequent. In plant communities not adapted to frequent or intense fires, native species, particularly shrubs and trees, may be adversely affected, and their populations may be greatly reduced, creating opportunities for greater increases in invasive species populations (Brooks and Pyke 2001). Increases in fire frequency or severity may thus result in a reduction of biodiversity and may promote the conversion of some habitats (such as shrubland, or shrub-steppe) to other types, prolonging or preventing the development of mature native habitats (BLM 2007).

The deposition of fugitive dust (including associated salts) generated during clearing and grading activities and/or during the construction and use of access roads, or deposition that results from wind erosion of exposed soils, could reduce photosynthesis and productivity (Thompson et al. 1984; Hirano et al. 1995), increase water loss (Eveling and Bataille 1984) in plants near project areas, and result in injury to leaves. Considerable amounts of fugitive dust could be generated from the large areas of disturbed soil on a solar energy project site. Plant community composition could subsequently be altered, resulting in habitat degradation. In addition, pollinator species could be affected by fugitive dust, potentially reducing pollinator populations in the vicinity. Localized impacts on plant populations and communities could occur if seed production in some plant species is reduced.

Impacts on surface water and groundwater systems could affect terrestrial plant communities, wetlands, and riparian habitats, particularly in arid environments. Soil compaction and the removal of vegetation could reduce the infiltration of precipitation or snowmelt, resulting in increased runoff and subsequent erosion and sedimentation. Reduced infiltration and altered surface runoff and drainage characteristics could result in changes in soil moisture, reduced recharge of shallow groundwater systems, and changes in the hydrologic regimes of streams and associated wetlands and riparian areas located downstream of a project site. Hydrologic changes could also result from the elimination of ephemeral or intermittent streams on a project site. Soils on steep slopes could be particularly susceptible to increased erosion resulting from changes in stormwater flow patterns. Erosion and reductions in soil moisture could alter terrestrial plant communities near a project site, resulting in reduced growth and reproduction and changes in species composition. Altered hydrologic regimes, such as reductions in the duration, frequency, or extent of inundation or soil saturation, could result in changes in plant species composition in wetlands or riparian communities, changes in community distribution, or reductions in community extent. If new drainage areas are developed, however, new riparian habitats could be created, depending on the timing and duration of soil saturation. Increased volumes or velocities of flows could affect wetland and riparian habitats, removing fine soil particles, organic materials, and shallow-rooted plants. Large-scale reductions in infiltration may increase flow fluctuations, reduce base flows, and increase flood flows, resulting in impacts on wetland and riparian community composition and extent. Sedimentation and associated increases in dissolved salts could degrade wetland and riparian plant communities. Effects may include mortality or reduced growth of plants, altered species composition of wetland or riparian communities, reduced biodiversity, or, in areas of heavy sediment accumulation, a reduction in the extent of wetland or riparian habitat.

Wetlands that collect surface water may be affected by soil disturbances. For example, the hydrology of playas, which are ephemeral lakes intermittently inundated because of impermeable soils, may be adversely affected by pipeline trenching or other soil disturbances that disrupt the storage of surface water, potentially reducing the frequency or duration of inundation.

Many native wetland species that are indicative of high-quality habitats are sensitive to disturbance, and they may be displaced by species more tolerant of disturbance or by invasive non-native species, thereby reducing biodiversity. Disturbance-tolerant species may become dominant in communities affected by these changes in hydrology and water quality. Increased

sedimentation, turbidity, or other changes in water quality may provide conditions conducive to the establishment of invasive species.

Direct impacts on plant communities and habitats would be expected to occur along the ROWs for access roads, pipelines, and transmission lines. Vegetation would be cleared for roadway, pipeline, or transmission tower construction. Riparian habitats or wetlands may be affected by ROWs that cross streams or other water bodies. Areas along ROWs that would be temporarily affected by construction activities would be restored in the same manner as other temporarily disturbed project areas. Tree removal from wetlands or riparian areas along ROWs may result in indirect impacts, such as reductions in soil moisture, erosion of exposed substrates, increases in water temperatures, or sedimentation. Removal of trees within or along forest or woodland areas would potentially result in an indirect disturbance to forest or woodland interior areas through changes in light and moisture conditions. The plant communities that become established on any area disturbed during ROW construction would depend on the restoration practices implemented, including the species selected, the species present in adjacent habitats, the degree of disturbance to vegetation and substrates, and the vegetation management practices selected for implementation.

5.10.1.1.3 Operations. Impacts on plant communities and habitats during facility operations could include the continued effects of fugitive dust, effects from long-term changes in surface water or groundwater hydrology, effects of hazardous material spills, and the continued spread of non-native invasive plant species that can result in and perpetuate altered fire regimes. These impacts can lead to further losses of native plant communities in the area surrounding a project site. Solar energy facilities may extend over considerable areas of land. For example, a 750-MW dish engine or PV facility may be approximately 6,750 acres (27.3 km^2) in size, with most of the land surface remaining devoid of vegetation. The exposed soil would provide a continual source of fugitive dust throughout the life of the facility, resulting in the long-term deposition of particulates onto plants in the vicinity. Such deposition could lead to long-term changes in plant community composition and productivity in the vicinity of a solar energy facility. Impacts on surface water quality from deposition of atmospheric dust from wind erosion of a solar facility could degrade terrestrial, wetland, and riparian habitats.

Considerable volumes of water may be required for the operation of a solar energy facility (see Section 5.9.2). Groundwater use for facility operation may result in the alteration of groundwater flow in project areas, which may affect wetlands and riparian habitats that directly receive groundwater discharge, such as at springs or seeps (Patten et al. 2008). Streamflows that are supported by groundwater discharge could be reduced in the vicinity of the project, resulting in impacts on associated wetlands and riparian habitats. Wetlands and riparian communities at considerable distances from a solar facility may be affected by reduced flows. Groundwater withdrawals in alluvial or basin-fill aquifers may cause water level declines that result in reduced discharges to wetlands or riparian communities. Wetland or riparian habitats could be eliminated or reduced in distribution or extent by reductions in groundwater discharge resulting from groundwater withdrawals, and plant communities could be degraded by changes in community composition.

Water withdrawals from surface water sources, such as rivers and streams, could result in considerable reductions in streamflows and in water quality downstream. Reduced flows and water quality may reduce the extent or distribution of wetlands and riparian areas along these water bodies or degrade these plant communities.

Upland habitats contribute to the hydrologic inflow to wetlands within their watershed through groundwater recharge or surface drainage. Depending on soil type, soils in some areas may have altered drainage and infiltration characteristics due to compaction, resulting in greater runoff. Increases in surface runoff and reductions in infiltration rates over large land areas as a result of soil compaction or constructed surfaces could contribute to a localized lowering of the groundwater table. Springs, seeps, and streamflows that are supported by groundwater discharge could be reduced if a large portion of the recharge area is affected, resulting in impacts on associated wetlands and riparian areas outside the solar energy facility site. Terrestrial plant species that access groundwater, such as phreatophytic species, could also be adversely affected by changes in groundwater levels. In addition, surface flows (i.e., sheet flows) provide important water resources to upland species occupying alluvial fans where perennial water sources are rare.

Increased runoff from impervious or compacted surfaces can increase the degree of fluctuation of water surface elevations in relation to precipitation events in wetlands within the watershed, causing more rapid increases in water surface elevations during and immediately following storm events, as well as more rapid reductions in water levels between precipitation events. Such changes may result in greater extremes of high and low water levels, including the reduction of stream base flows and increases in flood flows. Wetland types typically supported by groundwater flows may be greatly affected by increases in surface water inflows or altered surface drainage patterns.

Changes in streamflows as a result of altered surface water drainage patterns, such as from the elimination of ephemeral drainages or grading and land contouring, could also affect wetlands and riparian communities along affected streams. Streamflows may be increased or reduced by the alteration of land surfaces. Plant communities and habitats could be adversely affected by changes in water quality or availability, resulting in plant mortality or reduced growth, with subsequent changes in community composition and declines in habitat quality. Increased streamflows as a result of altered surface drainage patterns can result in erosion, sedimentation, and increased salinities in surface water. Moderate sedimentation may reduce photosynthesis in, and therefore the productivity of, submerged plants. Heavy sedimentation may cover vegetation, resulting in reduced growth or mortality. Other effects of sedimentation can include the displacement of sensitive species by more tolerant species, which may occur in high-quality, undisturbed wetlands. Wetlands and riparian areas could be adversely affected by decreased water quality and increased sedimentation, resulting in potential losses of or reductions in the extent of these habitats or in habitat degradation along affected streams.

Plant communities and habitats could be adversely affected by impacts on water quality, resulting in plant mortality or reduced growth, with subsequent changes in community composition and declines in habitat quality. Some facilities would store and use large volumes of hazardous chemicals, oils, or other fluids. Accidental spills of hazardous materials would adversely affect plant communities. Impacts on water quality could also result from the discharge

of cooling tower blowdown in the event that a wet-cooling system is used. Direct contact with contaminants could result in the mortality of plants or the degradation of habitats. Contaminants could affect the quality of shallow groundwater and indirectly affect terrestrial plants whose root systems reach groundwater sources, such as phreatophytic plants. If shallow groundwater becomes contaminated, wetland and riparian communities supported by groundwater discharge could be adversely affected, resulting in habitat degradation.

5.10.1.1.4 Decommissioning/Reclamation. The decommissioning of solar energy facilities would also result in impacts on terrestrial and wetland plant communities. Decommissioning activities would likely include the dismantling and removal of all aboveground structures as well as some underground structures, such as natural gas pipelines. Some buried pipelines may potentially be purged, cleaned, and left in place. The types of impacts resulting from decommissioning would be similar to those associated with facility construction. Decommissioning would result in soil disturbance, potentially including the regrading of some project areas. Ground disturbance would also occur in temporary work areas and storage areas. Vegetation would be removed or damaged in areas of disturbed soils, and these areas would require the re-establishment of plant communities. Excavation activities could occur in wetlands, and wetlands could be temporarily drained during the removal of some structures. Decommissioning activities would generally affect areas previously disturbed by initial facility construction.

Indirect impacts associated with decommissioning activities could include erosion, sedimentation, soil compaction, changes to surface water or groundwater hydrology, establishment of invasive species, deposition of airborne dust, and potential spills of hazardous materials. However, effects of facility operations, such as water withdrawals from groundwater or surface water sources, and the effects of ROW management would decrease following decommissioning. Public access to some areas may decline with the cessation of ROW management in woodland or forested areas. Plant communities may be difficult to restore following decommissioning. In some locations, such as in deserts and other arid regions, the re-establishment of plant communities may require considerable periods of time. In some locations, permanent differences between restored plant communities and nearby undisturbed areas would likely remain. Restoration would focus on the establishment of native plant communities similar to those present in the vicinity of the project site, and restoration efforts would be required to meet success criteria developed in coordination with the BLM.

5.10.1.1.5 Transmission Lines and Roads. Direct impacts on plant communities during construction of transmission line ROWs or during upgrades to existing lines would primarily include habitat losses resulting from the placement of towers and construction of access roads, as well as habitat modification by tree removal in forest or woodland communities. Site preparation activities may include the grading of soils to provide a level working area for equipment installation. Additional areas may be cleared for construction laydown areas and staging areas. Damage to plants may also occur from equipment operation near land-clearing and construction areas.

Indirect impacts on terrestrial and wetland habitats could result from erosion, sedimentation, altered drainage patterns, fugitive dust, tree cutting, herbicide use, and ROW maintenance. Indirect impacts could include the degradation of adjacent habitat or, in the case of wetlands, habitat within the watershed.

The operation of heavy equipment within transmission line ROWs may result in loss or destruction of existing vegetation and biological soil crusts and in the compaction and disturbance of soils. Soil aeration, infiltration rates, moisture content, and erosion rates could be affected. These factors could affect the rate or success of vegetation recovery or re-establishment.

Habitats adjacent to a ROW may become fragmented or isolated as a result of construction. Biodiversity may subsequently be reduced in fragmented or isolated habitats. The fragmentation of large, undisturbed habitats of high quality by ROW construction would be considered a greater impact than that of previously disturbed or fragmented habitat.

Maintenance programs for transmission line ROWs may result in the establishment of plant communities different from those in adjacent undisturbed areas and may prevent the development of mature habitat types. Herbicides used in ROW maintenance could be carried to wetland and riparian areas by surface runoff or could be carried by air currents to nearby nontarget terrestrial communities. The presence of a ROW may increase access to adjacent lands that previously had limited access. Disturbances resulting from increased access may include trampling, erosion, increased frequency of fires, unauthorized OHV use, illegal dumping, and illegal collection of plants from these areas (PBS&J 2002). The spread of invasive plant species may also be promoted by increased access along ROWs. These impacts could lead to changes in the abundance and distribution of plant species and changes in community composition within and adjacent to ROWs.

5.10.1.2 Technology-Specific Impacts

The general types of impacts on plant communities and habitats from the construction, operation, and decommissioning of a solar energy facility are described in Section 5.10.1.1. Potential impacts associated with specific technologies for solar energy are based on the anticipated resource requirements and activities likely to occur at facilities utilizing currently established technologies. Section 3.1 discusses the land and water requirements for each of the solar technologies based on an assumed range of power output. While these requirements differ by technology, the types of impacts are quite similar.

Much of the land area (e.g., 2,000 acres [8.1 km^2] for a 400-MW parabolic trough facility, 3,600 acres [15 km^2] for a 400-MW power tower facility, or 6,750 acres [27 km^2] for a 750-MW dish engine or PV facility) would be cleared and maintained as an unvegetated or sparsely vegetated surface throughout the life of the facility. In addition to the extensive loss of habitat, the project site would be a continual source of particulates deposited on surrounding plant communities. Adjacent plant communities could be affected by those factors associated with site preparation and management discussed in Section 5.10.1.1, including increased runoff, altered hydrology, sedimentation, reduced water quality, and erosion.

Water use varies among the technologies (see Section 5.9.2); the effects of water withdrawals on groundwater or surface water sources, however, would also depend on facility location. Wetland or riparian habitats supported by these water sources would potentially be affected by altered hydrologic regimes. If localized lowering of groundwater levels occurs, terrestrial plant species that access groundwater, such as phreatophytic species, may be adversely affected. In addition, changes in surface flows may affect upland species and habitats.

Hazardous materials used and stored on the project site also vary by technology. Hazardous materials present at a parabolic trough facility or a power tower facility could include HTF, molten salt, fuel oil, lubricating oils, water treatment chemicals, or other materials. Dish engine and PV system facilities may use and store dielectric fluids, lubricating oils, gasoline, diesel fuel, or other materials. Dish engine facilities may also use and store ethylene glycol. Spills of these hazardous materials could affect plant communities near the facility through surface runoff or contaminated groundwater discharge.

5.10.2 Wildlife (Amphibians and Reptiles, Birds, and Mammals)

5.10.2.1 Common Impacts

All utility-scale solar energy facilities that would be constructed and operated have the potential to affect wildlife. The following discussion provides an overview of the potential impacts on wildlife that could occur from the site characterization, construction, operation, and decommissioning of solar energy projects. Similar impacts could occur from transmission lines required to connect solar energy projects to the grid. However, some wildlife impacts would either be unique to a transmission line or be more likely to have a higher magnitude of impact compared with impacts from a solar energy facility. These impacts are discussed in Section 5.10.2.1.5. The use of mitigation measures (see Section 5.10.5) would minimize impacts on wildlife species and their habitats. Mitigation specifics would be established through coordination with federal and state agencies and other stakeholders.

5.10.2.1.1 Site Characterization. Before a solar energy project and its ancillary facilities (e.g., access roads, transmission lines, and, if necessary, water and gas pipelines) could be constructed, the potential project site areas would have to be precisely characterized, as described in Section 3.2.1. Impacts on wildlife from site evaluation activities would primarily result from disturbance (e.g., due to equipment and vehicle noise and the presence of workers and their vehicles). Such impacts would generally be temporary and at a smaller scale than those during other phases of the project. If drilling or road construction were necessary during this phase, impacts from these activities would be similar in character to those during the construction phase (see Section 5.10.2.1.2) but generally of smaller magnitude. Temporary impoundments for well drilling fluids and cuttings might be required. These activities would result in a localized loss of existing wildlife habitat. If a meteorological tower were required (especially one requiring guy wires), some bird and bat mortality could be expected. A meteorological tower required for site characterization for a solar energy project would only be

about 164 ft (50 m) tall. Therefore, a large number of bird kills would not be expected (this contrasts to large communication towers of 1,000 ft [305 m] or more for which high levels of bird mortalities have occurred [see Longcore et al. 2008]).

5.10.2.1.2 Construction. Impacts from the construction of a solar energy project, including ancillary facilities (e.g., access roads, transmission lines, and, if necessary, water and gas pipelines) would involve (1) habitat disturbance, (2) wildlife disturbance, (3) injury or mortality of wildlife, and (4) exposure to contaminants or fires.

Habitat Disturbance

Habitat disturbance could result in major impacts on wildlife (e.g., a large loss of important habitat attributes such as crucial winter range or migration corridors) from the construction of a solar energy project. Habitats within the construction footprint would be reduced or altered. The construction of a solar energy project could also make movement between habitat fragments more difficult. Habitat fragmentation could cause loss of genetic interchange among populations (Mills et al. 2000; Wang and Schreiber 2001; Willyard et al. 2004; Epps et al. 2005; Dixon et al. 2007).

A solar energy project (particularly its associated transmission line and pipeline ROWs) could establish edge habitat. Edge habitat could (1) increase predation and parasitism of vulnerable forest interior animals in the vicinity of edges; (2) have negative consequences on wildlife by modifying their distribution and dispersal patterns; (3) be detrimental to species requiring large undisturbed areas, because increases in edges are generally associated with concomitant reductions in habitat size and possible isolation of habitat patches and corridors (habitat fragmentation); and (4) change local wildlife composition and abundance in such areas. The ecological importance of edge habitat largely depends on how different it is from the regional landscape. For example, the influence of the edge is less ecologically important where the landscape has a high degree of heterogeneity. Landscapes with a patchy composition (e.g., tree-, shrub-, and grass-dominated cover) may already contain edge-adapted species that make the influence of a newly created edge less likely (Harper et al. 2005).

Development of a solar energy project site would represent a loss of habitat (including loss of foraging habitats and prey base for predators), which could result in a long-term reduction in wildlife abundance and richness within the project area overall. A species affected by habitat disturbance might be able to shift its habitat use for a short period. For example, the density of several forest-dwelling bird species has been found to increase within a forest stand soon after the onset of fragmentation as a result of displaced individuals moving into remaining habitat (Hagan et al. 1996). However, it is generally presumed that the habitat into which displaced individuals move would be unable to sustain the same level of use over the long term. The subsequent competition for resources in adjacent habitats would likely preclude the incorporation of the displaced individuals into the resident populations. If it is assumed that areas used by wildlife before development were preferred habitat, then an observed shift in distribution

because of development would be toward less preferred and presumably less suitable habitats (Sawyer et al. 2006).

Although habitats adjacent to solar energy projects (including ancillary facilities) might remain unaffected, wildlife might tend to make less use of these areas (primarily because of the disturbance that would occur within the project site). This impact could be considered indirect habitat loss, and it could be of greater consequence than direct habitat loss (Sawyer et al. 2006). For example, mule deer (*Odocoileus hemionus*) use declined within 1.7 to 2.3 mi (2.7 to 3.7 km) of gas well pads (Sawyer et al. 2006), while the density of sagebrush obligates, particularly Brewer's sparrow (*Spizella breweri*) and sage sparrow (*Amphispiza belli*), was reduced by 39 to 60% within a 328-ft (100-m) buffer around dirt roads (Ingelfinger and Anderson 2004). The loss of effective habitat (amount of habitat actually available to wildlife) due to roads was reported to be 2.5 to 3.5 times as great as the actual habitat loss (Reed et al. 1996). Many of the individuals that make use of areas adjacent to a road or other development could be subjected to increased physiological stress as a result of complications from overcrowding (e.g., increased competition for space and food, increased vulnerability to predators, and increased potential for the propagation of diseases and parasites). Overcrowding of species such as mule deer in winter ranges could cause density-dependent effects, such as increased fawn mortality (Sawyer et al. 2006). This combination of avoidance and stress would reduce the capability of wildlife to use habitat effectively (WGFD 2004). Overall, direct and indirect habitat losses could potentially reduce the carrying capacity within the species range and result in population-level effects, such as reduced survival or reproduction (Sawyer et al. 2006). Direct habitat loss may affect raptors through the loss of breeding, wintering, and foraging areas. Some raptors may shift the center of their territories to make use of transmission towers, but unless prey increases, raptor abundance would most likely remain the same.

However, some species, such as the common raven (*Corvus corax*), might become more abundant along roads, because there would be vehicle-generated carrion; also, common ravens and other raptors might become more common along transmission lines because of the presence of perch and nest sites (Knight and Kawashima 1993). Similarly, raven populations may increase on and around solar energy projects due to human subsidies such as garbage, water, and perch sites.

Wildlife migration corridors would also be vulnerable to project development, particularly at pinch points where physiographic constrictions force herds through relatively narrow corridors (Berger 2004). Loss of habitat continuity along migration routes would severely restrict the seasonal movements necessary to maintain healthy big game populations (Sawyer and Lindzey 2001; Thomson et al. 2005). As summarized by Strittholt et al. (2000), roads have impeded the movements of invertebrates, reptiles, and small and large mammals.

Water needs for construction could lead to localized water depletions. Water depletions could be expressed in a number of ways: decreases in soil moisture, reduced flow of springs and seeps, loss of wetlands, and drawdowns of larger rivers and streams. A number of direct and indirect impacts on wildlife could result from water depletions. These impacts could include reduction and degradation of habitat; reduction in vegetative cover, forage, and drinking water; attraction to human habitations for alternative water or food sources; increase in stress, disease,

insect infestations, and predation; alterations in migrations and concentrations of wildlife; loss of diversity; reduced reproductive success and declining populations; increased competition with livestock; and increased potential for fires (IUCNP 1998; UDWR 2006).

Habitat disturbance could facilitate the spread and introduction of invasive plant species (Section 5.10.1). Roads (and other linear corridors) could facilitate the dispersal of invasive plant species by altering existing habitat conditions, stressing or removing native plant species, and allowing easier movement by wildlife or human vectors (Trombulak and Frissell 2000). Wildlife habitat could also be adversely affected if invasive vegetation became established in the construction-disturbed areas and adjacent off-site habitats.

Construction activities might result in increased erosion and runoff from freshly cleared and graded sites. The potential for soil erosion and the resulting sediment loading of nearby aquatic or wetland habitats would be proportional to the amount of surface disturbance, the condition of disturbed lands at any given time, and the proximity to aquatic or wetland habitats. Erosion and runoff could reduce water quality in on-site and surrounding water bodies used by amphibians, thereby affecting their reproduction, growth, and survival. The potential for water quality impacts during construction would be short term for the duration of construction activities and postconstruction soil stabilization (e.g., from the use of mitigation measures to control erosion or the re-establishment of natural or man-made ground cover). Although the potential for runoff would be temporary, erosion could result in significant impacts on local amphibian populations if an entire recruitment class were eliminated (e.g., complete recruitment failure could occur in a given year because of the siltation of eggs or mortality of aquatic larvae).

Little information is available regarding the effects of fugitive dust on wildlife; however, if exposure was of sufficient magnitude and duration, the effects could be similar to those on humans (e.g., breathing and respiratory symptoms, including dust pneumonia). A more probable effect would be the dusting of plants, which could make forage less palatable. This localized effect would be short term and generally coincide with the displacement of and stress to wildlife from human activity. Fugitive dust is not expected to result in any long-term individual or population-level effects. Dusting impacts could be potentially more pervasive along unpaved access roads.

Overall, the effects of habitat disturbance would be related to the type and abundance of the habitats affected and to the wildlife that occurred in those habitats. For example, on large project sites (e.g., up to 6,750 acres [27.3 km^2]), habitat disturbance could represent a significant impact on local wildlife, especially species whose affected habitats were uncommon and not well represented in the surrounding landscape. In contrast, fewer impacts would be expected from smaller solar energy projects (e.g., those involving 90 acres [0.4 km^2] or less) located on currently disturbed lands.

Wildlife Disturbance

Activities associated with the construction of a utility-scale solar energy project could cause wildlife disturbance, including interference with behavioral activities. The response of

wildlife to disturbances caused by noise and human presence would be highly variable and species specific. Intraspecific responses could also be affected by the physiological or reproductive condition of individuals; distance from the disturbance; and type, intensity, and duration of the disturbance. Wildlife could respond to a disturbance in various ways, including attraction, habituation, and avoidance (Knight and Cole 1991). All three behaviors are considered adverse. For example, wildlife might cease foraging, mating, or nesting near areas where construction was occurring. In contrast, wildlife like bears, foxes, and squirrels would readily habituate and might even be attracted to human activities, primarily when a food source was accidentally or deliberately made available.

Disturbance could reduce the relative value of the habitat to wildlife such as mule deer, especially during periods of heavy snow and cold temperatures. Under adverse weather conditions, wildlife experience increased physiological stress and require higher levels of energy for survival and reproductive success. Increased human presence can further increase energy expenditures, which can lead to reduced survival or reproductive outcome. Furthermore, disturbance could prevent access to the amount of forage needed to sustain individuals. Hobbs (1989) determined that mule deer doe mortality during a severe winter period could double if the does were disturbed twice a day and caused to move a minimum of 1,500 ft (457 m) per disturbance.

The average mean flush distance for several raptor species in winter was 387 ft (118 m) due to disturbance from people walking and 246 ft (75 m) due to disturbance from vehicles. However, raptor response varies among species and between populations (Holmes et al. 1993). Bighorn sheep (*Ovis canadensis*) have been reported to respond at a distance of 1,640 ft (500 m) from roads with more than one vehicle per day, while deer and elk (*Cervus canadensis*) respond at a distance of 3,280 ft (1,000 m) or more (Gaines et al. 2003).

Mule deer can habituate to and ignore motorized traffic, provided they are not pursued (Yarmoloy et al. 1988). Harassment, an extreme type of disturbance caused by intentional actions to chase or frighten wildlife, generally causes the magnitude and duration of displacement to be greater. As a result, there is an increased potential for physical injury from fleeing and higher metabolic rates due to stress. Bears can become habituated to human activities, particularly moving vehicles, making them more vulnerable to legal and illegal harvest (McLellan and Shackleton 1989).

Principal sources of noise during construction would include vehicle traffic, operation of machinery, and, if necessary, blasting. The average noise levels from typical construction equipment range from 74 dBA for a roller to 101 dBA for a pile driver at a distance of 50 ft (15 m), with noise levels from most construction equipment ranging from 75 to 90 dBA at 50 ft (15 m). Noise levels would drop to 40 dBA at a distance of 1 mi (1.6 km). Where pile drivers or rock drills are used (e.g., for dish engine facilities), ground-borne vibration would also occur in the immediate vicinity of construction sites. At 25 ft (7.6 m), vibration levels from a roller would be 94 VdB. This level would diminish to 65 VdB (the threshold of perception for humans) at 230 ft (70 m). Based on these measurements, noise impacts on wildlife would be of greater concern than vibration. (See Section 4.5 and Section 5.13.1.2 for a more thorough discussion of the acoustic environment and impacts from noise and vibration, respectively.)

Sound levels above 90 dB are likely to adversely affect wildlife (Manci et al. 1988). Excessive noise levels can alter wildlife habitat use and activity patterns (e.g., exacerbating fragmentation impacts), increase stress levels, decrease immune response, reduce reproductive success, increase predation risk, degrade communication, and cause hearing damage (Habib et al. 2007; Manci et al. 1988; Pater et al. 2009). The response of wildlife to noise would vary by species; physiological or reproductive condition; distance; and the type, intensity, and duration of the disturbance. Regular or periodic noise could cause adjacent areas to be less attractive to wildlife and result in a long-term reduction in use by wildlife in those areas.

Wildlife can habituate to noise (Krausman et al. 2004). However, this is likely to occur only with frequently repeated, predictable exposures, and acclimation can be lost if enough time passes between repeat exposure (Wright et al. 2007). Also, it could be the visual element of the event rather than, or in addition to, the auditory component that causes the observed reaction in wildlife (AMEC Americas Limited 2005). Acclimation to a noise stimulus does not prevent other effects such as hearing loss. The apparent tolerance to noise stress could be the result of the animal or population having to remain in the area because of the absence of alternative habitats, high energetic costs associated with avoidance, or even reduced hearing from the frequency of the noise stimulus (Wright et al. 2007). Also, acclimation could cause possible sensitization, such that the animal may demonstrate an enhanced stress response when exposed to a different new stressor (Wright et al. 2007).

Responses of birds to disturbance often involve activities that are energetically costly (e.g., flying) or affect their behavior in a way that might reduce food intake (e.g., shift away from a preferred feeding site) (Hockin et al. 1992). A variety of adverse effects of noise on raptors have been demonstrated, but for some species, the effects were temporary, and the raptors became habituated to the noise (Brown et al. 1999; Delaney et al. 1999). A review of the literature by Hockin et al. (1992) showed that the effects of disturbance on bird breeding and breeding success include reduced nest attendance, nest failures, reduced nest building, increased predation on eggs and nestlings, nest abandonment, inhibition of laying, increased absence from nest, reduced feeding and brooding, exposure of eggs and nestlings to heat or cold, retarded chick development, and lengthening of the incubation period. The most adverse impacts associated with noise could occur if critical life-cycle activities were disrupted (e.g., mating and nesting). For instance, disturbance of birds during the nesting season could result in nest or brood abandonment. The eggs and young of displaced birds would be more susceptible to cold or predators.

Brattstrom and Bondello (1983) reported that peak sound pressure levels reaching 95 dB resulted in a temporary shift in the hearing sensitivity of kangaroo rats (*Dipodomys* spp.) and that at least 3 weeks was required for the recovery of hearing thresholds. The authors postulated that such hearing shifts could affect the ability of the kangaroo rat to avoid approaching predators. Construction noise could cause a localized disruption to wild horses, particularly during the foaling season (BLM 2006b). Krausman et al. (2004) reported that desert ungulates do not hear sound pressure levels generated by military jet aircraft as well as humans do (i.e., 14 to 19 dB lower).

More recently, concerns are beginning to focus on the impacts of chronic anthropogenic noise exposure on wildlife (Barber et al. 2010; Bayne et al. 2008). Noise exposure can cause physiological stress either directly (as described above) or indirectly through secondary stressors such as annoyance. These secondary stressors can increase the ambiguity in received signals or cause animals to leave a preferred resource area (Wright et al. 2007). Increased noise levels can also reduce the distance and area over which an animal perceives natural acoustic signals (Barber et al. 2010). Chronic noise can reduce habitat quality, especially for species that rely on acoustic signals for communication (Bayne et al. 2008). Bayne et al. (2008) found total passerine abundance was 33% lower near noise-producing energy sites (sites with compressor stations) than near noiseless energy sites (natural gas well pads). Overall, chronic noise exposure can result in changes in foraging and anti-predator behavior, reproductive success, and density and community structure (Barber et al. 2010).

Wildlife Injury or Mortality

Clearing, grading, and trenching activities could result in the direct injury or death of wildlife species not mobile enough to avoid construction operations (e.g., reptiles, small mammals) or those that used burrows (e.g., desert tortoise [*Gopherus agassizii*], ground squirrels, and burrowing owls [*Athene cunicularia*]). If clearing or other construction activities occurred during the spring and summer, bird nests and eggs or nestlings could be destroyed. Although more mobile wildlife species, such as deer and adult birds, might avoid the initial clearing activity by moving into habitats in adjacent areas, it is conservatively assumed that adjacent habitats are at carrying capacity for the species that live there and could not support additional biota from the construction areas. The subsequent competition for resources in adjacent habitats would likely preclude the incorporation of the displaced individuals into the resident populations.

The abundance of the affected species on the site and in the surrounding areas would have a direct influence on population-level effects. Impacts on common and abundant species would probably be less than impacts on uncommon species. The greater the size of the project site, the greater the potential for more individual wildlife to be injured or killed. Also, the timing of construction activities could directly affect the number of individual wildlife injured or killed. For example, construction during the reproductive period of ground-nesting birds, such as sage grouse, would have a greater potential to kill or injure birds than construction at a different time.

Direct mortality from vehicle collisions would be expected to occur along access roads, especially in wildlife concentration areas or travel corridors. When access roads cut across migration corridors, the effects can be dangerous for both animals and humans. Amphibians, being somewhat small and inconspicuous, are vulnerable to road mortality when they migrate between wetland and upland habitats; reptiles are vulnerable because they use roads for thermal cooling and heating. Greater sage-grouse (*Centrocercus urophasianus*) are susceptible to road mortality in spring, because they often fly to and from leks near ground level. They are also susceptible to vehicular collision along dirt roads, because they are sometimes attracted to them to take dust baths (Strittholt et al. 2000). Golden eagles and other raptors can also incur vehicle collisions because of their reliance on scavenging.

ROW and access road development increases the use of public lands for recreation and other activities; increasing the amount of human presence increases the potential for harassment and legal or illegal taking of wildlife. This might include the collection of live animals, particularly reptiles and amphibians, for pets. Direct mortality of small mammals might increase due to the use of snowmobiles and OHVs, because the animals that occupy subnivean spaces could be crushed or suffocated, and the access of the animals to predators would increase when they move over compacted vehicular trails (Gaines et al. 2003). Direct mortality also occurs when OHV users carry firearms into areas not normally accessed by people or vehicles. Rabbits, squirrels, and raptors are often used as "targets."

Exposure to Contaminants or Fires

Wildlife could be exposed to accidental fuel spills or releases of other hazardous materials. Pesticides, lead, and other contaminants already are background stressors. Additive effects may increase stress. For example, lead poisoning may cause raptors to be less capable of flight and to have less coordination associated with flight, leading to increased potential for injury or mortality. Potential impacts on wildlife would vary according to the material spilled, volume of the spill, location of the spill, length and intensity of exposure (i.e., chronic versus acute exposure), and the exposed species. A spill would be expected to have a population-level adverse impact only if it were very large (or in the case of a small spill if the substance was highly toxic) or if it contaminated a crucial habitat area where a large number of individual animals were concentrated. The potential for either event is very unlikely. In addition, use of the project area by wildlife during construction would be limited, since there would be construction-related disturbances, thus greatly reducing the potential for contaminant exposure.

Increased human activity could increase the potential for fires. In general, the effects of fire on wildlife would be related to the impacts on vegetation, which, in turn, would affect habitat quality and quantity, including the availability of forage and shelter (Hedlund and Rickard 1981; Groves and Steenhof 1988; Sharpe and Van Horne 1998; Lyon et al. 2000b). While individuals caught in a fire could incur increased mortality, most wildlife would be expected to escape by either outrunning the fire or seeking underground or aboveground refuge within the fire (Ford et al. 1999; Lyon et al. 2000a). However, some mortality of burrowing mammals from asphyxiation in their burrows during fire has been reported (Erwin and Stasiak 1979).

5.10.2.1.3 Operations. The ongoing reduction, alteration, and fragmentation of habitat due to the presence of the solar project and ancillary ROWs represent the greatest potential impacts on wildlife from the operation of a solar project. During the operation and maintenance of a utility-scale solar energy facility, wildlife might also be affected by (1) wildlife disturbance (e.g., from noise and the presence of workers), (2) collisions with aboveground facilities (including power tower/heliostats, dish engines, troughs, or PV panels), (3) exposure to contaminants or fires, and (4) the increased potential for fire. Also, while this situation is not well studied, birds, bats, and insects that fly through a solar energy project could also be burned by flying through standby points and reflection beams in the reflector area (McCrary et al. 1986;

Tsoutsos et al. 2005). Glare could also affect birds at solar energy facilities. While not well studied, glare impacts could range from disorientating a bird in flight to causing eye damage.

Habitat Disturbance

In general, the solar energy development could result in areas that were once considered areas with a high probability of being used by wildlife becoming areas of low or no use (e.g., the presence of the solar energy infrastructure, lack of vegetation, and fencing around the facility would result in the long-term loss of habitat for some species such as large mammals), while other areas with a low probability of use could be used more frequently. This change might cause a shift of wildlife use to presumably less-suitable habitat (Sawyer et al. 2006). Because solar energy projects would be fenced, big game and many other mammal species would be excluded from the project area. Wildlife might also be affected if a solar energy facility or its associated ROWs interfered with migratory or other movement patterns. Migrating birds and bats would be expected to simply fly over these facilities and continue their migratory movement. However, herd animals, such as elk, deer, and pronghorn (*Antilocapra americana*), could potentially be affected if a large solar energy project transected the migration paths between their winter and summer ranges or were located in crucial habitats, such as calving areas. Movement patterns of nonherding species such as cougars, foxes, and desert tortoises could also be affected. Furthermore, a solar energy development could alter habitats and connectivity among habitats for species existing as a metapopulation such as bighorn sheep.

Water needs for operation, particularly for the cooling system, could lead to localized water depletions. The types of impacts on wildlife from water depletions would be similar to those previously described for construction (Section 5.10.2.1.2). However, the potential extent of impacts could be greater due to the increased volume of water needed for cooling for some solar facilities and for mirror washing over the life of a project. Impacts could be minimized if withdrawals do not exceed the sustainable yield (Section 5.9.3.4).

Wildlife Disturbance

During the operation and maintenance of solar energy projects, wildlife could be disturbed by noise and the presence of workers. The activities associated with solar energy facility operations that could generate noise include transmission lines (corona), vehicles, maintenance equipment, and actual plant operations (e.g., cooling towers, dish engines). In general, the noise-generating activities in the solar field area are minimal, with the possible exception of the solar dish engine technology. The sound level from transformers would be about 51 dBA at 492 ft (150 m) and 40 dBA (typical background for rural areas) at 1,800 ft (550 m). No major equipment that can cause ground vibration would be used during operations (see Section 5.13.1.3). The response of wildlife to these disturbances would be highly variable and depend on the species; distance; and the type, intensity, and duration of the disturbance. Disturbance impacts on wildlife during operation and maintenance of a solar energy project would be similar to those discussed for the construction phase (Section 5.10.2.1.2). For example, some individual wildlife might temporarily or permanently move from the project area. Wildlife

permanently moving from the area might incur high mortality rates if the surrounding habitats were at or near carrying capacity or if the surrounding areas lacked habitat capable of supporting the displaced individuals.

During the operations phase, vegetation clearing or alteration would be required (e.g., clearing portions within the solar energy project area and maintaining low-growing vegetation within ROWs and portions of project areas). Because of the temporary nature of maintenance activities, disturbance from noise and human presence would be localized and of short duration. The most notable impact would be from habitat modification. During vegetation clearing and maintenance operations, wildlife would be displaced to adjacent undisturbed habitats; however, less mobile individuals could be destroyed. Impacts on local wildlife populations would be minor, particularly within the solar energy project site, where the quantity and quality of habitats would likely be limited.

During the operations phase, the mirrors on the solar collectors would have to be routinely cleaned. This would generally be done with high-pressure water sprayed from trucks during evening hours. The mirror-cleaning operations would cause a minor, localized disturbance to wildlife. Water that did not evaporate from the washing operations would collect on the ground around the collectors. This could benefit vegetation growth near the collectors, which could enhance habitat or forage for wildlife species that inhabit the project site. This may attract raptors and increase the likelihood of them colliding with solar facilities.

Night lighting could also disturb wildlife in the solar energy project area. Lights directly attract migratory birds (particularly in inclement weather and during low-visibility conditions), and they can indirectly attract birds and bats by attracting flying insects. As discussed below, attraction to lights can result in birds colliding with structures.

Collisions

The presence of the solar energy facilities would create a physical hazard to some wildlife. In particular, birds could collide with the solar facilities, while mammals could collide with project fencing. However, ground-level collisions at solar energy project sites would be infrequent, since the human activity, noise, and limited quantity and quality of habitat within the project site would discourage the presence of most wildlife in the immediate project area.

Limited information exists on the potential of bird collisions at solar energy facilities. However, since birds are prone to collisions with reflective surfaces, it could be expected that a utility-scale solar energy project could cause bird mortality. Appropriate studies are lacking, but glare could possibly disorientate a bird in flight and cause it to collide with solar energy project facilities or other objects. Also, lights could increase bird and bat collisions with structures by disorienting or attracting them to the project area (Hockin et al. 1992; Longcore et al. 2008). At the 10-MW Solar One (a 10-MW pilot power tower facility located in the Mojave Desert in San Bernardino County, California, that operated from 1982 to 1988), 70 bird fatalities involving 26 species were documented during a 40-week study (81% of the birds died from colliding with mirrored heliostats, while the rest died from burns received by flying through

standby points). The rate of mortality was estimated to be 1.9 to 2.2 birds per week. It was estimated that this represented 0.6 to 0.7% of the local population present at any given time. While this loss was considered minimal, it was concluded that larger facilities could produce nonlinear increases in the rate of avian mortality and, when coupled with the removal of large tracts of land from biological production, could be of concern with regard to the ecological effects of a solar energy project (McCrary et al. 1986).

Mortality resulting from bird collisions with power towers or other project structures is considered unavoidable. However, mortality levels are not anticipated to result in long-term loss of population viability in any individual species or lead to a trend toward listing as a rare or endangered species, because mortality levels would be expected to be low.

Exposure to Contaminants or Fires

During operation of the solar energy project, wildlife might be exposed to herbicides (see Section 5.10.2.1.5), fuel, or other hazardous materials (e.g., HTFs, lubricating oils, sulfuric acid, sodium hydroxide, and ethylene glycol). Additionally, compounds that are not toxic in low concentrations could become toxic at higher concentrations resulting from recycling of cooling water or in the evaporation ponds. These compounds can include chloride, sodium, sulfate, TDS, biphenyl, diphenyl oxide, potassium, selenium, and phosphate. Therefore, animals that can access the evaporation ponds could potentially be exposed to cooling water blowdown contaminants. Potential exposure to hazardous materials would be most likely from a spill. A spill could result in direct contamination of individual animals, contamination of habitats, and contamination of food resources. Acute (short-term) effects generally occur from direct contamination; chronic (long-term) effects usually occur from factors such as the accumulation of contaminants from food items and environmental media (Irons et al. 2000). Acute exposure is most often fatal or causes severe biological harm. Chronic exposure can reduce reproduction, hatching success, and growth and cause a variety of pathological conditions. Contaminant ingestion during preening or feeding might impair endocrine and liver functions, reduce breeding success, and reduce growth of offspring.

The impacts on wildlife from a spill would depend on factors such as the time of year, volume of the spill, type and extent of habitat affected, and home range and density of the wildlife species. A population-level adverse impact would be expected only if the spill was very large or if it contaminated a crucial habitat area where a large number of individual animals were concentrated. The potential for either event would be unlikely. Because the amounts of most fuels and other hazardous materials are expected to be small, an uncontained spill would affect only a limited area. Also, the avoidance of contaminated areas by wildlife during spill response activities (due to disturbance from human presence) would minimize the potential for wildlife exposure. Furthermore, given the limited quantity and quality of wildlife habitat within the boundaries of a solar energy project, few individual animals would be exposed to contaminants.

Impacts on wildlife from fires during the operations phase would be similar to those described for the construction phase (Section 5.10.2.1.2). The high temperature of coolant (e.g., hundreds of degrees) could present a fire risk if the coolant was accidentally released

(Tsoutsos et al. 2005). However, because vegetation would be sparse within a project area, there would little potential for fuel buildup.

5.10.2.1.4 Decommissioning/Reclamation. Decommissioning (including reclamation) of a utility-scale solar energy project would reduce or eliminate the impacts from construction and operation to the extent practicable by re-establishing habitat. The effectiveness of any reclamation activity would depend on the specific actions taken; the best results, however, would occur where original site topography, hydrology, soils, and vegetation patterns could be re-established. However, as discussed in Section 5.10.1.1.4, this might not be possible under all situations. Impacts on wildlife from decommissioning activities would be similar to those from construction, but they could be more limited in scale and shorter in duration. This result would depend, in part, on whether decommissioning would involve full removal of facilities, partial removal of key components, or abandonment. For example, leaving buried components in place (a common industry practice) would reduce the amount of trenching and soil disturbance required and contribute to reduced impacts relative to those that would occur during construction.

Decommissioning activities could affect wildlife by altering existing habitat characteristics and the species supported by those habitats. These activities would vary among locations, depending on the extent of infrastructure that would need to be removed, projected future land use, and the amount of site restoration (e.g., type of revegetation) required. Decommissioning activities that could affect wildlife include the following:

- The dismantling process,
- Purging and cleaning of structures left in place,
- Generation of waste materials,
- Regrading of project areas,
- Revegetation activities, and
- Accidental releases (spills) of potentially hazardous materials.

During decommissioning activities, localized obstruction of wildlife movement could occur in the areas where the solar energy facilities and transmission lines were being dismantled. However, seasonal stipulations for the protection of wildlife contained in the solar facility and related ROWs would also apply to the decommissioning phase. There would also be an increase in noise and visual disturbance associated with removal of project facilities and site restoration. Increased traffic levels during decommissioning would result in increased roadkill, but injury and mortality rates of wildlife would probably be lower than during construction.

Most wildlife would avoid areas while decommissioning activities were taking place. Avoidance would be a short-term impact. However, animal feeding and nuisance animal issues

might become problematic because of the increased number of workers who might have a shorter term view of the consequences of their actions. A problematic animal (e.g., a bear or mountain lion [*Puma concolor*]) might have to be deliberately displaced to protect lives and property, either through harassment or live-trapping and release to another part of its range.

Other potential environmental concerns resulting from decommissioning would include the disposal of solid wastes and hazardous materials and the remediation of contaminated soils. Some fuel and chemical spills could also occur, but these would be generally confined to access roads and project site areas. The probability that wildlife would be exposed to such spills would be small and limited to a few individuals. After decommissioning activities were complete, there would be no fuel or chemical spills associated with the utility-scale solar energy facility, gas or water pipelines, or, if the lines were not maintained as part of the energy grid, transmission lines.

Removal of aboveground facilities would reduce potential nesting, perching, and resting habitats for several bird species, particularly raptors and common ravens. However, this could benefit species such as small mammals and greater sage-grouse that are preyed upon by those species. Removal of aboveground facilities would also reduce bird collisions. In addition, the removal of aboveground facilities would ensure free passage of wildlife. The revegetation of decommissioned solar energy facilities and associated ROWs would increase wildlife habitat diversity, since control of vegetation (including cutting of woody vegetation) would cease, allowing native shrubs and trees to grow and increase in density. As disturbed areas would become revegetated, any impacts from fragmentation that existed during the lifetime of the project would diminish. Habitats that had been avoided by wildlife because of the proximity of facilities and humans could become re-inhabited.

How soon wildlife resources in the solar energy facility site area could return to pre-project conditions would partly depend on the habitat and vegetation conditions that existed prior to construction. In the extreme, natural recovery to pre-disturbance plant cover and biomass in desert ecosystems may take 50 to 300 years, with complete ecosystem recovery potentially requiring more than 3,000 years (Lovich and Bainbridge 1999). In the long term, decommissioning and reclamation would increase species diversity and habitat quality within the project area.

5.10.2.1.5 Transmission Lines and Roads. Impacts on wildlife from the site characterization, construction, operation and maintenance, and decommissioning of transmission lines, or during upgrades to existing lines, would be similar to those discussed for solar energy facilities (Sections 5.10.2.1.1 through 5.10.2.1.4). Potential construction impacts of transmission corridor development on wildlife would result primarily from ground disturbance, vegetation removal, and excavation during clearing of the ROWs and from installation of access roads and structures (e.g., transmission line towers, substations, or pipelines) The following discussion addresses potential wildlife impacts that would either be unique to transmission lines or be more likely to have a higher magnitude of impact compared with impacts from solar energy facilities.

Transmission lines could fragment existing habitat, establish altered habitat within the ROW, and establish edge habitat at the borders of the ROW and the existing habitat.

Construction of transmission lines in a forest has been found to decrease the quality of habitat for forest interior species for distances up to 300 ft (91 m) from the edge of the ROW (Anderson et al. 1977). Line construction would thus reduce the density and diversity of forest interior species in an area much larger than that of the actual cleared ROW segment. Conversely, species that prefer open habitats, such as the red-tailed hawk (*Buteo jamaicensis*), American kestrel (*Falco sparverius*), brown-headed cowbird (*Molothrus ater*), and yellow warbler (*Dendroica petechia*), might increase in numbers. An increase in brown-headed cowbird populations could adversely affect other bird species, since the cowbird is a brood parasite, laying its eggs in the nests of other species, especially warblers, vireos, and sparrows.

Nests along the forest edge could also be more vulnerable to predators, such as raccoons (*Procyon lotor*) and jays. Predators such as coyotes (*Canis latrans*) and foxes commonly use ROWs for hunting, because there are more small mammals that prefer open areas there. The cleared ROW segments might also encourage increases in the populations of invasive bird species, such as the house sparrow (*Passer domesticus*) and European starling (*Sturnus vulgaris*), which compete with many native species.

Although most fragmentation research has focused on forested areas, similar ecological impacts have been reported for the more arid and semiarid landscapes of the western United States, particularly shrub-steppe habitats that are dominated by sagebrush or salt desert scrub communities. For example, habitat fragmentation, combined with habitat degradation, has been shown to be largely responsible for the declines in populations and distributions of sage grouse species (Strittholt et al. 2000).

The transmission line ROW could function as:

- A specialized habitat for some species;
- A travel lane that would enhance species movement, predation, and spread of non-native, invasive plant species;
- A barrier to the movement of species, energy, or nutrients (because it would fragment existing habitat);
- Sources of biotic and abiotic effects on the adjacent ecosystem matrix; and
- A sink—wildlife would enter the corridor and die (e.g., by colliding with transmission lines).

Similar impacts could occur from gas or water pipeline ROWs. The degree to which a ROW would carry out these functions would depend on the wildlife species, the width and length of the ROW, and the habitat contrast between the ROW and adjacent areas (Williams 1995; Jalkotzy et al. 1997).

Transmission lines and other project structures could provide perch sites for raptors and corvids (e.g., ravens, crows, and magpies), thereby increasing predatory levels on other wildlife

(e.g., small mammals, birds). The lines and structures would enable birds, such as the golden eagle (*Aquila chrysaetos*), great-horned owl (*Bubo virginianus*), red-tailed hawk, ferruginous hawk (*Buteo regalis*), common raven, prairie falcon (*Falco mexicanus*), American kestrel, and osprey, to nest or perch in otherwise treeless landscapes (BirdLife International 2003; Fernie and Reynolds 2005). Transmission support structures could also protect some bird species from mammalian predators, range fires, and heat (Steenhof et al. 1993). However, high winds could cause the nests of birds that use transmission line support structures to fall apart. Entanglement in tower support structures might be another hazard (Steenhof et al. 1993). A transmission line might also lead to a loss of usable feeding areas for those species that avoid the proximity of these facilities (BirdLife International 2003). For example, the lesser prairie-chicken (*Tympanuchus pallidicinctus*) seldom nests within 1,300 ft (396 m) of transmission lines (Pitman et al. 2005).

Except under unusual circumstances, no electrocution of raptors or other birds would be expected, because the spacing between the conductors or between a conductor and ground wire or other grounding structure would exceed the wing span of the California condor (*Gymnogyps californianus*), the largest bird to occur in the six-state study area. However, although a rare event, electrocution can occur during current arcing when flocks of small birds cross a line or when several roosting birds take off simultaneously. This is most likely to occur in humid weather conditions (Bevanger 1995; BirdLife International 2003). Arcing can also occur from the waste streamers of large birds roosting on the crossarms above insulators (BirdLife International 2003). The electrocution of other wildlife from contact with electrical transmission lines is even less common. Nonavian wildlife species that have been electrocuted include snakes, mice, squirrels, raccoons, bobcat (*Lynx rufus*), and American black bear (*Ursus americanus*) (Edison Electric Institute 1980; Williams 1990). Among the mammals, squirrels are among the most commonly reported species to be electrocuted because of their penchant for chewing on electrical wires. Because of the relatively rare nature of electrocutions, they are not expected to adversely affect populations of wildlife species in the vicinity of a utility-scale solar energy project.

The potential effects of electric and magnetic field (EMF) exposure on animal behavior, physiology, endocrine systems, reproduction, and immune functions have been found to be negative, very minor, or inconclusive (WHO 2007). In general, these results are for exposures much higher and longer than would be encountered by wildlife under actual field conditions. Also, there is no evidence that EMF exposure alone causes cancer in animals, and the evidence that EMF exposure in combination with known carcinogens can enhance cancer development is inadequate (WHO 2007).

The potential for bird collisions with transmission lines depends on variables such as habitat, relation of the line to migratory flyways and feeding flight patterns, migratory and resident bird species, and structural characteristics of the lines (Beaulaurier et al. 1984). Birds that migrate at night, fly in flocks, and/or are large and heavy with limited maneuverability are at particular risk (BirdLife International 2003). Waterfowl, wading birds, shorebirds, and passerines are most vulnerable to colliding with transmission lines near wetlands, while in habitats away from wetlands, raptors and passerines are most susceptible (Faanes 1987). Of highest concern with regard to bird collisions are locations where lines span flight paths; these include river

valleys, wetland areas, lakes, areas between waterfowl feeding and roosting areas, and narrow corridors (e.g., passes that connect two valleys). A disturbance that would lead to a panic flight could increase the risk of collision with transmission lines (BirdLife International 2003).

The shield wire is often the cause of bird losses associated with higher voltage lines, because birds fly over the more visible conductor bundles, only to collide with the relatively invisible, thin shield wire (Thompson 1978; Faanes 1987). Young, inexperienced birds, as well as migrants in unfamiliar terrain, appear to be more vulnerable to wire strikes than resident breeders. Also, many species appear to be most highly susceptible to collisions when they are alarmed, pursued, searching for food while flying, engaged in courtship, taking off, landing, and otherwise preoccupied and not paying attention to where they are going, and during the night and inclement weather (Thompson 1978). Sage grouse and other upland game birds are vulnerable to colliding with transmission lines, because they lack good acuity and because they are generally poor flyers (Bevanger 1995).

Meyer and Lee (1981) concluded that although waterfowl (in Oregon and Washington) were especially susceptible to colliding with transmission lines, no adverse population or ecological results occurred, because all species affected were common and because collisions occurred in less than 1% of all flights observed. A similar conclusion was reached by Stout and Cornwell (1976), who suggested that less than 0.1% of all nonhunting waterfowl mortality nationwide was due to collisions with transmission lines. The potential for waterfowl and wading birds to collide with transmission lines could be assumed to be related to the extent of the preferred habitats that are crossed by the lines and the extent of other waterfowl and wading bird habitats within the immediate area.

While not immune to collisions, raptors have several attributes that decrease their susceptibility to collisions with transmission lines: (1) they have keen eyesight; (2) they soar or fly by using relatively slow, flapping motions; (3) they can generally maneuver while in flight; (4) they learn to use utility poles and structures as hunting perches or nests and become conditioned to the presence of lines; and (5) they do not fly in groups (like waterfowl), so their position and altitude are not determined by other birds. Therefore, raptors are not as likely to collide with transmission lines except when they are distracted (e.g., while focusing on prey that they are pursuing) or when other environmental factors (e.g., weather) increase their susceptibility (Olendorff and Lehman 1986).

Mortality resulting from birds colliding with transmission lines is considered unavoidable. However, mortality levels are not anticipated to result in long-term loss of population viability in any individual species or lead to a trend toward listing as a rare or endangered species, because mortality levels would be expected to be low.

Periodic maintenance of transmission line ROWs in forested areas would maintain the ROW in an early stage of plant community succession, which could benefit small mammals and their predators. Regrowth of willows and other trees following maintenance could benefit ungulates that use browse. Conversely, habitat maintenance would have localized adverse effects on certain species, such as the red squirrel (*Tamiasciurus hudsonicus*), southern red-backed vole (*Myodes gapperi*), and American marten (*Martes americana*), that prefer late-successional or

forested habitats. ROW vegetation maintenance would not be expected to occur more often than once every 3 years. This would lessen impacts on migratory birds and other wildlife species that might use the ROWs.

Most herbicides used on BLM-administered lands would pose little or no risk to wildlife unless the animals were exposed to accidental spills or direct spray or drift or unless they consumed herbicide-treated vegetation. Herbicide applications would be conducted by following label directions and applicable permits and licenses. Thus, any adverse toxicological threat from herbicides on wildlife would be unlikely. The response of wildlife to herbicide use would be attributable primarily to habitat changes resulting from treatment rather than to toxic effects of the applied herbicide. However, accidental spills or releases of these materials could affect exposed wildlife. Effects could include organ damage, decrease in growth, decrease in reproductive output, adverse impacts on the condition of offspring, and death (BLM 2007). For example, herbicides can cause reproductive effects in birds such as reduced fertility, suppression of egg formation, eggshell thinning, and embryo toxicity (Bishop et al. 2000; Fry 1995; Hoffman and Albers 1984). Overall, most commonly used herbicides degrade quickly once they enter the environment; thus, they are not persistent, nor do they bioaccumulate (Tatum 2004).

Following decommissioning activities (e.g., removal of aboveground structures), the recreational use of ROWs (e.g., as a travel corridor by OHVs) might increase, which could lead to increased wildlife disturbance and mortality. However, removal of aboveground facilities would reduce the potential for bird collisions.

5.10.2.1.6 Summary of Common Impacts on Wildlife. Overall, impacts from site characterization, construction, operation, and decommissioning of a solar energy project (including the transmission line) on wildlife populations would depend on the following:

- The type and amount of wildlife habitat that would be disturbed;
- The nature of the disturbance (e.g., long-term reduction because of project structure and access road placement; complete, long-term alteration due to transmission line, gas pipeline, and water pipeline placement; or temporary disturbance in construction staging areas);
- The wildlife that occupied the facility site and surrounding areas; and
- The timing of construction activities relative to the crucial life stages of wildlife (e.g., breeding season).

In general, impacts on most wildlife species would be proportional to the amount of their specific habitats directly and indirectly disturbed. Table 5.10-2 summarizes the potential impacts on wildlife species resulting from a solar energy project.

TABLE 5.10-2 Potential Impacts on Wildlife Species Associated with Utility-Scale Solar Energy Facilities, Including Associated Access Roads and Transmission Line Corridors

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Plant Communities[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
Individual Impacting Factor[d]							
Alteration of topography and drainage patterns	Construction, operations	Changes in surface temperature, soil moisture, and hydrologic regimes, and distribution and extent of aquatic, wetland, and riparian habitats; erosion; changes in groundwater recharge; spread of invasive species.	None	Reptiles, mammals	Amphibians, birds	None	Can be mitigated by avoiding development of drainages and using appropriate stormwater management strategies.
Human presence and activity	Site characterization, construction, operations, decommissioning	Behavioral disturbance, harassment, nest abandonment, avoidance of areas, territory adjustments, reduction in carrying capacity.	None	None	Amphibians, reptiles, small mammals	Birds, large mammals	Can be mitigated during site characterization and construction by timing activities to avoid sensitive periods. Difficult to mitigate impacts during operations.
Blockage of dispersal and movement	Construction, operations	Genetic isolation, loss of access to important habitats, reduction in diversity, reduction in carrying capacity.	None	Birds, bats	Amphibians, reptiles, small mammals	Large mammals	Can be mitigated by restricting project size, avoiding important movement corridors.
Erosion	Construction, operations, decommissioning	Habitat degradation; loss of plants; sedimentation of adjacent areas especially aquatic, wetland, systems, loss of productivity; reduction in carrying capacity; spread of invasive species.	None	Amphibians, reptiles, birds, mammals	None	None	Easily mitigated with standard erosion control practices.

TABLE 5.10-2 (Cont.)

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Plant Communities[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
Individual Impacting Factor[d] (Cont.)							
Equipment noise	Site characterization, construction, operations, decommissioning	Behavioral disturbance, harassment, nest abandonment, avoidance of areas, territory adjustments, reduction in carrying capacity.	None	Amphibians, reptiles, small mammals	Birds, large mammals	None	Can be mitigated using mufflers and other sound-dampening devices.
Fugitive dust	Site characterization, construction, operations, decommissioning	Decrease in photosynthesis, reduction in productivity, increase turbidity and sedimentation in aquatic habitat, spread of invasive species.	None	Amphibians, reptiles, birds, mammals	None	None	Can be mitigated by retaining vegetative cover, soil covers, or soil stabilizing agents.
Groundwater withdrawal	Construction, operations	Change in hydrologic regime, reduction in surface water, reduction in soil moisture, reduction in productivity.	None	Reptiles, birds, mammals	Amphibians	None	Can be mitigated by reducing water consumption requirements. May be difficult to mitigate for all but PV systems.
Habitat fragmentation	Construction, operations	Genetic isolation, loss of access to important habitats, reduction in diversity, reduction in carrying capacity, spread of invasive species.	None	None	Amphibians, reptiles, birds, small mammals	Large mammals	Difficult to mitigate; requires minimizing disruption of intact communities especially by linear features such as transmission lines and roads.
Increased human access	Construction, operations	Harassment, collection, increased predation risk, increased collision mortality risk.	None	None	Amphibians, reptiles, birds, mammals	None	Can be mitigated by reducing the number of new transmission lines and roads in important habitats.

TABLE 5.10-2 (Cont.)

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Plant Communities[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
Individual Impacting Factor[d] (Cont.)							
Oil and contaminant spills	Site characterization, construction, operations, decommissioning	Death of directly affected individuals, uptake of toxic materials, reproductive impairment, reduction in carrying capacity.	None	None	Amphibians, reptiles, birds, mammals	None	Can be mitigated using project mitigation measures (e.g., pipeline check valves) and spill prevention and response planning.
Project infrastructures	Operations	Increased predation rates from predators using tall structures, collision mortality.	Large mammals	Amphibians	Reptiles, birds, and small mammals	None	Can be mitigated using appropriate warning lights on towers, markers on lines and guy wires, or elimination of guy wires.
Restoration of topography and drainage patterns	Decommissioning	Beneficial changes in temperature, soil moisture, and hydrologic regimes.	None	None	Amphibians, reptiles, birds, mammals	None	Mostly beneficial; adverse impacts can be mitigated by using standard erosion and runoff control measures.
Restoration of topsoil	Decommissioning	Beneficial changes in soil moisture, increased productivity and carrying capacity.	None	None	Amphibians, reptiles, birds, mammals	None	Mostly beneficial; adverse impacts can be mitigated using standard erosion and runoff control measures.
Restoration of native vegetation	Decommissioning	Beneficial changes in soil moisture, increased productivity and carrying capacity, increased diversity.	None	None	Amphibians, reptiles, birds, mammals	None	Mostly beneficial; adverse impacts can be mitigated by ensuring species mix includes a diverse weed-free mix of hardy native species.

TABLE 5.10-2 (Cont.)

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Plant Communities[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
Individual Impacting Factor[d] (Cont.)							
Site lighting	Construction, operations	Behavioral disturbance, harassment, nest abandonment, avoidance of areas, territory adjustments, reduction in carrying capacity, collision with structures.	None	Amphibians, reptiles	Birds, mammals	None	Easily mitigated by ensuring lighting is minimized to that needed for safe construction and operations and does not project past site boundaries.
Soil compaction	Site characterization, construction, operations, decommissioning	Reduction in productivity, reduction in diversity, reduction in carrying capacity, increased runoff and erosion, spread of invasive species.	None	Amphibians, reptiles, birds, mammals	None	None	Easily mitigated by aerating soil after being compacted.
Topsoil removal	Construction, operations	Reduction in productivity, reduction in diversity, reduction in carrying capacity, direct mortality of individuals, increased sedimentation in aquatic habitat, spread of invasive species.	None	None	Amphibians, reptiles, birds, mammals	None	Readily mitigated by stockpiling soils to maintain seed viability, vegetating to reduce erosion, and replacing at appropriate depths when other site activities are complete.

TABLE 5.10-2 (Cont.)

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Plant Communities[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
Individual Impacting Factor[d] (Cont.)							
Vegetation clearing	Construction, operations	Elimination of habitat, habitat fragmentation, direct mortality of individuals, loss of prey base, changes in temperature and moisture regimes, erosion, increased fugitive dust emissions, reduction in productivity, reduction in diversity, reduction in carrying capacity, spread of invasive species.	None	None	None	Amphibians, reptiles, birds, mammals	Difficult to mitigate; most project areas are likely to require clearing. Restoration of a vegetative cover consistent with the intended land use would reduce some impacts.
Vegetation maintenance	Operations	Reduction in vegetation cover or vegetation maintained in early successional-stage or low-stature, habitat fragmentation, direct mortality of individuals, reduction in diversity, reduction in carrying capacity, spread of invasive species.	None	None	Amphibians, reptiles, birds, mammals	None	Can be mitigated by managing for low-maintenance vegetation (e.g., native shrubs, grasses, and forbs), invasive species control, minimizing the use of herbicides near sensitive habitats (e.g., aquatic and wetland habitats), and only using approved herbicides consistent with safe-application guidelines.
Vehicle and equipment emissions	Construction, operations, decommissioning	Reduced productivity.	None	Amphibians, reptiles, birds, mammals	None	None	Readily mitigated by maintaining equipment in proper operating condition.

TABLE 5.10-2 (Cont.)

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Plant Communities[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
Individual Impacting Factor[d] (Cont.)							
Vehicle and foot traffic	Site characterization, construction, operations, decommissioning	Direct mortality of individuals through collision or crushing, soil compaction, increased fugitive dust emissions.	None	None	Amphibians, reptiles, birds, mammals	None	Can be mitigated using worker education programs, signage, and traffic restrictions.
All Impacting Factors Combined							
	Site characterization		None	Amphibians, reptiles, birds, mammals	None	None	Relatively easy.
	Construction		None	None	None	Amphibians, reptiles, birds, mammals	Relatively difficult; residual impact mostly dependent on the size of area developed.
	Operations		None	None	None	Amphibians, reptiles, birds, mammals	Relatively difficult; residual impact mostly dependent on the size of area developed.
	Decommissioning		None	None	Amphibians, reptiles, birds, mammals (short-term adverse impacts, long-term benefits)	None	Relatively easy to mitigate adverse impacts of decommissioning. May be difficult to achieve restoration objectives.

TABLE 5.10-2 (Cont.)

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Plant Communities[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
All Impacting Factors Combined (Cont.)							
	Overall project		None	None	None	Amphibians, reptiles, birds, mammals	Relatively difficult; residual impact mostly dependent on the size of area developed and the success of restoration activities.

[a] Relative impact magnitude categories were based on professional judgment utilizing CEQ regulations for implementing NEPA (40 CFR 1508.27) by defining significance of impacts based on context and intensity. Similar impact magnitude categories and definitions were used in BLM (2008a, b) and assume no wildlife species mitigation. Impact categories were as follows: (1) *none*—no impact would occur; (2) *small*—effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource (e.g., ≤1% of the population or its habitat would be lost in the region); (3) *moderate*—effects are sufficient to alter noticeably but not to destabilize important attributes of the resource (e.g., >1 but ≤10% of the population or its habitat would be lost in the region); and (4) *large*—effects are clearly noticeable and are sufficient to destabilize important attributes of the resource (e.g., >10% of a population or its habitat would be lost in the region). Actual impact magnitudes on wildlife species would depend on the location of projects, project-specific design, application of mitigation measures (including avoidance, minimization, and compensation), and the status of wildlife species and their habitats in project areas.

[b] Wildlife species are placed into groups based on taxonomy (amphibians, reptiles, birds, and mammals). Other categories such as ecological system (aquatic, wetland, riparian, and terrestrial) or size (e.g., small and large mammals) are used when the category is relevant to impact magnitude.

[c] Actual ability to mitigate impacts will depend on site-specific conditions and the species present in the project area. Recommended mitigation measures are presented in Section 5.10.5.

[d] Impacting factors are presented in alphabetical order.

5.10.2.2 Technology-Specific Impacts

The general types of impacts on wildlife from site characterization, construction, operation, and decommissioning of a utility-scale solar energy project are described in Section 5.10.2.1. The main impact on wildlife from a solar energy project, regardless of the technology used, would be due to the large footprint needed for the project. Impacts on wildlife would be proportional to the amount of habitat disturbance associated with the construction and operation of a utility-scale solar energy project (based on land areas of 2,000 acres [8 km^2] for a 400-MW parabolic trough facility, or 3,600 acres [15 km^2] for a 400-MW power tower facility, or up to 6,750 acres [27.3 km^2] for a 750-MW dish engine facility or a PV facility). It is conservatively assumed that the developed portion of the project site would be cleared and maintained as an unvegetated or sparsely vegetated area to allow for solar array placement and access and to reduce fire hazards. The land area encompassed by a large solar energy project would cause habitat loss and fragmentation and would alter wildlife corridors for big game species.

The types of hazardous materials that could be used and stored at a solar energy project are listed in Section 5.20.1.2 by technology. Spills of these materials could cause acute impacts (e.g., mortality) on the wildlife that would come in contact with the materials, but it is more likely that a spill and subsequent cleanup would result in a localized loss of habitat. However, since habitat quality within a solar energy project would be limited, habitat loss due to a spill and spill cleanup would not be significant.

Additional aspects of specific technologies used to produce solar energy that could affect wildlife or wildlife habitat are presented in this section. The impacts are based on the anticipated resource requirements and activities likely to occur at solar energy projects that use currently established technologies.

5.10.2.2.1 Parabolic Trough. A gas pipeline could be required to supply gas for the boilers used to warm up the HTF each morning in order to reduce plant start-up times and to provide fluid freeze protection. Construction of a gas pipeline would cause short-term habitat loss and fragmentation, while long-term habitat alteration would result from the presence of the gas pipeline ROW during the operational lifetime of the solar energy project. Similar impacts would be expected if water needed for the project were obtained from a pipeline coming from an off-site location rather than from on-site wells. One or more evaporation ponds could be required to contain cooling water discharges (more or larger ponds would be anticipated for projects that use wet rather than dry cooling). These ponds would attract wildlife such as shorebirds and waterfowl because of the aquatic invertebrates, such as water boatmen and brine shrimp, that can become abundant in them (Tanji et al. 2002). However, these ponds would develop hypersaline conditions that could cause salt toxicosis to these birds and other wildlife. Also, if water withdrawals to meet plant needs affected the hydrologic regimes of wetland or riparian areas, the wildlife that used those habitats could be adversely affected.

5.10.2.2.2 Power Tower. Impacts from a possible gas pipeline and the use of evaporation ponds would be similar to those discussed for a parabolic trough facility (Section 5.10.2.2.1).

At a power tower solar energy project, birds that would fly between the heliostats and the power tower could be injured or killed by the heat intensity of the reflected sunlight. However, most birds would avoid the area during the day because of the limited habitat and food resources within the solar energy project site. At night, the project would not be operating, and most birds that migrate at night would do so at elevations higher than those of most of the project components. Therefore, bird collisions would be minimal. Potential increases in bird collisions at night could occur during inclement weather or other under low-visibility conditions, because birds would be attracted to the lighting that would be on the power tower (if it were higher than 200 ft [61 m]). Nevertheless, the potential for collisions would be expected to be much less than for other tall structures (such as communication towers, which are much taller than a power tower and have guy wires).

5.10.2.2.3 Dish Engine and PV Systems. Strips of land between groups of dish engines could remain vegetated. These could be expected to provide habitat for common wildlife, such as snakes, lizards, birds, and small mammals.

Unlike solar energy technologies that might use gas to warm HTFs (i.e., parabolic trough and power tower), dish engine and PV solar energy projects would not have this requirement. Therefore, there would be no impacts on habitat from the construction and operation of a gas pipeline.

Since a dish engine and PV solar energy project does not require water for generating electricity, potential impacts on wildlife due to water use would be minimal. Nevertheless, if water for mirror washing were obtained from an off-site location rather than an on-site well, a water pipeline might be required. Construction of a water pipeline would cause short-term habitat loss and fragmentation, while long-term habitat alteration would result from the presence of the water pipeline ROW during the operational lifetime of the solar energy project. No evaporation ponds would be required for dish engine projects. Also, if water withdrawals to meet plant needs affected the hydrologic regimes of wetland or riparian areas, the wildlife that used those habitats could be adversely affected. However, the likelihood of such impacts would be low, especially compared to a similarly sized wet-cooled parabolic trough or power tower project that would also require large amounts of water for cooling.

5.10.3 Aquatic Biota and Habitats

5.10.3.1 Common Impacts

Utility-scale solar energy facilities that would be constructed and operated have the potential to affect aquatic biota and habitats. The following discussion provides an overview

of the potential impacts on aquatic ecosystems that could occur from site characterization, construction, operation, and decommissioning of a solar energy project. The use of mitigation measures (see Section 5.10.5) would minimize impacts on aquatic species and their habitats. Specific mitigation measures would be identified through coordination with federal and state agencies and other stakeholders.

Impacts on aquatic biota and habitats from solar energy projects could occur in a number of ways, including (1) habitat loss, alteration, or fragmentation; (2) disturbance and displacement of aquatic organisms; (3) mortality; and (4) increase in human access. Aquatic biota and habitats may also be affected by human activities not directly associated with a solar energy project or its workforce, but associated with the potentially increased access by the public to areas that had previously received little use.

5.10.3.1.1 Site Characterization. Before a solar energy project and its ancillary facilities (e.g., transmission line and gas and water pipeline ROWs) can be constructed, the potential project site areas must be characterized. Activities associated with characterization are presented in Section 3.2.1.

Potential impacts on aquatic habitats from site characterization activities would primarily be associated with ground disturbance, because it increases soil erosion that can lead to increases in sedimentation and turbidity in downgradient surface water habitats. Overall, it is anticipated that ground-disturbing activities would be conducted on a smaller scale than that used during other phases of the project. Some site characterization activities would assist developers in designing a specific project to avoid or minimize impacts on aquatic resources during future phases of the project. It is anticipated that characterization facilities (e.g., meteorological towers, drill rigs, and temporary impoundments for drilling fluids or cutting) and most of the associated characterization activities would be located in upland areas and not directly within aquatic habitats. In such cases, direct impacts on aquatic habitats and biota would be minimal. Because the amount of ground disturbance would be small, the resulting effects on aquatic habitats and biota from these impacting factors should also be small. If drilling activities were required as part of site characterization, accidental releases of drilling fluids could affect downstream habitats because of sedimentation or the introduction of contaminants.

In some cases, vehicles would be driven through portions of the site in order to transport workers or equipment. If vehicles are driven through aquatic habitats or if workers walk through those habitats, some aquatic biota could be crushed and killed. Vehicular traffic can result in rutting and accumulation of cobbles in some stream crossings, which can interfere with fish passage in streams during periods of low flows. If such changes prevent fish and other aquatic species from leaving stream areas that periodically dry out and entering portions of streams that contain adequate water, mortality of trapped individuals would be expected. The significance of such impacts would depend on the types of aquatic communities present, with greater impacts anticipated in regionally unique habitats that support rare or endemic species.

5.10.3.1.2 Construction. Impacts on aquatic resources from the construction of utility-scale solar energy projects and associated transmission facilities could occur because of (1) direct disturbance of aquatic habitats within the footprint of construction or operation activities, (2) sedimentation of nearby aquatic habitats as a consequence of soil erosion from construction areas, or (3) changes in water quantity or water quality as a result of grading that affects surface runoff patterns, depletions or discharges of water into nearby aquatic habitats, or releases of chemical contaminants into nearby aquatic systems.

As described in Section 5.10.3.1.1, vehicles or machinery used in aquatic habitats and worker foot traffic through aquatic habitats could crush and kill aquatic organisms. Draining and filling of aquatic habitats within the construction footprint for the solar energy facility or within associated transmission corridors would also result in direct loss of any aquatic habitats or organisms within the construction footprint. For many projects, however, such direct impacts on aquatic habitats within the general project area could be minimized by restricting placement of solar energy structures and the associated infrastructure to upland areas. If water for construction activities needed to be withdrawn from waterways on or near the site, the resulting depletions could reduce the amount of aquatic habitat available, depending upon the proportion of the available water being withdrawn. Using groundwater during construction could also reduce surface water resources. However, the use of groundwater for construction activities is unlikely, as is its use in quantities sufficient to affect surface water. Water needs for construction activities could also be met by trucking in water from off-site.

Turbidity and sedimentation from erosion are part of the natural cycle of physical processes in water bodies, and most populations of aquatic organisms have adapted to short-term changes in these parameters. However, sediment inputs can adversely affect aquatic biota, depending on the species present and the geochemical composition, particle size, concentration, and duration of exposure to the suspended material compared to natural conditions (Waters 1995; Bilotta and Brazier 2008). Increased sediment loads can suffocate aquatic vegetation, invertebrates, and fish; decrease the rate of photosynthesis in plants and phytoplankton; decrease fish feeding efficiency; decrease the levels of invertebrate prey; reduce fish spawning success; and adversely affect the survival of incubating fish eggs, larvae, and fry. In addition, some migratory fishes may avoid streams that contain excessive levels of suspended sediments (Waters 1995; Bilotta and Brazier 2008).

The potential for soil erosion and sediment loading of nearby aquatic habitats is in part proportional to the amount of surface disturbance and the proximity to aquatic habitats. However, several additional factors, such as topography, wind speeds, particle size, soil humidity, and plant cover, are also important (Field et al. 2010). Removal of riparian vegetation may also result in greater levels of sediment entering the aquatic habitat with which the vegetation is associated. It is anticipated that upland areas disturbed during construction of solar energy projects would have a higher erosion potential than nondisturbed areas because of site grading and removal of vegetated cover. Fugitive dust from disturbed areas could also contribute turbidity and sedimentation if it settles in aquatic habitats in sufficient quantity (Field et al. 2010). In addition to areas directly affected by the construction of solar energy facilities, surface disturbance could occur outside of the project areas as a result of the development of access roads, transmission lines, utility corridors, and similar infrastructure elements.

Implementation of measures to control erosion and runoff into aquatic habitats (e.g., silt fences, retention ponds, runoff-control structures, and earthen berms) would reduce the potential for impacts from increased sedimentation.

In addition to potentially resulting in increased sediment loads, the removal of riparian vegetation, especially taller trees, could potentially affect the temperature regime in aquatic systems by altering the amount of solar radiation that reaches the water surface. This thermal effect may be most pronounced in small stream habitats, where a substantial portion of the stream channel may be shaded by vegetation. The level of thermal impact associated with the clearing of riparian vegetation would be expected to increase as the amount of affected shoreline increases. However, several studies also indicate local vegetative stream cover may only weakly influence stream temperature. Regional or upstream canopy cover, hyporheic exchange, and in-stream debris are other primary determinants of stream temperature that need to be considered (Ice et al. 2010).

If water temperature increases, the level of dissolved oxygen in the water generally decreases. Consequently, changes in temperature regimes of aquatic habitats can affect the ability of some species to survive within the affected areas, especially during periods of elevated temperatures. Water temperatures during some periods in many aquatic habitats in the desert southwest (where solar insolation regimes may be most conducive to development of utility-scale solar energy projects) may sometimes approach levels lethal to resident species under natural conditions. Consequently, alterations to the environment that increase water temperatures in such areas by even a few degrees could result in mortality to aquatic organisms during such periods.

Fish exposed to stressful temperatures generally move along the temperature gradient until acceptable temperatures are encountered (Hazel 1993). Fish typically avoid elevated temperatures by swimming to areas of groundwater inflow, deep holes, or shaded areas. If thermal refuge is unavailable, fish exposed to excessive temperatures may die.

Contaminants could be introduced into aquatic habitats as a result of the accidental release of fuels, lubricants, or pesticides/herbicides used during the construction of solar energy projects. Because the concentrations of accidentally introduced contaminants in aquatic habitats will depend largely on the dilution capability and therefore the flow of the receiving waters, impacts would be more likely if contaminated runoff from project areas drains into small perennial streams rather than larger streams. The level of impacts from releases of toxicants would depend on the type and volume of chemicals entering the waterway, the location of the release, the nature of the water body (e.g., size, volume, and flow rates), and the types and life stages of organisms present in the receiving waterway. In general, lubricants and fuel would not be expected to enter waterways in appreciable quantities as long as heavy machinery is not used in or near waterways, fueling locations for construction equipment are situated away from the waterway, and measures are taken to control spills that do occur.

In areas where access roads, pipelines, or utility corridors cross streams, obstructions to fish movement can occur if culverts, low-water crossings, or buried pipelines are not properly installed, sized, or maintained. During periods of low water, vehicular traffic can result in rutting

and accumulation of cobbles in some crossings that can interfere with fish movements. In streams with low flows, flow could become discontinuous if disturbance of the streambed during construction activities results in increased porosity or if alteration of the channel spreads flow across a wider area than usual. Restrictions to fish movement would likely be most significant if they occur in streams supporting species that need to move to specific areas in order to reproduce, or in smaller streams where aquatic organisms may need to move to avoid desiccation or heat stress during low-flow periods.

In addition to the potential for the direct impacts identified above, indirect impacts on fisheries could occur as a result of increased public access to remote areas via newly constructed access roads and transmission lines. Access to the solar energy project area would likely be restricted by the construction of fences in order to prevent unauthorized access to the site, potentially reducing public access to some waterways. Fishing pressure in surface waters with recreation species could increase if there is greater road access, and other human activities (e.g., OHV use) could disturb riparian vegetation and soils, resulting in erosion and sediment-related impacts on water bodies, as discussed above. In areas where perennial surface waters or intermittent streams connected to perennial surface waters are present, non-native aquatic species may become established because of the new road access either as a result of their use as bait or in an effort to stock the waterway with desirable recreational species. Such impacts would be smaller in locations where existing access roads or utility corridors that already provide access to waterways are utilized. In addition, there is the potential for introducing non-native aquatic species via construction or maintenance equipment. Decontaminating equipment as appropriate, especially equipment used to convey water (i.e., water pumps), would reduce the risk of non-native species introductions.

5.10.3.1.3 Operations. During the operations and maintenance phase of a utility-scale solar energy facility, aquatic habitats and aquatic biota may be affected by water withdrawn from aquatic habitats for cooling purposes, continued erosion and sedimentation due to altered land surfaces, exposure to contaminants, and continued increases in public access.

If the solar energy technology used by a particular project requires water for producing steam for driving turbines or for cooling the produced steam during operation, there is a potential for water depletion impacts on aquatic habitats within the vicinity. Water depletion impacts on aquatic resources would depend on the proportion of water withdrawn from a particular water body and the types of organisms present. If a water source supports unique or rare organisms, the potential for negative population-level effects would be greater than if the types of organisms present were common and widespread. If groundwater were used for cooling, there could still be depletion impacts on aquatic habitats such as springs or spring-fed streams that rely on the groundwater source for recharge. If water is withdrawn from a surface water source, there is also a potential for impingement and entrainment of aquatic organisms at the water intake and, depending on the numbers of individuals of particular species that are killed, population-level impacts could result. Similarly, if the cooling water were discharged into existing surface water, it could raise the temperature of the receiving water beyond the thermal tolerance of resident species, resulting in adverse affects at the individual (heat-related stress or mortality, avoidance, and sublethal changes in physiology) and ultimately the community level (decreased diversity

and abundance; increase in pathogens). This is particularly true in desert streams where species may already be near their thermal tolerance. Discharging the cooling water into evaporation or infiltration ponds would eliminate the potential for thermal pollution in existing surface water.

Use of closed-cycle cooling technologies, especially dry cooling, would greatly reduce the quantity of water required and therefore reduce the potential for impacts on aquatic habitats or biota. Fish screening technologies commonly used by power plants could be used to reduce the potential for impingement impacts on aquatic biota. Depletion impacts on nearby aquatic habitats could also be reduced or avoided through the use of alternate water sources.

As identified in Section 5.10.3.1.2, the potential for soil erosion and sediment loading of nearby aquatic habitats is in part proportional to the amount of surface disturbance and the proximity to aquatic habitats. During the operation phase, some level of vegetation clearing (e.g., regularly within the solar energy project area and every 3 or more years within ROWs) would be required to maintain the site and any associated ROWs for transmission lines. Although the potential for erosion at a given project site and the resulting levels of turbidity and sedimentation in nearby aquatic habitats would likely be less during the operations phase than during the construction phase because of the establishment of some level of ground cover, the levels would be greater than those that occurred preconstruction and would continue throughout the operational life of the project.

The potential exists for toxic materials (e.g., fuel, lubricants, HTFs, lubricating oils, sulfuric acid, sodium hydroxide, ethylene glycol, and herbicides) to be accidentally introduced into waterways during operation and maintenance of solar energy facilities. The level of impacts from releases of toxicants would depend on the type and volume of chemicals entering the waterway, the location of the release, the nature of the water body (e.g., size, volume, and flow rates), and the types and life stages of organisms present in the waterway. Because the amounts of most fuels and other hazardous materials are expected to be small, an uncontained spill would probably affect only a limited area. In general, lubricants and fuel would not be expected to enter waterways as long as heavy machinery is not used near waterways, fueling locations for maintenance equipment are situated away from waterways, and measures are taken to control potential spills. Mitigation measures for maintenance of transmission line corridors generally restrict the use of machinery near waterways. Similarly, restrictions are generally placed on the application methods, quantities, and types of herbicides used in the vicinity of waterways in order to limit the potential for impacts on aquatic ecosystems.

5.10.3.1.4 Decommissioning/Reclamation. Decommissioning (including reclamation) of a utility-scale solar energy project would reduce or eliminate impacts that occurred from construction and operation to the extent practicable by re-establishing affected habitat. The effectiveness of any reclamation activity would depend on the specific actions taken; the best results, however, would occur where original site topography, hydrology, soils, and vegetation patterns could be re-established. However, full restoration of site features may not be possible under all situations. Impacts on aquatic habitats and biota during decommissioning activities would be similar to those from construction but may be of more limited scale and shorter duration. This would depend, in part, on whether decommissioning would involve full removal

of facilities, partial removal of key components, or abandonment. For example, leaving buried components in place would reduce the amount of trenching and soil disturbance required and therefore result in lower levels of sediments being introduced into nearby aquatic habitats.

Water withdrawals associated with site operations would be discontinued following decommissioning. Depending on the water source used for site operations, impacts may cease immediately or last years to decades. There could be temporary increases in the use of vehicles or machinery and in worker foot traffic through aquatic habitats that could crush and kill aquatic organisms. Recreational use of the decommissioned project site might also increase after aboveground structures were removed, which could lead to increased pressure on adjacent fishery resources if present. Fencing may remain for a short period of time after reclamation and would reduce access in the short term. Most public land management agencies do not allow off-road travel, and signage can be posted to keep travelers on authorized roads and trails. Thus, if access is kept limited, it is anticipated that the increase in fishing pressure would be small.

Other potential environmental concerns resulting from decommissioning would include disposal of solid wastes, hazardous materials, and remediation of contaminated soils. Some fuel and chemical spills could also occur; generally these would be confined to access roads and project site areas. As described previously, the level of impacts from releases of toxicants would depend on the type and volume of chemicals entering a waterway, the location of the release, the nature of the water body (e.g., size, volume, and flow rates), and the types and life stages of organisms present in the waterway. After decommissioning activities were complete, there would be no fuel or chemical spills associated with the solar energy facility or with gas or water pipelines.

Whether aquatic habitats would recover from impacts following decommissioning and how long such recovery would take depends on the type and magnitude of potential impacts and also on the ability of affected populations of organisms to become re-established in restored areas.

5.10.3.1.5 Transmission Lines and Roads. In general, many of the potential impacts on aquatic habitats and biota identified in Sections 5.10.3.1.1 through 5.10.3.1.4 are also applicable to the design, construction, operation, and decommissioning of transmission lines, and to upgrades to existing lines. Potential construction impacts of transmission corridor development on aquatic biota would result primarily from ground disturbance, vegetation removal, and excavation during clearing of the ROWs and from installation of access roads and structures (e.g., transmission line towers, substations, or pipelines) near or in water bodies. Potential impacts could include changes in surface water flow patterns, deposition of sediment in surface water bodies, changes in water quality or temperature regimes, loss of riparian vegetation, introduction of toxic materials, restrictions to fish movements, and changes in human access to water bodies. The severity of impacts would depend upon such factors as the type of aquatic habitat and the types of organisms present, season of construction, size of the aquatic habitat, the length and width of the area to be cleared, construction procedures used, and the quality of the existing habitat.

During the construction of transmission corridors, ground disturbance, removal of vegetation (especially riparian vegetation), and direct disturbance of stream bottoms could result in increased suspended sediment loads both during construction activities and for a limited period of time after construction activities cease. These suspended sediments typically settle to the bottom within some distance downstream of the construction area; that distance depends on factors such as the size of sediment particles and water velocity in the receiving body of water. The overall area of aquatic habitat affected by sediment from a particular construction activity would then include the footprint of the disturbed area plus an area downstream of the activity. In most cases, transmission line towers can be located to minimize the need to place structures directly within aquatic habitats as long as the span between adjacent towers is not too great.

The level of effects from increased sediment loads depends on the natural condition of the receiving waters, the biota present, and the timing of sediment inputs. Whereas most aquatic systems might be expected to be affected by large increases in levels of suspended and deposited sediments, aquatic habitats in which waters are normally turbid may be less sensitive to small to moderate increases in suspended sediment loads than habitats that normally have clear waters. Similarly, increased sedimentation during periods of the year in which sediment levels might naturally be elevated (e.g., during wet parts of the year) may have smaller impacts than during periods in which natural sediment levels would be expected to be lower.

Characteristics of surface water runoff, such as flow direction and flow rates following rain events, are controlled, in part, by local topography and vegetation cover. Consequently, construction activities that affect the terrain and vegetation during corridor development could alter the water flow patterns. Impacts on aquatic ecosystems could result if these alterations affect the amount, timing, or flashiness of runoff entering a particular water body. In general, attempts are made to control or reduce such impacts on aquatic ecosystems by ensuring that the overall grade of a corridor remains similar to the grade present prior to construction by maintaining some vegetative cover in corridors and by maintaining a relatively unaltered buffer of vegetation along the margins of water bodies.

As described in Section 5.10.3.1.2, the removal of riparian vegetation, especially taller trees, can affect, but will not necessarily affect, the temperature regime in aquatic habitat. If local riparian habitat is a significant influence on stream temperature, the thermal impact associated with the clearing of riparian vegetation for transmission corridors would increase as the amount of affected shoreline increases.

During the operational phase of a project, aquatic systems could be adversely affected by maintenance activities along transmission corridors, especially vegetation control. For most transmission line corridors, vegetation control in a particular area is relatively infrequent (generally no more often than once every 3 to 4 years), and the amount of vegetation disturbed is much less than that which would occur during construction. Selected trees might be removed or trimmed if they are considered likely to pose a risk to the transmission system. If control of vegetation along shorelines can be accomplished by using manual techniques, the erosion of stream banks from maintenance activities would be expected to be relatively minor.

The mechanisms by which toxic materials (e.g., fuel, lubricants, and herbicides) could be accidentally introduced into waterways during construction and maintenance activities for transmission corridors would be similar to those described in Sections 5.10.3.1.2 and 5.10.3.1.3. The level of impacts from releases of toxicants would depend on the type and volume of chemicals entering the waterway, the location of the release, the nature of the water body (e.g., size, volume, and flow rates), and the types and life stages of organisms present in the receiving waterway.

Low-water crossings used to accommodate vehicular traffic during construction or maintenance of transmission lines could interfere with fish passage in some cases, as identified in Section 5.10.3.1.2.

In addition to the potential for the direct impacts identified above, indirect impacts on fisheries could occur as a result of increased public access to remote areas via transmission line ROWs and associated access roads. Fishing pressure in surface waters with recreation species could increase if there is greater road access, and other human activities (e.g., OHV) use) could disturb vegetation and soils, resulting in erosion and sediment-related impacts on water bodies, as discussed above. Also, because of the new road access, wherever perennial surface waters or intermittent streams connected to perennial surface waters are present, non-native aquatic species may become established either as a result of their use as bait or in an effort to stock the waterway with desirable recreational species. Such impacts would likely be smaller in locations where corridors could be co-located with roads or existing ROWs or where they would be located close to existing features (e.g., trails or logging roads) that already provide access to waterways. In addition, there is the potential for introducing non-native aquatic species via construction or maintenance equipment. Decontaminating equipment as appropriate, especially equipment used to convey water (i.e., water pumps), would reduce the risk of non-native species introductions.

Decommissioning of transmission corridors would also result in impacts on aquatic habitats and associated biota. Decommissioning activities would be expected to include the dismantling and removal of structures such as electricity transmission towers. The types of impacts resulting from decommissioning would be similar to those associated with energy project construction, including increased erosion and sedimentation, potential changes to surface water hydrology, potential establishment of invasive species, and potential spills of oil or other toxic materials associated with the operation of heavy machinery.

Decommissioning would generally result in soil disturbance, potentially including regrading of areas within the ROWs. Establishment and use of temporary work areas and storage areas would also result in some surface disturbance. Vegetation adjacent to aquatic habitats at stream crossings could be removed or damaged during decommissioning, thereby increasing the potential for erosion and subsequent sedimentation in nearby aquatic habitats.

Decommissioning activities would generally affect habitat previously disturbed by initial project construction. Depending on the time since initial construction was completed, the type of construction activities that occurred, and the type of aquatic habitat present, the aquatic communities present at the time of decommissioning may closely resemble nearby undisturbed areas. Some aquatic habitats would again recover from the disturbance associated with

decommissioning after a period of time. Recovery time could range from months to many years, depending on the nature of the disturbance and the type of aquatic habitats present. Within some ROWs, permanent differences between aquatic communities in disturbed areas and nearby undisturbed areas may remain.

Recreational use of the decommissioned transmission corridors (e.g., as a travel corridor by OHVs) might also increase after aboveground structures were removed, which could increase fishing pressure in surface waters with recreation species. However, it is anticipated that the resulting impacts would be small.

5.10.3.1.6 Summary of Common Impacts on Aquatic Biota and Habitats. Overall, impacts from site characterization, construction, operation, and decommissioning of a utility-scale solar energy project on aquatic habitats and aquatic biota would depend on the following:

- The type and amount of aquatic habitat that would be disturbed;
- The nature of the disturbance (e.g., long-term reduction due to project structure and access road placement; complete, long-term alteration due to transmission line, gas pipeline, and water pipeline placement; or temporary disturbance in construction staging areas); and
- The types, numbers, and uniqueness of the aquatic biota that occupy the facility site and surrounding areas.

Potential impacts on aquatic resources (without mitigation) from the various impacting factors associated with solar energy projects are summarized in Table 5.10-3. The potential magnitudes of the impacts that could result from solar energy project development are presented separately for aquatic invertebrates and for fish. Potential impacts on federally listed, state-listed, and BLM-designated sensitive aquatic species are presented in Section 5.10.4, and potential impacts on other types of organisms that could occur in aquatic habitats (e.g., amphibians and waterfowl) are presented in Section 5.10.2.

5.10.3.2 Technology-Specific Impacts

The general types of impacts on aquatic habitats and biota from site characterization, construction, operation, and decommissioning of a solar energy project are described in Section 5.10.3.1. One of the main impacts on aquatic biota from a solar energy project, regardless of the technology utilized, would be associated with the amount of aquatic habitat lost as part of the construction footprint needed for the project. The biological impacts from turbidity and sedimentation due to erosion would be primarily proportional to the amount of upland habitat disturbance and its proximity to surface water. For comparison, a 400-MW power tower, dish engine, or PV facility would occupy about 3,600 acres (14.6 km^2). Less than half to nearly all of the site would be cleared and maintained as an unvegetated or sparsely vegetated area that

TABLE 5.10-3 Potential Impacts on Aquatic Resources Associated with Utility-Scale Solar Energy Facilities, Including Associated Access Roads and Transmission Line Corridors

Impacting Factor	Project Phase	Consequence	Expected Impact[a]	Ability to Mitigate Impacts[b]
Individual Impacting Factor[c]				
Alteration of topography and drainage patterns	Construction, operations	Changes in water temperature; change in distribution and structure of aquatic, wetland, and riparian habitat and communities; erosion; changes in groundwater recharge.	Large	Can be mitigated by avoiding development of drainages and using appropriate stormwater management strategies.
Human presence and activity	Site characterization, construction, operations, decommissioning	Ground disturbance from vehicles and foot traffic; behavioral avoidance of areas; habitat degradation; non-native species introductions.	Small	Can be mitigated during site characterization and construction by timing activities to avoid sensitive periods and locations. Difficult to mitigate impacts during operations. Decontaminating equipment would reduce the risk of non-native species introductions.
Blockage of dispersal and movement	Construction, operations	Genetic isolation; loss of access to important habitats; change in community structure; reduction in carrying capacity.	Small	Can be mitigated by restricting project size, avoiding important movement corridors.
Erosion	Construction operations, decommissioning	Sedimentation of adjacent aquatic systems; loss of productivity; change in communities; physiological stress.	Moderate	Easily mitigated with standard erosion control practices.
Fugitive dust	Site characterization, construction, operations, decommissioning	Increase in turbidity and sedimentation in aquatic habitat; decrease in photosynthesis; change in community structure; physiological stress.	Small	Can be mitigated by retaining vegetative cover, soil covers, or soil stabilizing agents.
Groundwater withdrawal	Construction, operations	Change in hydrologic regime; reduction in productivity and aquatic habitat at the surface.	Moderate	Can be mitigated by reducing water consumption requirements. May be difficult to mitigate for all but PV systems.

TABLE 5.10-3 (Cont.)

Impacting Factor	Project Phase	Consequence	Expected Impact[a]	Ability to Mitigate Impacts[b]
Individual Impacting Factor[c] (Cont.)				
Habitat fragmentation	Construction, operations	Genetic isolation; loss of access to important habitats; reduction in carrying capacity; change in community structure.	Moderate	Difficult to mitigate; requires minimizing disruption of intact communities especially by linear features such as transmission lines and roads.
Increased human access	Construction, operations	Habitat degradation; fishing pressure.	Moderate	Can be mitigated by reducing the number of new transmission lines and roads in important habitats.
Oil and contaminant spills	Site characterization, construction, operations, decommissioning	Mortality; physiological stress; reproductive impairment; reduction in carrying capacity.	Large	Can be mitigated using project mitigation measures (e.g., pipeline check valves) and spill prevention and response planning.
Restoration of topography and drainage patterns	Decommissioning	Impacts initially adverse; some degree of restoration to pre-construction conditions.	Moderate	Mostly beneficial; adverse impacts can be mitigated using standard erosion and runoff control measures.
Restoration of topsoil and native vegetation	Decommissioning	Reduced erosion and fugitive dust; increased productivity.	Moderate	Mostly beneficial; adverse impacts can be mitigated using standard erosion and runoff control measures.
Site lighting	Construction, operations	Behavioral disturbance; avoidance of areas.	Small	Minimize lighting to that needed for safe construction and operations; avoid projecting past site boundaries.
Topsoil removal	Construction, operations	Increased sedimentation in aquatic habitat; change in community structure; physiological stress.	Moderate	Readily mitigated by stockpiling soils to maintain seed viability, vegetating to reduce erosion, and replacing at appropriate depths when other site activities are complete.

TABLE 5.10-3 (Cont.)

Impacting Factor	Project Phase	Consequence	Expected Impact[a]	Ability to Mitigate Impacts[b]
Individual Impacting Factor[c] (Cont.)				
Vegetation clearing and maintenance	Construction, operations	Change in water temperature; increased sedimentation from erosion and fugitive dust; changes in productivity and diversity; reduction in carrying capacity; herbicide inputs; acute and chronic toxicological impacts.	Large	Difficult to mitigate; most project areas are likely to require clearing. Can be mitigated by managing for low-maintenance vegetation (e.g., native shrubs, grasses, and forbs), invasive species control, minimizing the use of herbicides near sensitive habitats (e.g., aquatic and wetland habitats), and using only approved herbicides consistent with safe application guidelines. Restoration of a vegetative cover consistent with the intended land use would reduce some impacts.
Vehicle traffic	Site characterization, construction, operations, decommissioning	Direct mortality of individuals through crushing; increased fugitive dust emissions.	Small	Can be mitigated using worker education programs, signage, and traffic restrictions.
All Impacting Factors Combined				
	Site characterization			Relatively easy.
	Construction			Relatively difficult; residual impact mostly dependent on the size of area developed.
	Operations			Relatively difficult; residual impact mostly dependent on the size of area developed.
	Decommissioning			Relatively easy to mitigate adverse impacts of decommissioning. May be difficult to achieve restoration objectives.
	Overall project			Relatively difficult; residual impact mostly dependent on the size of area developed and the success of restoration activities.

Footnotes on next page.

TABLE 5.10-3 (Cont.)

[a] Relative impact magnitude categories were based on professional judgment utilizing CEQ regulations for implementing NEPA (40 CFR 1508.27) by defining significance of impacts based on context and intensity. Similar impact magnitude categories and definitions were used in BLM (2008a,b). Impact categories were as follows: (1) *none*—no impact would occur; (2) *small*—effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource. (e.g., <1% of the population or its habitat would be lost in the region); (3) *moderate*—effects are sufficient to alter noticeably but not to destabilize important attributes of the resource (e.g., >1 but <10% of the population or its habitat would be lost in the region); and (4) *large*—effects are clearly noticeable and are sufficient to destabilize important attributes of the resource (e.g., >10% of a population or its habitat would be lost in the region). Assigned impact magnitudes assume no mitigation. Actual magnitudes of impacts on aquatic habitat and biota would depend on the location of projects, project-specific design, application of mitigation measures (including avoidance, minimization, and compensation), and the ecological condition of aquatic habitat and biota in project areas.

[b] Actual ability to mitigate impacts will depend on site-specific conditions and the species present in the project area. Recommended mitigation measures are presented in Section 5.10.5.

[c] Impacting factors are presented in alphabetical order.

would provide only a limited ability to control erosion of surface soils and subsequent runoff into nearby water bodies.

The types of hazardous materials that could be used and stored at a solar energy project are listed in Section 5.20. Spills of these materials could cause impacts on aquatic organisms if they were to enter aquatic habitats. The level of impacts from releases of toxicants would depend on the type and volume of chemicals entering the waterway, the location of the release, the nature of the water body (e.g., size, volume, and flow rates), and the types and life stages of organisms present in the waterway.

Additional impacts on aquatic habitats and biota from specific technologies that could be utilized to produce solar energy are presented in this section. These impacts are based on the anticipated resource requirements and activities likely to occur at solar energy projects utilizing currently established technologies.

5.10.3.2.1 Parabolic Trough and Power Tower. A natural gas pipeline could be required to supply gas for the boilers used to warm up the HTF each morning in order to reduce plant start-up times and to provide HTF freeze protection. Construction of a gas pipeline would cause short-term impacts at stream crossings. It also would create the potential for longer term impacts during the operational life of the project if the stream crossing altered the ability of aquatic organisms to move upstream or downstream of the crossing. Such impacts could be minimized or eliminated by implementing appropriate mitigation measures for pipeline crossings. Similar impacts would be expected if water needs for the project were obtained by a pipeline from an off-site location rather than from on-site wells or other on-site sources. One or more evaporation or infiltration ponds could be required to receive cooling water discharges (more or larger ponds would be anticipated for projects that use wet vs. dry cooling). These ponds may provide some limited value as aquatic habitat, depending on the specific design. However, the discharged cooling water may also contain contaminants that may bind to surface sediments or enter groundwater in the case of infiltration ponds. Operation of a 400-MW parabolic solar energy plant or a power tower facility that uses wet cooling could require up to 6,200 ac-ft/yr (7.6 million m^3/yr) of water for all the anticipated water needs (Table 3.1.5-1). Water requirements would be less if other cooling technologies were implemented (Table 3.1.5-1). If water withdrawals to meet plant needs come from nearby surface water habitats, the resulting depletions could result in some habitat loss. The magnitude of the impacts would depend upon the proportion of the available surface water volume that was withdrawn and the specific types of aquatic habitat and biota present in the affected water body.

5.10.3.2.2 Dish Engine and PV Systems. Unlike solar energy technologies that may use natural gas burners to warm HTFs (i.e., parabolic trough and power tower), dish engine and PV solar energy projects would not have this requirement. Therefore, there would be no impacts on aquatic habitats due to construction of stream crossings for a natural gas pipeline using these technologies.

The water needs for a dish engine or PV solar energy project are small. Because there are no cooling water needs, evaporation ponds would not be required for dish engine or PV projects. Operation of a 750-MW dish engine solar energy plant or PV facility could require up to 375 ac-ft/yr (0.5 million m^3/yr) of water for mirror cleaning (Table 3.1.5-1). If water for this purpose is obtained from an off-site location rather than an on-site well, a water pipeline might be required. The impacts of constructing such a pipeline would be similar to those for the parabolic trough and power tower technologies. If water withdrawals to meet plant needs come from nearby surface water areas, the resulting depletions could result in some aquatic habitat loss. The magnitude of the impacts would depend on the proportion of the available surface water volume withdrawn and the specific types of aquatic habitat and biota present in the affected water body. However, the likelihood of impacts on aquatic habitats would be low, especially compared with a similarly sized parabolic trough or power tower project, which would require larger amounts of water for cooling. Alternatively, if the water requirements are low enough, water for cleaning mirrors could be trucked to the site.

5.10.4 Special Status Species (Threatened, Endangered, Sensitive, and Rare Species)

5.10.4.1 Common Impacts

Special status species are considered those species that are either federally listed as threatened or endangered under the Endangered Species Act (ESA); candidate or proposed for listing under the ESA; BLM-designated sensitive; state-listed as either endangered, threatened, or a species of special concern; or a rare species as defined by a state rank S1 or S2. Species that are considered rare globally (i.e., species with a global rank of G1 or G2) are invariably considered rare at the state level (i.e., a state rank of S1 or S2) and thus are included in this discussion. Numerous special status species are present within the six-state study area that could be affected by solar energy development. These species are discussed in Section 4.10.4. Note that some of the categories of species included here do not fit BLM's definition of special status species as defined in *BLM Manual 6840* (BLM 2008c). These species are included here to ensure broad consideration of species that may be most vulnerable to impacts of solar development.

Impacts on special status species that could result from utility-scale solar energy development include those associated with initial site characterization, facility construction, operations, and decommissioning. The potential impacts would be directly related to the amount of land disturbance, the duration and timing of construction and operation periods, and the habitats affected by development (i.e., the location of the project). Indirect effects, such as those resulting from the erosion of disturbed land surfaces and disturbance and harassment of animal species, are also possible, but their magnitude is considered proportional to the amount of land disturbance.

The discussion in this section assumes that no mitigation would occur. In reality, there are BMPs typically required by the BLM and a number of federal and state laws and regulations that would entail consultation with federal and state natural resource agencies, and in the course of that consultation, mitigations for many of the impacts described here would be developed.

Section 7 of the ESA requires that the federal action agency consult with the U.S. Fish and Wildlife Service (USFWS) if any listed species or designated critical habitats could be affected by project activities. This consultation would identify the species that could be affected, the expected magnitude of the impacts, and mitigations that would reduce or eliminate impacts. These mitigations would do much to reduce or eliminate impacts on special status species.

Impacts on special status species are fundamentally similar to or the same as those described for impacts on plant communities and habitats, wildlife, and aquatic resources (Sections 5.10.1, 5.10.2, and 5.10.3, respectively). However, because of their small population sizes and often specialized habitat needs or dependence on rare habitats, special status species may be more vulnerable to impacts than common and widespread species. Small population size makes them more vulnerable to the effects of habitat fragmentation, habitat alteration, habitat degradation, human disturbance and harassment, mortality of individuals, and the loss of genetic diversity. Specific impacts associated with development would depend on the locations of projects relative to species populations and the details of project development. Impacts on special status species are discussed separately for each project phase in the following sections.

5.10.4.1.1 Site Characterization. The impacts of site characterization on special status species would depend on the location of the project and the type of technology being considered. Most characterization activities (e.g., surface hydrology and floodplain mapping) involve minimum or no site disturbance and are unlikely to affect special status species. However, some characterization activities may require ground disturbances that might affect local plants and wildlife species. Some of these activities include the installation of groundwater monitoring wells (for those projects that anticipate the use of groundwater) or the construction of meteorological towers to obtain climatic data for projects in remote areas. In addition, increased human presence in the area may affect local populations of plants and animals through collection and/or through inadvertent or unintentional harassment.

5.10.4.1.2 Construction. The potential impacts that could result from utility-scale solar energy development are presented for different species types in Table 5.10-4. During construction, it is assumed that the entire project area would be graded and all vegetation would be removed. These activities could remove suitable habitat for special status plant and animal species (note that, in actual practice, mitigation may include avoidance and protection of occupied or suitable habitats for special status species; see related discussion in Section 5.10.1). Local vegetation within the project area would be destroyed, and plants close to the project area could be affected by runoff from the site due to erosion or sedimentation. In addition, fugitive dust, vehicle emission particulates, and other contaminants (e.g., fuel, oil) may accumulate in areas near the project area, which may be absorbed by plant leaf surfaces and roots. Such processes can reduce photosynthesis and metabolism rates in the plants and subsequently affect plant vigor. Disturbed areas within and near the project area could be colonized by exotic invasive plant species. Invasive plant species are generally more tolerant of disturbed conditions, and their establishment within and surrounding the project area could be facilitated by the level of disturbance associated with project activities. Further, invasive plant species, if left unchecked, can develop high population densities, which can exclude the re-establishment of

native species for long periods. This may especially affect species status plant species that occur in small populations.

Larger, more mobile animals such as birds and medium-sized or large mammals would be most likely to leave the project area during site preparation and construction activities. Development of the site would represent a loss of habitat for these species and potentially a reduction in carrying capacity (i.e., the number of individuals of a species that can be supported in an area) in the area. Smaller animals, such as small mammals, tortoises, lizards, snakes, and amphibians, are more likely to be killed during clearing and construction activities. If land-clearing and construction activities occurred during the spring and summer, bird nests and nestlings in the project area could be destroyed. Longer term impacts, such as increased vulnerability to predators and diseases, could occur as a result of habitat destruction during the construction phase and may continue to affect special status plants and animals beyond the life of the project.

5.10.4.1.3 Operations. Project operations could also affect protected special status plant and animal species, as presented in Table 5.10-4. Throughout the operational period, the site would have reduced plant cover, and the entire site would be fenced. This would represent a direct loss of habitat and productivity on the site, as well as create a barrier to most wildlife movements. Further, the developed site could lead to fragmentation of otherwise intact habitat and, in some cases, isolation of the remaining suitable habitat patches from one another. Such habitat fragmentation can have negative effects on some species by increasing the amount of edge habitat, making individuals more vulnerable to predation, diseases, and human collection and/or harassment. Special status animals in and adjacent to project areas would be disturbed by human activities and would tend to avoid the area while activities were occurring. Site lighting, reflectivity, and operational noise from equipment could affect animals on and off the site, resulting in avoidance or reduction in use of an area larger than the project footprint. Runoff from the site during site operations could result in erosion and sedimentation of adjacent habitats. Fugitive dust during operations could affect adjacent plant populations and result in reduced productivity. Long-term changes in surface water or groundwater quality associated with site operations could affect local plant and animal populations. Groundwater withdrawals to support construction and operational needs could result in drawdown of aquifers and subsequent reductions in stream and other surface water levels. These reductions could reduce baseflows, reduce aquatic habitat availability and quality, and affect wetlands and riparian habitats dependent on those water levels. Maintenance programs to support transmission ROWs may also affect listed plant and animal species.

5.10.4.1.4 Decommissioning/Reclamation. In general, the impacts on special status plant and animal species associated with decommissioning of utility-scale solar energy facilities would be short term and similar to those associated with facility construction (Table 5.10-4). For the most part, decommissioning activities would occur only in areas previously disturbed by project construction activities and operations, although adjacent areas could be affected. Decommissioning would likely include soil disturbances to remove aboveground and

TABLE 5.10-4 Potential Impacts on Special Status Species Associated with Utility-Scale Solar Energy Facilities, Including Associated Access Roads and Transmission Line Corridors

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Species Groups[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
Individual Impacting Factor[d]							
Alteration of topography and drainage patterns	Construction, operations	Changes in surface temperature, soil moisture, and hydrologic regimes, and distribution and extent of aquatic, wetland, and riparian habitats; erosion; changes in groundwater recharge; spread of invasive species.	None	Terrestrial reptiles, mammals	Terrestrial plants, invertebrates, amphibians, and birds	Aquatic, wetland, and riparian plant and animals species	Can be mitigated by avoiding development of drainages and using appropriate stormwater management strategies.
Human presence and activity	Site characterization, construction, operations, decommissioning	Behavioral disturbance, harassment, nest abandonment, avoidance of areas, territory adjustments, reduction in carrying capacity.	All plants	Invertebrates, fish	Amphibians, reptiles, small mammals	Birds, large mammals	Can be mitigated during site characterization and construction by timing activities to avoid sensitive periods. Difficult to mitigate impacts during operations.
Blockage of dispersal and movement	Construction, operations	Genetic isolation, loss of access to important habitats, reduction in diversity, reduction in carrying capacity.	All plants	Invertebrates, fish, birds, bats	Amphibians, reptiles, small mammals	Large mammals	Can be mitigated by restricting project size, avoiding important movement corridors.
Erosion	Construction operations, decommissioning	Habitat degradation; loss of plants; sedimentation of adjacent areas especially aquatic, wetland systems; loss of productivity; reduction in carrying capacity; spread of invasive species.	None	Terrestrial plants, invertebrates, amphibians, reptiles, birds, mammals	Aquatic, wetland, and riparian plant and animals species	None	Easily mitigated with standard erosion control practices.

TABLE 5.10-4 (Cont.)

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Species Groups[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
Individual Impacting Factor[d] (Cont.)							
Equipment noise	Site characterization, construction, operations, decommissioning	Behavioral disturbance, harassment, nest abandonment, avoidance of areas, territory adjustments, reduction in carrying capacity.	All plants, invertebrates	Amphibians, reptiles, and small mammals	Birds, large mammals	None	Can be mitigated using mufflers and other sound-dampening devices.
Fugitive dust	Site characterization, construction, operations, decommissioning	Decrease in photosynthesis, reduction in productivity, increased turbidity and sedimentation in aquatic habitat, spread of invasive species.	None	Animals	All plants	None	Can be mitigated by retaining vegetative cover, soil covers, or soil-stabilizing agents.
Groundwater withdrawal	Construction, operations	Change in hydrologic regime, reduction in surface water, reduction in soil moisture, reduction in productivity.	None	Terrestrial plants and animals	Aquatic, wetland, and riparian plants and animals	None	Can be mitigated by reducing water consumption requirements. May be difficult to mitigate for all but PV systems.
Habitat fragmentation	Construction, operations	Genetic isolation, loss of access to important habitats, reduction in diversity, reduction in carrying capacity, spread of invasive species.	None	None	All plants and animals	None	Difficult to mitigate; requires minimizing disruption of intact communities especially by linear features such as transmission lines and roads.
Increased human access	Construction, operations	Harassment, collection, increased predation risk, increased collision mortality risk.	None	Plants	Animals	None	Can be mitigated by reducing the number of new transmission lines and roads in important habitats.

TABLE 5.10-4 (Cont.)

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Species Groups[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
Individual Impacting Factor[d] (Cont.)							
Oil and contaminant spills	Site characterization, construction, operations, decommissioning	Death of directly affected individuals, uptake of toxic materials, reproductive impairment, reduction in carrying capacity.	None	None	Terrestrial plants and animals	Aquatic, wetland, and riparian plants and animals	Can be mitigated using project mitigation measures (e.g., pipeline check valves) and spill prevention and response planning.
Project infrastructures	Operations	Increased predation rates from predators using tall structures, collision mortality.	All plants, large mammals	Invertebrates, amphibians	Reptiles, birds, and small mammals	None	Can be mitigated using appropriate warning lights on towers, markers on lines and guy wires, or elimination of guy wires.
Restoration of topography and drainage patterns	Decommissioning	Beneficial changes in temperature, soil moisture, and hydrologic regimes.	None	None	All plants and animals	None	Mostly beneficial; adverse impacts can be mitigated using standard erosion and runoff control measures.
Restoration of topsoil	Decommissioning	Beneficial changes in soil moisture, increased productivity and carrying capacity.	None	None	All plants and animals	None	Mostly beneficial; adverse impacts can be mitigated using standard erosion and runoff control measures.
Restoration of native vegetation	Decommissioning	Beneficial changes in soil moisture, increased productivity and carrying capacity, increased diversity.	None	None	All plants and animals	None	Mostly beneficial; adverse impacts can be mitigated by ensuring species mix used includes a diverse weed-free mix of hardy native species.

TABLE 5.10-4 (Cont.)

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Species Groups[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
Individual Impacting Factor[d] (Cont.)							
Site lighting	Construction, operations	Behavioral disturbance, harassment, nest abandonment, avoidance of areas, territory adjustments, reduction in carrying capacity, collision with structures.	All plants	Fish, invertebrates, amphibians, and reptiles	Birds and mammals	None	Easily mitigated by ensuring lighting is minimized to that needed for safe construction and operations and does not project past site boundaries.
Soil compaction	Site characterization, construction, operations, decommissioning	Reduction in productivity, reduction in diversity, reduction in carrying capacity, increased runoff and erosion, spread of invasive species.	None	All plants and animals	None	None	Easily mitigated by aerating soil after being compacted.
Topsoil removal	Construction, operations	Reduction in productivity, reduction in diversity, reduction in carrying capacity, direct mortality of individuals, increased sedimentation in aquatic habitat, spread of invasive species.	None	None	All plants and animals	None	Readily mitigated by stockpiling soils to maintain seed viability, vegetating to reduce erosion, and replacing at appropriate depths when other site activities are complete.
Vegetation clearing	Construction, operations	Habitat loss, habitat fragmentation, direct mortality of individuals, changes in temperature and moisture regimes, erosion, increased fugitive dust emissions, reduction in productivity, reduction in diversity, reduction in carrying capacity, spread of invasive species.	None	None	None	All plants and animals	Difficult to mitigate; most project areas are likely to require clearing. Restoration of a vegetative cover consistent with the intended land use would reduce some impacts.

TABLE 5.10-4 (Cont.)

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Species Groups[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
Individual Impacting Factor[d] (Cont.)							
Vegetation maintenance	Operations	Reduction in vegetation cover or vegetation maintained in early successional stage or low-stature, habitat fragmentation, direct mortality of individuals, reduction in diversity, reduction in carrying capacity, spread of invasive species.	None	Fish	Plants and animals (other than fish)	None	Can be mitigated by managing for low-maintenance vegetation (e.g., native shrubs, grasses, and forbs), controlling invasive species, minimizing the use of herbicides near sensitive habitats (e.g., aquatic and wetland habitats), and using only approved herbicides consistent with safe application guidelines.
Vehicle and equipment emissions	Construction, operations	Reduced productivity.	None	All plants and animals	None	None	Readily mitigated by maintaining equipment in proper operating condition.
Vehicle and foot traffic	Site characterization, construction, operations, decommissioning	Direct mortality of individuals through collision or crushing, soil compaction, increased fugitive dust emissions.	None	Aquatic and wetland animals, all plants, all invertebrates.	Terrestrial amphibians, reptiles, birds, mammals	None	Can be mitigated by using worker education programs, signage, and traffic restrictions.

TABLE 5.10-4 (Cont.)

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Species Groups[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
All Impacting Factors Combined							
	Site characterization	Direct mortality of individuals, habitat loss, behavioral disturbance, soil compaction, increased fugitive dust emissions, increased runoff and erosion, spread of invasive species.	None	All plants and animals	None	None	Relatively easy.
	Construction	Direct mortality of individuals, habitat loss, behavioral disturbance, reduced productivity and diversity, reduced carrying capacity, habitat fragmentation, soil compaction, increased fugitive dust emissions, spread of invasive species, changes in temperature and moisture regimes, increased sedimentation in aquatic habitat, increased runoff and erosion, changes in groundwater recharge.	None	None	None	All plants and animals	Relatively difficult; residual impact mostly dependent on the size of area developed.

TABLE 5.10-4 (Cont.)

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Species Groups[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
All Impacting Factors Combined (Cont.)							
	Operations	Direct mortality of individuals, habitat loss, behavioral disturbance, reduction in vegetation cover or vegetation maintained in early successional stage or low-stature, reduced productivity and diversity, reduced carrying capacity, habitat fragmentation, soil compaction, increased fugitive dust emissions, changes in temperature and moisture regimes, increased sedimentation in aquatic habitat, increased runoff and erosion, changes in groundwater recharge.	None	None	None	All plants and animals	Relatively difficult; residual impact mostly dependent on the size of area developed.
	Decommissioning	Beneficial changes in soil moisture, temperature, and hydrologic regimes, increased productivity and carrying capacity, increased diversity, direct mortality of individuals, habitat loss, behavioral disturbance, soil compaction, increased fugitive dust emissions.	None	None	All plants and animals (benefits)	None	Relatively easy to mitigate adverse impacts of decommissioning. May be difficult to achieve restoration objectives.

TABLE 5.10-4 (Cont.)

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Species Groups[b]				Ability to Mitigate Impacts[c]
			None	Small	Moderate	Large	
All Impacting Factors Combined (Cont.)							
	Overall project	Direct mortality of individuals, habitat loss, behavioral disturbance, reduced productivity and diversity, reduced carrying capacity, habitat fragmentation, soil compaction, increased fugitive dust emissions, changes in temperature and moisture regimes, increased sedimentation in aquatic habitat, increased runoff and erosion, changes in groundwater recharge.	None	None	None	All plants and animals	Relatively difficult; residual impact mostly dependent on the size of area developed and the success of restoration activities.

[a] Relative impact magnitude categories were based on professional judgment utilizing CEQ regulations for implementing NEPA (40 CFR 1508.27) by defining significance of impacts based on context and intensity. Similar impact magnitude categories and definitions were used in BLM (2008a and b) and assume no special status species mitigation. Impact categories were as follows: (1) *none*—no impact would occur; (2) *small*—effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource. (e.g., <1% of the population or its habitat would be lost in the region); (3) *moderate*—effects are sufficient to alter noticeably but not to destabilize important attributes of the resource (e.g., >1 but <10% of the population or its habitat would be lost in the region); and (4) *large*—effects are clearly noticeable and are sufficient to destabilize important attributes of the resource (e.g., >10% of a population or its habitat would be lost in the region). Actual magnitudes of impacts on special status species would depend on the location of projects, project-specific design, application of mitigation measures (including avoidance, minimization, and compensation), and the status of species status species and their habitats in project areas.

[b] Special status species are placed into groups based on taxonomy (plants, invertebrates, amphibians, reptiles, birds, and mammals). Other categories such as ecological system (aquatic, wetland, riparian, and terrestrial) or size (e.g., small and large mammals) are used when the category is relevant to impact magnitude.

[c] Actual ability to mitigate impacts will depend on site-specific conditions and the species present in the project area. Recommended mitigation measures are presented in Section 5.10.5.

[d] Impacting factors are presented in alphabetical order.

belowground structures. During decommissioning, fugitive dust and other particulates may be spread to adjacent areas and adversely affect special status plant species. Increased human presence, traffic, and noise associated with decommissioning activities may also affect special status animal species through human collection, altered behavioral patterns, or mortality (e.g., vehicle collisions).

Decommissioning activities would also include reclamation efforts. During this phase, the site would be regraded if needed and revegetated with native species in attempts to restore the site to pre-disturbance conditions. Other reclamation activities may include re-establishing natural drainage and hydrological processes and limiting human access to the site. Although reclamation efforts may increase habitat availability and quality from project operation conditions, it may take many years for the project site to be fully restored to pre-disturbance conditions.

5.10.4.1.5 Transmission Lines and Roads. The impacts on special status species from the construction of transmission lines and ROW maintenance, and from upgrades to existing lines, associated with utility-scale solar energy projects would be similar to those from other activities presented in Table 5.10-4. Potential construction impacts of transmission corridor development on sensitive species would result primarily from ground disturbance, vegetation removal, and excavation during clearing of the ROWs and from installation of access roads and structures (e.g., transmission line towers, substations, or pipelines). Activities include the clearing of land for the establishment of transmission line ROWs, construction of transmission facilities and related infrastructure, and ROW maintenance. Impacts on special status species resulting from transmission line construction, operation, and maintenance could include the following:

- Habitat destruction or degradation resulting from clearing ROWs, construction of energy transmission facilities and related infrastructure, altered topography, altered hydrologic patterns, soil removal and/or erosion, sedimentation, fugitive dust, contaminant spills, and the spread of invasive species.

- Habitat and population fragmentation resulting from the establishment of transmission line ROWs through intact patches of habitat, thereby preventing the movement of organisms throughout the population area. Note that this impact is most likely only in those habitats that would require vegetation clearing and management (e.g., forest). In most parts of the arid west, little if any clearing may be necessary and habitat fragmentation would not be a concern.

- Disturbance and harassment of animals from noise and human activities during transmission line construction and ROW maintenance operations. Disturbances that occur during the breeding season would have the greatest adverse impacts and could result in animals abandoning traditional breeding grounds and nest sites.

- Increased predation of special status species resulting from the increase in localized predator populations. Such predators (e.g., raccoons, skunks) are attracted to habitat edges established by transmission line corridors.

- Special status aquatic species may be affected by increases in water temperature in areas crossed by transmission facilities resulting from the removal of riparian vegetation that would otherwise shade surface water.

- Special status plant species may be affected by the spread of invasive exotic species in or near areas that have been disturbed by activities associated with transmission line construction and/or maintenance. Invasive plant species generally possess characteristics that allow them to thrive in disturbed habitats, thereby displacing native plant species and limiting their ability to compete for sunlight and soil nutrients.

5.10.4.2 Technology-Specific Impacts

This section discusses the potential impacts on special status species associated with specific technologies for utility-scale solar energy development. These impacts are fundamentally similar to those described for impacts on plant communities and habitats, wildlife, and aquatic resources (Sections 5.10.1.1, 5.10.1.2, and 5.10.1.3), which are based on the activities anticipated to occur at sites utilizing currently established technologies. As described in previous sections, the estimated land area and water demands vary among facilities using specific technologies.

The magnitude of the impacts of facilities utilizing each solar power technology on special status species would largely depend on the size (i.e., extent) and location of the project. The land area of each facility (regardless of technology type) would be graded, cleared of all surface vegetation, and fenced during project construction. Maximum estimated land area requirements are greatest for facilities utilizing dish engine and PV technologies (6,750 acres [27 km^2] each). Facilities utilizing parabolic trough and power tower technologies would require an estimated maximum land area of 2,000 acres (8 km^2) and 3,600 acres (15 km^2), respectively. For any technology type, the altered land area would be maintained throughout the life of the facility, representing a direct loss of habitat and productivity on the site and creating a barrier to movements of some wildlife species. Natural runoff patterns would also be affected by such developments, which could influence downgradient plant communities and habitats through erosion and sedimentation. Plants in adjacent habitats could also be affected by the deposition of fugitive dust or other particulates. Spills of hazardous materials (e.g., fuel, synthetic oils) could affect plants and animals on and near the project site. Special status animal species (e.g., amphibians, reptiles, and small mammals) may be affected by being killed during development or by alteration of their behavior (e.g., they would avoid the disturbed area), thereby reducing the amount of available suitable habitat or the carrying capacity of habitats in the area. Increased noise levels associated with operations (e.g., noise associated with dish engines) may also affect wildlife behavior by deterring movements and further reducing the area's carrying capacity.

Water use by utility-scale solar power facilities has the potential to affect plant and wildlife species depending on facility location and the technology used. Parabolic trough and power tower technologies require cooling systems; therefore, facilities utilizing these technologies would require greater amounts of water (maximum 6,400 ac-ft/yr [7.8 million m^3/yr]). Dish engine and PV technologies do not require cooling systems. As such, facilities utilizing these technologies would require less water, and this water would be needed only for cleaning, dust control, and potable water needs (maximum 375 ac-ft/yr [0.5 million m^3/yr]). Withdrawals from groundwater or surface water sources may alter hydrological regimes and affect local plant and animal species. Habitat may be lost or degraded for aquatic and semi-aquatic species. Hydrological dynamics within wetland and riparian areas may also be affected, thereby potentially affecting the aquatic and terrestrial plant and animal species that utilize these resources.

Project-specific operation methods may also affect plant and wildlife species. The method to create, convert, and store energy is unique to each technology. Parabolic trough facilities and power tower facilities use HTFs to store and transfer energy (e.g., synthetic oils, molten salt). Dish engine facilities utilize solar insolation to expand gas and generate mechanical energy, which is later converted to electricity. PV facilities utilize solar cells (and associated semiconductors) to convert solar energy to electricity. Accidental release of HTFs (parabolic trough and power tower technologies) may result in leaching of materials into groundwater or runoff into nearby habitats where plants and aquatic resources may be affected. Wildlife that drink or consume contaminated water or plants may also be affected depending on the concentrations and toxicity of released materials. Noise levels associated with dish engines may also affect local wildlife by deterring their movements and reducing the area's overall carrying capacity. PV projects would not have impacts associated with spills or noise.

5.10.5 Potentially Applicable Mitigation Measures

Many mitigation measures are similar for the different types of ecological resources (plant communities and habitats, wildlife, aquatic resources, and special status species). Many of the mitigation measures are applicable for ecological resources in general. The more general measures are presented first for each phase and then by more specific measures for specific resource types.

5.10.5.1 Siting and Design

- To the extent practicable, projects should be sited on previously disturbed lands close to energy load centers to avoid and minimize impacts on remote, undisturbed lands.

- Existing access roads, utility corridors, and other infrastructure should be used to the maximum extent feasible.

- As practical, staging and parking areas should be located within the site of the utility-scale solar energy facility to minimize habitat disturbance in areas adjacent to the site.

- Appropriate agencies (e.g., the BLM, the USFWS, and state resource management agencies) should be contacted early in the planning process to identify potentially sensitive ecological resources, including but not limited to aquatic habitats, wetland habitats, unique biological communities, crucial wildlife habitats, and special status species locations and habitats, as well as designated critical habitat, that might be present in the area proposed for a solar energy facility and associated access roads and ROWs. This coordination should be used to identify the need for and scope of pre-disturbance surveys of the project area and vicinity.

- All pre-disturbance surveys should be conducted by qualified biologists following accepted protocols established by the USACE, BLM, USFWS, or other federal or state regulatory agencies, as determined appropriate by the managing agency, to identify and delineate the boundaries of important, sensitive, or unique habitats in the project vicinity including waters of the United States, wetlands, springs, seeps, ephemeral streams, intermittent streams, 100-year floodplains, ponds and other aquatic habitats, riparian habitat, remnant vegetation associations, rare or unique natural communities, and habitats supporting special status species populations.

- Projects shall be sited and designed to avoid direct and indirect impacts on important, sensitive, or unique habitats in the project vicinity, including, but not limited to, waters of the United States, wetlands (both jurisdictional and nonjurisdictional), springs, seeps, streams (ephemeral, intermittent, and perennial), 100-year floodplains, ponds and other aquatic habitats, riparian habitat, remnant vegetation associations, rare or unique biological communities, crucial wildlife habitats, and habitats supporting special status species populations (including designated and proposed critical habitat). For cases in which impacts cannot be avoided, they shall be minimized and mitigated appropriately. Project planning shall be coordinated with the appropriate federal and state resource management agencies.

- Projects should not be sited in designated critical habitat, ACECs, or other specially designated areas that are considered necessary for special status species and habitat conservation.

- Projects should be designed to avoid, minimize, and mitigate impacts on wetlands, waters of the United States, and other special aquatic sites.

- Project facilities and activities, including associated roads and utility corridors, should not be located in or near occupied habitats of special status animal species. Buffer zones should be established, (e.g., identified in the

land use plan or substantiated by best available information or science), around these areas to prevent any destructive impacts associated with project activities.

- Buffer zones should be established around sensitive habitats, and project facilities and activities should be excluded or modified within those areas (e.g., identified in the land use plan or substantiated by best available information or science).

- Habitat loss, habitat fragmentation, and resulting edge habitat due to project development should be minimized to the extent practicable. Habitat fragmentation could be reduced by consolidating facilities (e.g., access roads and utilities could share common ROWs, where feasible), reducing the number of access roads to the minimum amount required, minimizing the number of stream crossings within a particular stream or watershed, and, locating facilities in areas where habitat disturbance has already occurred. Individual project facilities should be located and designed to minimize disruption of animal movement patterns and connectivity of habitats.

- Locating solar power facilities near open water or other areas known to attract a large number of birds should be avoided.

- Plant species that would attract wildlife should not be planted along high-speed or high-traffic roads.

- Tall structures should be located to avoid known flight paths of birds and bats.

- Transmission line conductors should span important or sensitive habitats within limits of standard structure design.

- If cattle guards are identified for the design for new roads, they should be wildlife friendly. To the extent practicable, improvements should be made to existing ways and trails that require cattle to pass through existing fences, fence-line gates, new gates, and standard wire gates alongside them.

- Fences should be built (as practicable) to exclude livestock and wildlife from all project facilities, including all water sites.

- Project developers should identify surface water runoff patterns at the project site and develop mitigation that prevents soil deposition and erosion throughout and downhill from the site.

- Developers should avoid the placement of facilities or roads in drainages and make necessary accommodations for the disruption of runoff.

- Any necessary stream crossings should be designed to provide instream conditions that allow for and maintain uninterrupted movement and safe passage of fish during all project periods. Section 5.9.3 presents mitigation recommendations to minimize impacts on water quality associated with stream crossings.

- Projects should avoid surface water or groundwater withdrawals that affect sensitive habitats (e.g., aquatic, wetland, and riparian habitats) and any habitats occupied by special status species. Applicants should demonstrate, through hydrologic modeling, that the withdrawals required for their project are not going to affect groundwater discharges that support special status species or their habitats.

- The capability of local surface water or groundwater supplies to provide adequate water for the operation of proposed solar facilities should be considered early in the project siting and design. Technologies that would result in large withdrawals that would affect water bodies that support special status species should not be considered.

- New roads should be designed and constructed to meet the appropriate BLM road design standards, such as those described in *BLM Manual 9113* (BLM 1985), and be no larger than necessary to accommodate their intended functions (e.g., traffic volume and weight of vehicles). Roads internal to solar facility sites should be designed to minimize ground disturbance.

- Pipelines that transport hazardous liquids (e.g., oils) that will pass through aquatic or other habitats containing sensitive species should be designed with block or check valves on both sides of the waterway or habitat to minimize the amount of product that could be released as a result of leaks. Such pipelines should be constructed of double-walled pipe at river crossings.

5.10.5.2 General Multiphase Measures

General mitigation measures for eliminating or reducing impacts on plant communities and habitats, wildlife resources, aquatic resources, and special status species that apply to all or nearly all of the project phases include the following:

- Project developers should designate a qualified biologist who will be responsible for overseeing compliance with all mitigation measures related to the protection of ecological resources throughout all project phases, particularly in areas requiring avoidance or containing sensitive biological resources, such as special status species and important habitats. Additional qualified biological monitors may be required on-site during all project phases as determined by the authorizing federal agency, the USFWS, and appropriate state agencies.

- All personnel should be instructed on the identification and protection of ecological resources (especially for special status species), including knowledge of mitigation measures required by federal, state, and local agencies. Workers must be aware that only qualified biologists are permitted to handle listed species according to specialized protocols approved by the USFWS. Workers should not approach wildlife for photographs or feed wildlife.

- The collection, harassment, or disturbance of plants, wildlife, and their habitats (particularly special status species) should be reduced through employee and contractor education about applicable state and federal laws. In addition, the following measures should be implemented: (1) all personnel should be instructed to avoid harassment and disturbance of local plants and wildlife; (2) personnel should be made aware of the potential for wildlife interactions around facility structures; (3) food refuse and other garbage should be placed in closed containers so it is not available to scavengers; and (4) workers should be prohibited from bringing firearms and pets to project sites.

- Projects should maintain native vegetation cover and soils to the extent possible and minimize grading to reduce flooding, maintain natural infiltration rates, maintain wildlife habitat, maintain soil health, and reduce erosion potential. All short (i.e., less than 7-in. [18-cm] tall) native vegetation should be retained to the maximum extent possible. Blading within the project site should be minimized to the maximum extent possible. Where necessary and feasible, shrub cover may be mowed and/or raked to smooth out the surface. Retention of native root structure and seeds within the project area would help retain soil stability, minimize soil erosion, and minimize fugitive dust pollution. Retention of native seed and roots within the project site will also facilitate recovery of vegetative cover. Use of native plant species will minimize the need to water the vegetation because native species are already adapted to the local climate and moisture regime of the area.

- Plants, wildlife, and their habitats should be protected from fugitive dust. See Section 5.11.3 for recommended dust abatement practices.

- Activities should be timed to avoid, minimize, or mitigate impacts on wildlife. For example, crucial winter ranges for elk, deer, pronghorn, and other species should be avoided especially during their periods of use. If activities are planned during bird breeding seasons, a nesting bird survey should be conducted first. If active nests are detected, the nest area should be flagged, and no activity should take place near the nest (at a distance determined in coordination with the USFWS) until nesting is completed (i.e., nestlings have fledged or the nest has failed) or until appropriate agencies agree that construction can proceed with the incorporation of agreed-upon monitoring

measures. The timing of activities should be coordinated with the authorizing federal agency, USFWS, and appropriate state agencies.

- Noise reduction devices (e.g., mufflers) should be employed to minimize the impacts on wildlife and special status species populations. Explosives should be used only within specified times and at specified distances from sensitive wildlife or surface waters as established by the managing agency or other federal and state agencies. Operators should ensure that all equipment is adequately muffled and maintained in order to minimize disturbance to wildlife.

- Mitigation measures for hazardous materials and waste management regarding refueling, equipment maintenance, and spill prevention and response should be applied to reduce the potential for impacts on ecological resources.

- Low-water crossings (fords) should be used only as a last resort and then during the driest time of the year. Rocked approaches to fords should be used. The pre-existing stream channel, including bed and banks, should be restored after the need for a low-water ford has passed.

- The number of areas where wildlife could hide or be trapped (e.g., open sheds, pits, uncovered basins, and laydown areas) should be minimized. For example, an uncovered pipe that has been placed in a trench should be capped at the end of each workday to prevent animals from entering the pipe. If a special status species is discovered inside a component, that component must not be moved or, if necessary, moved only to remove the animal from the path of activity, until the animal has escaped.

- During all project phases, buffer zones should be established around sensitive habitats, and project facilities and activities should be excluded or modified within those areas, to the extent practicable.

- Project activities should not be located in or near occupied habitats of special status animal species. Buffer zones should be established around these areas (e.g., identified in the land use plan or substantiated by best available information or science), to prevent any destructive impacts associated with project activities.

- If any federally listed threatened and endangered species are found during any phase of the project, the USFWS should be consulted as required by Section 7 of the ESA, and an appropriate course of action should be determined to avoid or mitigate impacts.

- Access roads should be appropriately constructed, improved, maintained, and provided with signs to minimize potential wildlife/vehicle collisions and facilitate wildlife movement through the project area.

- Project vehicle speeds should be limited in areas occupied by special status animal species. Appropriate speed limits should be determined through coordination with federal and state resource management agencies. Traffic should stop to allow wildlife to cross roads. Shuttle vans or car pooling should be used where feasible to reduce the amount of traffic on access roads.

- Unless authorized, personnel should not attempt to move live, injured, or dead wildlife off roads, ROWs, or the project site. Honking horns, revving engines, yelling, and excessive speed are inappropriate and considered a form of harassment. If traffic is being unreasonably delayed by wildlife in roads, personnel should contact the project biologist and security, who will take any necessary action.

- Road closures or other travel modifications (e.g., lower speed limits, no foot travel) should be considered during crucial periods (e.g., extreme winter conditions, calving/fawning seasons). Personnel should be advised to minimize stopping and exiting their vehicles in the winter ranges of large game while there is snow on the ground.

- Any vehicle-wildlife collisions should be immediately reported to security. Observations of potential wildlife problems, including wildlife mortality, should be immediately reported to the BLM or other appropriate agency authorized officer. Procedures for removal of wildlife carcasses on-site and along access roads should be addressed in the Nuisance Animal and Pest Control Plan, to avoid vehicle-related mortality of carrion-eaters.

- A Nuisance Animal and Pest Control Plan should be developed that identifies management practices to minimize increases in nuisance animals and pests in the project area, particularly those individuals and species that would affect human health and safety or that would have the potential to adversely affect native plants and animals. The plan would identify nuisance and pest species that are likely to occur in the area, risks associated with these species, species-specific control measures, and monitoring requirements.

- An Integrated Vegetation Management Plan should be developed that is consistent with applicable regulations and agency policies for the control of noxious weeds and invasive plant species. The plan should address monitoring; ROW vegetation management; the use of certified weed-free seed and mulching; the cleaning of vehicles to avoid introducing invasive weeds; and the education of personnel on weed identification, the manner in which weeds spread, and the methods for treating infestations. For transmission line ROWs, the plan should be consistent with the existing vegetation management plan for that ROW. Principles of integrated pest management, including biological controls, should be used to prevent the spread of invasive species, per the *Vegetation Treatments Using Herbicides on BLM Lands in 17 Western States*, and the *National Invasive Species Management Plan, 2009.* The plan

should cover periodic monitoring, reporting, and immediate eradication of noxious weed or invasive species occurring within all managed areas. A controlled inspection and cleaning area should be established to visually inspect construction equipment arriving at the project area and to remove and collect seeds that may be adhering to tires and other equipment surfaces. To prevent the spread of invasive species, project developers should work with the local BLM field office to determine whether a pre-activity survey is warranted and, if so, to conduct the survey. If invasive plant species are present, project developers should work with the local BLM field office to develop a control strategy. The plan should include a postconstruction monitoring element that incorporates adaptive management protocols.

- Where revegetation and restoration are used as tools to mitigate or rehabilitate project impacts following construction and/or decommissioning, the project developer should assist in ongoing BLM efforts to procure and develop locally and regionally appropriate native plant materials. Where conditions permit, the developer could collect and voucher seeds from native plant species identified on BLM target lists for regional native plant material development following the BLM Seeds of Success Protocol as described in BLM's *Integrated Vegetation Management Handbook* (BLM 2008e). On the basis of the expected need for native plant materials, the project developer could contribute funding to support the BLM Native Plant Materials Development Program. The suggested funding rate is $100.00 USD per acre for each acre on which restoration or revegetation will be used to mitigate project impacts and for each acre expected to be rehabilitated following site decommissioning.

- To reduce the risk of non-native and nuisance aquatic species introductions, equipment used in surface water should be decontaminated as appropriate especially equipment used to convey water (i.e., pumps).

- Herbicide use should be limited to nonpersistent, immobile substances. Only herbicides with low toxicity to wildlife and nontarget native plant species should be used, as determined in consultation with the USFWS. The typical herbicide application rate rather than the maximum application rate should be used where effective. All herbicides should be applied in a manner consistent with their label requirements and in accordance with guidance provided in the Final PEIS on vegetation treatments using herbicides (BLM 2007). No herbicides should be used near or in surface water, streams (including ephemeral, intermittent, or perennial), riparian areas, or wetlands. Setback distances should be determined through coordination with federal and state resource management agencies. Before herbicide treatments are begun, a qualified biologist should conduct bird nest surveys and special status species surveys to identify the special measures or BMPs necessary to avoid and minimize impacts on migratory birds and special status species.

- An Ecological Resources Mitigation and Monitoring Plan should be developed to avoid (if possible), minimize, or mitigate adverse impacts on important ecological resources. The plan should include but not necessarily be limited to the following element, where applicable:

  - Revegetation, soil stabilization, and erosion reduction measures that should be implemented to ensure that all temporary use areas are restored. The plan should require that restoration occur as soon as possible after activities are completed in order to reduce the amount of habitat converted at any one time and to speed up the recovery to natural habitats.

  - Mitigation and monitoring unavoidable impacts on waters of the United States, including wetlands.

  - Compensatory mitigation and monitoring to address any significant direct, indirect, and cumulative impacts on and loss of habitat for special status plant and animal species.

  - Demonstration of compliance of the project with the regulatory requirements of the Bald and Golden Eagle Protection Act. The plan should be developed in coordination with the USFWS.

  - Measures to protect birds (including migratory species protected under the Migratory Bird Treaty Act) developed in coordination with the appropriate federal and state agencies (e.g., BLM, USFWS, and state resource management agencies).

  - Measures to protect raptors developed in coordination with the appropriate federal and state agencies (e.g., BLM, USFWS, and state resource management agencies).

  - Measures to protect bats developed in coordination with the appropriate federal and state agencies (e.g., BLM, USFWS, and state resource management agencies).

  - Measures to mitigate and monitor impacts on special status species developed in coordination with the appropriate federal and state agencies (e.g., BLM, USFWS, and state resource management agencies).

  - Monitoring the potential for increase in predation of special status species (e.g., desert tortoise, Utah prairie dog, and greater sage-grouse) from ravens and other species that are attracted to developed areas and opportunistically use tall structures to spot vulnerable prey. Raven and other predator monitoring should also be addressed in the Nuisance Animal and Pest Control Plan.

- Clearing and translocation of special status species, including the steps to implement the translocation as well as the follow-up monitoring of populations in the receptor locations, as determined in coordination with the appropriate federal and state agencies. The need for a Special Status Species Clearance and Translocation Plan should be determined on a project-specific basis.

- At the project level, recommendations contained in the *Interim Golden Eagle Technical Guidance: Inventory and Monitoring Protocol; and Other Recommendations in Support of Golden Eagle Management and Permit Issuance* (Pagel et al. 2010) should be considered in project planning, as appropriate. In addition, Instruction Memorandum No. 2010-156, *Bald and Golden Eagle Protection Act—Golden Eagle National Environmental Policy Act and Avian Protection Plan Guidance for Renewable Energy* (BLM 2010b) should be adhered to until programmatic permits from the USFWS are available. The analysis of potential impacts on and mitigation for golden eagles should be made in coordination with the USFWS, and the initiation of interagency coordination on golden eagle issues should occur early in the planning process.

- Take[3] of golden eagles and other raptors should be avoided. Mitigation regarding the golden eagle should be developed in consultation with the USFWS and appropriate state natural resource agencies. A permit may be required under the Bald and Golden Eagle Protection Act.

- A Water Resources Monitoring and Mitigation Plan should be developed for each project. Changes in surface water or groundwater quality (e.g., chemical contamination, increased salinity, increased temperature, decreased dissolved oxygen, and increased sediment loads) or flow that result in the alteration of terrestrial plant communities or communities in wetlands, springs, seeps, intermittent streams, perennial streams, and riparian areas (including the alterations of cover and community structure, species composition, and diversity) off the project site should be avoided to the extent practicable. A monitoring plan should be developed that determines the effects of groundwater withdrawals on plant communities. See Section 5.9.3 for measures applicable to protecting water quality.

[3] Under the Bald and Golden Eagle Protection Act, "take" means to pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, destroy, molest, or disturb. "Disturb" means to agitate or bother a bald eagle or a golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, (1) injury to an eagle; (2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior; or (3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior.

- Ecological monitoring programs should provide for monitoring during all project phases, including periods prior to construction (to establish baseline conditions) and during construction, operations, and decommissioning.

- The monitoring program requirements, including adaptive strategies, should be established at the project level to ensure that potential adverse impacts are mitigated. Monitoring programs should consider the monitoring requirements for each ecological resource present at the project site, establish metrics against which monitoring observations can be measured, identify potential mitigation measures, and establish protocols for incorporating monitoring observations and additional mitigation measures into standard operating procedures and mitigation measures.

- A Spill Prevention and Emergency Response Plan should be developed that considers sensitive ecological resources. Spills of any toxic substances should be promptly addressed and cleaned up before they can enter aquatic or other sensitive habitats as a result of runoff or leaching. Section 5.9.3 also discusses the need for a Spill Prevention and Emergency Response Plan.

- A Fire Management and Protection Plan should be developed to implement measures that minimize the potential for a human-caused fire to affect ecological resources and that respond to natural fire situations.

- A Trash Abatement Plan should be developed that focuses on containing trash and food in closed and secured containers and removing them periodically to reduce their attractiveness to opportunistic species, such as common ravens, coyotes, and feral dogs that could serve as predators on native wildlife and special status animals.

- Prior to any ground-disturbing activity, seasonally appropriate walkthroughs should be conducted by a qualified biologist or team of biologists to ensure that important or sensitive species or habitats are not present in or near project areas. Attendees at the walkthrough should include appropriate federal agency representatives, state natural resource agencies, and construction contractors, as appropriate. Habitats or locations to be avoided (with appropriately sized buffers) should be clearly marked.

- If it is determined through coordination with the appropriate federal and state agencies (e.g., BLM, USFWS, and state resource management agencies) that it is necessary to translocate plant and wildlife species from project areas, developers should ensure that qualified biologists conduct pre- and post-translocation surveys for target species (especially if the target species are special status species) and release individuals to protected off-site locations as approved by the federal and state agencies. The biologists should coordinate with appropriate agencies the safe handling and transport of any special status species encountered.

- In accordance with adaptive management strategies, new BLM Instruction Memorandums (IMs) addressing wildlife and plants issues should be incorporated as appropriate.

5.10.5.3 Site Characterization

Site characterization activities would generally result in only minimal impacts on ecological resources. The amount and extent of necessary pre-project survey data would be determined, in part, on the basis of the environmental setting of the proposed project location. Potentially applicable mitigation measures include the following:

- Vehicles and site workers should avoid entering aquatic habitats such as streams and springs during site characterization activities until surveys by qualified biologists have evaluated the potential for unique flora and fauna to be present.

- Meteorological towers and solar sensors should be located to avoid sensitive habitats or areas where wildlife (e.g., sage-grouse) are known to be sensitive to human activities; applicable land use plans or best available information and science shall be referred to in order to determine avoidance distances. Installation of these components should be scheduled to avoid disrupting wildlife reproductive activities or migratory or other important behaviors. Guy wires on meteorological towers should be avoided whenever possible. If guy wires are necessary, permanent markers (bird flight diverters) should be attached to them to increase their visibility.

- Meteorological towers, soil borings, wells, and travel routes should be located to avoid important, sensitive, or unique habitats including but not limited to wetlands, springs, seeps, ephemeral streams, intermittent streams, 100-year floodplains, ponds and other aquatic habitats, riparian habitat, remnant vegetation associations, rare natural communities, and habitats supporting special status species populations, as identified in applicable land use plans or best available information and science.

5.10.5.4 Construction

Implementation of mitigation measures during the construction phase may eliminate or reduce the potential for direct or indirect impacts on ecological resources. Potentially applicable mitigation measures for ecological resources during the construction phase of a solar energy project include the following:

- Prior to construction of the facility, environmental training should be provided to contractor personnel whose activities or responsibilities could affect the environment during construction. An environmental compliance officer and

other inspectors, the contractor's construction field supervisor(s), and all construction personnel should be expected to play an important role in maintaining strict compliance with all permit conditions in order to protect wildlife and their habitats to the extent practicable during construction.

- Prior to construction, all areas to be disturbed should be surveyed by qualified biologists using approved survey techniques or established species-specific survey protocols to determine the presence of special status species in the project area.

- If possible, on-site construction access routes should be rolled and compacted to allow trucks and equipment to access construction locations. Following construction, disturbed areas should be lightly raked and/or ripped and reseeded with seeds from low-stature plant species collected from the immediate vicinity.

- To the extent practicable, vegetation clearing, grading, and other construction activities should occur outside of the bird breeding season. If activities are planned for the breeding season, a survey of nesting birds should be conducted first. If active nests are not detected, construction activities may be conducted. If active nests are detected, the nest area should be flagged, and no activity should take place near the nest (at a distance coordinated with the USFWS) until nesting is completed (i.e., nestlings have fledged or the nest has failed) or until appropriate agencies agree that construction can proceed with the incorporation of agreed-upon monitoring measures. If active nests are not detected, appropriate agencies should be consulted to confirm that construction may proceed.

- Explosives should be used only within specified times and at specified distances from sensitive wildlife or surface waters, as established by the managing agency, or other federal and state agencies. The occurrence of flyrock from blasting should be limited by using blasting mats.

- The extent of habitat disturbance during construction should be reduced by keeping vehicles on access roads and minimizing foot and vehicle traffic through undisturbed areas.

- Temporary or project-created access roads should be closed to unauthorized vehicle use, where appropriate.

- Where a pipeline trench may drain a wetland, trench breakers should be constructed and/or the trench bottom should be sealed to maintain the original wetland hydrology.

- Because open trenches could impede the seasonal movements of large game animals and alter their distribution, they should be backfilled as quickly as is

possible. Open trenches could also entrap smaller animals; therefore, escape ramps should be installed at regular intervals along open-trench segments at distances identified in the applicable land use plan or best available information and science.

- An appropriate number of qualified biological monitors (as determined by the federal authorizing agency and the USFWS) should be on-site during initial site preparation and during the construction period to monitor, capture, and relocate animals that could be harmed and are unable to leave the site on their own.

- When possible, any reptile or amphibian species found in harm's way should be relocated away from the activity.

- Construction debris, especially treated wood, should not be stored or disposed of in areas where it could come in contact with aquatic habitats.

- As directed by the local BLM field office, Joshua trees (*Yucca brevifolia*), other *Yucca* species, and most cactus species, shall be salvaged prior to land clearing, and they shall be transplanted, held for use to revegetate temporarily disturbed areas, or otherwise protected as prescribed by state or local BLM requirements.

- Project-specific Integrated Vegetation Management Plans shall investigate the possibility of revegetating parts of the solar array area. Where revegetation is accomplished, fire breaks are required, such that the vegetated areas would not result in increased fire hazard.

- Re-establishment of vegetation within temporarily disturbed areas shall be done immediately following the completion of construction activities, provided such revegetation will not compromise the function of the buried utilities. Species salvaged during construction could be transplanted into these areas at a density similar to preconstruction conditions. Revegetation shall focus on the establishment of native plant communities similar to those present in the vicinity of the project site. Species used shall consist of native species dominant within the plant communities that exist in adjacent areas and have similar soil conditions. Certified weed-free seed mixes of native shrubs, grasses, and forbs of local origin shall be used. In areas where suitable native species are unavailable, other plant species approved by the BLM could be used.

5.10.5.5 Operations

Mitigation measures that limit periodic or continued impacts from operations of a solar energy facility include the following:

- Areas left in a natural condition during construction (e.g., wildlife crossings) should be maintained in as natural a condition as possible within safety and operational constraints.

- To minimize habitat loss and fragmentation, as much habitat as possible should be re-established after construction is complete by maximizing the area reclaimed during solar energy operations.

- Lighting should be designed to provide the minimum illumination needed to achieve safety and security objectives. It should be shielded and orientated to focus illumination on the desired areas and to minimize or eliminate lighting of off-site areas or the sky. All unnecessary lighting should be turned off at night to limit attracting migratory birds or special status species.

- To minimize the potential for bird strikes, applicants should use audio visual warning system (AVWS) technology for any structures exceeding 200 ft (60 m) in height. If the FAA denies a permit for use of AVWSs, applicants should coordinate with the USFWS and appropriate state natural resource agencies to identify lighting that meets the minimum FAA safety requirements, and minimizes the possibility of bird strikes.

- Evaporation ponds should be fenced and netted, where feasible, to prevent use by wildlife. Open water sources in the desert provide subsidies to ravens and other predators that feed on special status species (e.g., desert tortoise). In addition, these water sources may have elevated levels of harmful contaminants (e.g., TDS and selenium) and could attract wildlife into an industrialized area where they are more likely to be killed. The lower 18 in. (46 cm) of the fencing should be a solid barrier that would exclude entrance by amphibians and other small animals.

- In order to prevent the effects of the West Nile virus on wildlife, a mosquito abatement program should be implemented for all evaporation ponds or other standing bodies of water that have the potential to support mosquito reproduction.

- Appropriate fish screens should be installed on cooling water intakes to limit the potential for impingement impacts on organisms in surface water sources used for cooling water. Intake designs should minimize the potential for aquatic organisms from surface waters to be entrained in cooling water systems.

- Pesticide/herbicide use should be conducted in accordance with an Animal, Pest, and Vegetation Control Plan (see Section 5.9.3.2).

5.10.5.6 Decommissioning/Reclamation

Mitigation measures to protect ecological resources during and following decommissioning and reclamation include the following:

- A Decommissioning and Site Reclamation Plan that is specific to the project should be developed, approved by the BLM, and implemented and should include the following elements:

  – The plan should contain an adaptive management component that allows for the incorporation of lessons learned from monitoring data.

  – The plan should require that land surfaces be returned to pre-development contours to the greatest extent feasible immediately following decommissioning.

  – The plan should be designed to expedite the re-establishment of vegetation and require restoration to be completed as soon as practicable.

  – To ensure rapid and successful re-establishment efforts, the plan should specify site-specific measurable success criteria, including target dates, which should be developed in coordination with the BLM and be required to be met by the operator.

  – Vegetation re-establishment efforts should continue until all success criteria have been met.

  – Bonding to cover the full cost of vegetation re-establishment should be required.

  – Species used for re-establishing vegetation should consist of native species that are dominant within the plant communities in adjacent areas that have similar soil conditions.

  – The plan should require the use of weed-free seed mixes of native shrubs, grasses, and forbs of local sources where available. When available, seeds of known origin, as labeled by state seed certification programs, should be used. Local native genotypes should be used. If cultivars of native species are used, certified seed (i.e., blue tag) should be used. “Source identified” seeds (i.e., yellow tag) should be used when native seeds are collected from wildland sites.

  – The cover, species composition, and diversity of the re-established plant community should be similar to those present on-site prior to project development and in the vicinity of the site. Baseline data should be collected in each project area prior to its development as a benchmark for

measuring the success of reclamation efforts. In areas where suitable native species are unavailable, other plant species approved by the BLM could be used. If non-native plants are necessary, they should be noninvasive, noncompetitive, and ideally, be short-lived, have low reproductive capabilities, or be self-pollinating to prevent gene flow into the native community. The non-native plants that are used should not exchange genetic material with common native plant species.

  – The plan should be developed in coordination with appropriate federal and state agencies.

- Access roads should be reclaimed when they are no longer needed. However, seasonal restrictions (e.g., nest and brood rearing) should be considered, as appropriate (e.g., identified in the land use plan or substantiated by best available information or science).

- All holes and ruts created by the removal of structures and access roads should be filled or graded.

- While structures are being dismantled, care should be taken to avoid leaving debris on the ground in areas where wildlife regularly move.

- Post-decommissioning protocols should include monitoring for the recovery of native vegetation, colonization and spread of invasive species; use by wildlife; and use by special status species. Monitoring data should be used to determine the success of reclamation activities and the need for changes in ongoing management or for additional reclamation measures. Ongoing visual inspections for a minimum of 5 years following decommissioning activities should be required to ensure that there is adequate restoration and minimal environmental degradation. This period should be extended until satisfactory results are obtained.

- The facility fence should remain in place for several years to help reclamation (e.g., the fence would preclude large mammals and vehicles from disturbing revegetation efforts). Shorter times for maintaining fencing may be appropriate in cases where the likelihood of disturbance by cattle and wildlife is low. In some cases, it may be appropriate to replace the original exclusion fence with a new fence that excludes cattle and vehicles but allows for use by pronghorn and large-game wildlife. This secondary fencing shall remain in place until the revegetation efforts meet success criteria.

5.10.5.7 Transmission Lines and Roads

Many of the mitigation measures presented above could also reduce, minimize, or avoid impacts on ecological resources from the construction and operation of transmission lines. In

addition, the following mitigation measures are specifically applicable to protecting ecological resources from transmission lines construction, operation, and maintenance:

- The placement of transmission towers within aquatic and wetland habitats should be avoided whenever feasible. If towers must be placed within these habitats, they should not impede flows or fish passage.

- If transmission lines are located near aquatic habitats or riparian areas (e.g., minimum buffers identified in the applicable land use plan or best available science and information), vegetation maintenance should be limited and performed mechanically rather than with herbicides. Cutting in wetlands or stream and wetland buffers should be done by hand or by feller-bunchers. Tree cutting in stream buffers should target only trees able to grow into a transmission line conductor clearance zone within 3 to 4 years. Cutting in such areas for construction or vegetation management should be minimized, and the disturbance of soil and remaining vegetation should be minimized.

- Habitat disturbance should be minimized by considering the use of helicopters for construction, to lessen the need for access roads, and by locating transmission facilities in previously disturbed areas. Existing utility corridors and other support structures should be used to the maximum extent feasible.

- The establishment and spread of invasive species and noxious weeds within the ROW and in associated areas where there is ground surface disturbance or vegetation cutting should be prevented. The area should be monitored regularly, and invasive species should be eradicated immediately.

- If needed, temporary access roads should be developed primarily by the removal of woody vegetation, although temporary timber mats should be used in areas of wet soils. Wide-tracked or balloon-tired equipment, timber corduroy, or timber mat work areas should be used on wet soils where wetland or stream crossings are unavoidable and where crossing on frozen ground is not possible in winter. Areas rutted by equipment should be immediately regraded and revegetated. Towers should be installed by airlift helicopters, where necessary, to avoid extensive crossing of wetlands or highly sensitive areas (such as those identified as rare natural habitats).

- ROW development and construction activities should adhere to locally established wildlife and/or habitat protection provisions. Exceptions or modifications to spatial buffers or timing limitations should be evaluated on a site-specific/species-specific basis in coordination with the local federal administrator and state wildlife agency.

- Restrictions on timing or duration may be required to minimize impacts on nesting birds (especially neotropical migrants and listed species), and should be developed in coordination with the USFWS.

- To the extent practicable, work personnel should stay within the ROW and/or easements.

- Removal of raptor nests should take place only if the birds are not actively using the nest, particularly during the nesting and brood-rearing period. Nests should be relocated to nesting platforms, when possible; otherwise, they must be destroyed when removed. An annual report on all nests moved or destroyed should be provided to the appropriate federal and/or state agencies. Coordination with the USFWS should occur in the event that a raptor nest is located on a transmission line support structure. Removal or relocation of a golden eagle or bald eagle nest (even an inactive nest) requires a permit from the USFWS.

- Raven nests should be removed from transmission towers to reduce predation pressure on sensitive species such as the desert tortoise, greater sage-grouse, and Utah prairie dog. Raven nests can be removed only when inactive (i.e., no eggs or young), if removal is otherwise necessary, a Migratory Bird Treaty Act take permit from the USFWS is required. The removal of raven nests should be addressed in the Nuisance Animal and Pest Control Plan.

- Current guidelines and methodologies (e.g., APLIC and USFWS 2005; APLIC 2006) would be used in the design and analysis of the proposed transmission facilities in order to minimize the potential for raptors and other birds to be electrocuted by them or collide with them.

- Transmission line support structures and other facility structures should be designed to discourage their use by raptors for perching or nesting (e.g., by use of anti-perching devices). This design would also reduce the potential for increased predation of special status species such as the desert tortoise, sage grouse, and Utah prairie dog. Mechanisms to visually warn birds (permanent markers or bird flight diverters) should be placed on transmission lines at regular intervals to prevent birds from colliding with the lines.

- To the extent practicable, the use of guy wires should be avoided because these pose a collision hazard for birds and bats. Guy wires should be clearly marked with bird flight diverters to reduce the probability of collision.

- Shield wires should be marked with devices that have been scientifically tested and found to significantly reduce bird collision potential.

- Any mortality of important bird species (e.g., raptors) that is associated with power lines should be monitored and reported to the managing agency and the USFWS, and measures should be taken to prevent future mortality.

5.11 AIR QUALITY AND CLIMATE

Solar energy development could affect air quality in the areas where it occurs as well as in areas that would benefit from reductions in emissions due to reduced use of fossil energy. Construction impacts would be distinct from operations impacts, while impacts on climate would be primarily associated with reductions in CO_2 emissions from displaced fossil energy sources. The following subsections discuss the common and technology-specific impacts on air quality and climate that could occur from solar development and the potentially applicable mitigation measures for such impacts.

5.11.1 Common Impacts

5.11.1.1 Site Characterization

Typically, potential air quality impacts from site characterization activities would be negligible, because these activities are short term, require minimum site disturbance, and can be conducted with a small crew and small equipment. In some instances, deep soil corings to obtain information necessary for the design of substantial structural foundations (e.g., power towers) or extensive drilling for the installation of monitoring/sampling wells and piezometers for on-site groundwater characterization may be required (see Section 3.2). These activities could require substantial ground disturbance and also large equipment with large access road requirements. However, the potential impacts of these site characterization activities on ambient air quality would be much lower than those of construction activities. Also, developers might elect to delay site characterization activities that would result in more extensive impacts until the construction phase of development.

5.11.1.2 Construction

Construction activities would involve a number of separate operations, including mobilization/staging, land clearing (grubbing and tree removal), topsoil stripping, cut-and-fill operations (i.e., earthmoving), road construction, ground excavation, drilling and blasting if required, foundation treatment, building/structure erection, electrical and mechanical installation, landscaping, testing, and shakedown. Construction would, in large part, be divided into two phases—site preparation and construction.[4] For most utility-scale solar facilities, the site preparation phase would be of relatively short duration (e.g., a few months) followed by a much longer construction phase (e.g., a few years).

Major heavy equipment used in the site preparation phase would include chain saws, chippers, dozers, scrapers, end loaders, trucks, cranes, rock drills, and equipment for blasting operations if required. The major equipment used in the construction phase would include cranes, end loaders, backhoes, dozers, trucks, and a temporary concrete batch plant if substantial

[4] The construction phase includes all activities after site preparation to the onset of operation.

amounts of concrete are needed and/or premixed concrete is unavailable from nearby vendors (e.g., for foundations for a solar power tower or the power block).

Fugitive dust from soil disturbances and engine exhaust from heavy equipment and commuter/delivery/support vehicular traffic within and around the facility would contribute to air emissions of criteria pollutants, volatile organic compounds (VOCs), greenhouse gases (GHGs, e.g., CO_2), and a small amount of hazardous air pollutants (HAPs) (e.g., benzene). Typically, potential impacts of fugitive dust emissions on ambient air quality would be higher than those of engine exhaust emissions.

For most construction projects, soil disturbance during the site preparation phase, which involves the intense use of heavy equipment over a short time period, has the greatest potential for air emissions and adverse air quality impacts (through the release of large amounts of fugitive dust). In addition, soil disturbance from heavy equipment used for access road construction and/or recontouring of land results in a greater potential for emissions and adverse air quality impacts. However, the construction of solar facilities would generally occur in desert environments with relatively flat, hard surfaces, and thus site preparation might be minimal. Therefore, air emissions during the construction phase, such as from the erection of structures and equipment installation, could be higher than those from the site preparation phase (Beacon Solar, LLC 2008).

Under unfavorable dispersion conditions, infrequent high concentrations of PM_{10} or $PM_{2.5}$ (particulate matter with a mean aerodynamic of 10 μm or less, or 2.5 μm or less, respectively) could exceed the standards at the site boundaries. However, for solar facilities located in remote areas (which is expected to be the case for most facilities), construction activities would probably contribute minimally to concentrations of air pollutants at the nearest residence or business. In addition, most state condition construction permits by requiring that mitigation measures to reduce fugitive dust emissions be employed.

Particularly in areas with highly erodible soils, such as sandy soils (see Sec. 5.7.1), fugitive dust from construction could cause unavoidable impacts for the duration of the site preparation and construction phases (2 to 4 years). In areas with more stable soils, e.g., areas covered with nonerodible elements such as stones or vegetation, dust emissions would be comparatively less. Fugitive dust emissions would be caused by site preparation, construction activities, and wind erosion and would cause unavoidable localized impacts. Construction activities would be limited to a portion of the site at any time and would occur during daytime when conditions generally favor dispersion of dust, both of which would reduce impacts. However, the large total area disturbed during construction could be exposed to wind erosion. Stabilizing soils in an area at the completion of construction would reduce these emissions. However, given that stabilization is never fully effective and particularly if disturbed soils cannot be stabilized, wind erosion from disturbed areas could continue throughout the remainder of the construction period and beyond into the operation and reclamation phases, particularly in case of the highly erodible soils. Direct emissions from construction activities and the persistent wind erosion from disturbed soils remaining after completion of construction need to be addressed in site-specific assessments during the ROW application process to assess the severity of these impacts.

5.11.1.3 Operations

In general, air emissions associated with generating electricity from solar technologies are negligible. Parabolic trough and power tower technologies may combust some fossil fuels during start-up to prevent freezing the HTF. Other technologies do not use fossil fuels routinely.

Solar facilities would generate very low levels of air emissions directly from the solar fields. Emissions from the solar fields would include fugitive dust and engine exhaust emissions from vehicles and heavy equipment associated with regular site inspections, infrequent maintenance activities (e.g., mirror washing, replacement of broken mirrors), and wind erosion from bare grounds and access roads. The types of emission sources and pollutants would be similar to those during construction, but the amounts would be small and insignificant.

For parabolic trough and solar power tower technologies only, power block emissions would include those from small-scale boilers for processing (e.g., for maintaining HTF temperatures) and from wet-cooling towers, if in use. Process boilers would emit typical combustion-related criteria pollutants and HAPs, and cooling towers would emit small amounts of particulate matter (PM)[5] as drift, although drift eliminators could be used to minimize emissions. Other combustion sources would include space-heating boilers, diesel-fueled emergency power generators (typically operating only a few hours per month for preventive maintenance purposes), and emergency fire-water pump engines. Storage tanks, including fuel tanks, would emit VOCs and a small amount of HAPs. Engine exhaust from commuter, delivery, and support vehicular traffic would also contribute emissions within and around the solar facility. These air emissions during operation would be minimal in comparison with those from fossil fuel–fired power plants.

Fugitive dust emissions from wind erosion and vehicle travel could cause impacts during operations. In areas with highly erodible soils, such as sandy soils (see Section 5.7.1), wind erosion of disturbed soils could affect particulate air quality. In areas where soils are more stable, for example, areas with nonerodible elements such as stones or vegetation, or where disturbed soils have been stabilized, fugitive emissions would be comparatively less. Based on the large area that could be disturbed and that the fact that stabilization is never fully effective, wind erosion during operation needs to be addressed in site-specific assessments during the ROW application process to assess the severity of these impacts. Traffic from workers, deliveries, and support is expected to be minimal during operations, with correspondingly small emissions. Emissions could be reduced by treating or surfacing roads and parking areas, particularly in areas with highly erodible soils, and by requiring vehicles to use roadways whenever possible. Although not large, emissions from vehicle travel should be addressed as a component of the site-specific assessments.

[5] After the evaporation of drift droplets, PM is formed by the crystallization of dissolved solids, which consist of mineral matter, chemicals used as biocides, corrosion/scale inhibitors, and the like.

5.11.1.4 Decommissioning/Reclamation

Decommissioning would include the dismantling of solar facilities and support facilities, such as buildings/structures and mechanical/electrical installations; disposal of debris; grading; and revegetation as needed. Activities for decommissioning would be similar to those used for construction but on a more limited scale. Potential impacts on ambient air quality would be correspondingly less than those for construction activities. The area disturbed during decommissioning/reclamation could be exposed to wind erosion. Stabilizing disturbed soils would reduce these emissions. However, given that stabilization is never fully effective and particularly if disturbed soils cannot be stabilized, wind erosion from disturbed areas could continue after decommissioning/reclamation, particularly in case of the highly erodible soils. The potential for persistent wind erosion from disturbed soils needs to be addressed in site-specific assessments during the ROW application process to assess the severity of these impacts.

5.11.1.5 Transmission Lines and Roads

The construction of transmission lines within a designated ROW to connect new solar projects to the nearest regional grid, and upgrading of existing lines, would result in measurable air emissions. The general sequence of activities for placing electricity transmission lines would involve surveying, land clearing (grubbing and tree removal), construction of access roads, drilling or excavation for support structures and concrete footings, and backfilling.

Tower structures would be carried to the site by truck in sections, assembled in laydown areas, and lifted into place with a crane. In limited circumstances, helicopters can be used for transmission line construction. To minimize fugitive dust emissions from helicopter operations, paved or vegetated areas near a major highway could be selected as staging areas, and if feasible, water spraying could be used on the area where the tower was being erected. Typically, the helicopter would be operating at a height above 100 ft (30 m) at the erection site. Dust emissions would be less those associated with landings and takeoffs, for which dust begins to be raised at operating heights below about 50 ft (15 m), and would also be less than those raised by long-distance truck traffic on unpaved roads. As in other construction activities, most of these activities would include fugitive dust emissions from soil disturbance and engine exhaust emissions from heavy equipment and commuter/delivery/support vehicles. Standard dust control measures (e.g., frequent water spraying on disturbed areas) would be implemented. Since most new facilities would be located within a few miles and some up to 25 mi (40 km) of existing transmission lines, transmission line construction could be performed in a short time period. In addition, construction sites along the transmission line ROWs would move continuously, so no air impacts would occur in a particular area for a prolonged period. Thus the potential impacts on ambient air quality would be minor and temporary.

The operations phase associated with transmission lines would generate criteria pollutants, VOCs, GHGs, and HAPs from activities such as periodic site inspection. Vehicles and other gasoline-powered equipment would be required to perform vegetation maintenance within the ROW. Other maintenance activities would include the repair or replacement of tower/pole components or conductors/insulators, painting of towers/poles, and emergency

response (e.g., during power outages) as needed. In addition, transmission lines could produce minute amounts of O_3 and NO_x associated with corona discharge (i.e., the breakdown of air near high-voltage conductors). Corona discharge is most noticeable for high-voltage lines during rain or fog conditions when the ambient O_3 concentration is typically at its minimum. All these emissions during the operation phase would be quite small, and therefore potential impacts on ambient air quality would be negligible.

Impacts from decommissioning and reclamation would be similar to those discussed in Section 5.11.1.4 but on a more limited scale. Potential impacts on ambient air quality would be correspondingly less than those for construction activities. The potential for persistent wind erosion from disturbed soils, especially in areas with highly erodible soils, needs to be addressed in site-specific assessments during the ROW application process to assess the severity of these impacts.

5.11.2 Technology-Specific Impacts

Although utility-scale solar facilities use various technologies, the construction activities and heavy equipment used would be similar. Important variables determining the impacts of facility construction on ambient air quality include power generation capacity, land area of a facility, the construction period, topographic features of the site (including terrain and vegetation), soil characteristics (including content of fine particles, crustiness, and soil strength), length of required transmission to the nearest grid and natural gas supply pipeline, local meteorological conditions (especially wind and precipitation), and distance to the site boundaries and nearest sensitive human receptors. Descriptions of construction activities, heavy equipment used, air pollutants emitted, and potential air impacts during the construction period are discussed in Section 5.11.1.2.

Whatever solar technology is used, emissions from solar facilities during operations would include fugitive dust and engine exhaust from site inspection and maintenance and repair activities for the solar field. These emissions would include a small amount of criteria pollutants, VOCs, GHGs, and HAPs (see Section 5.11.4 for GHGs). Commuter/delivery/support vehicles within and around the solar facility would be another common source of emissions for all solar technologies. These emissions would be intermittent and small, and fugitive dust emission control measures would be implemented in accordance with applicable laws, ordinances, regulations, and standards. As stated in Section 5.12.1, these emissions would have minor and intermittent impacts on ambient air quality.

The reduction or displacement of electricity generation in fossil-fuel–fired power plants by electricity from solar energy facilities could reduce overall emissions of combustion-related pollutants. To gain some perspective on the potential for reductions, Table 5.11-1 compares the annual emissions associated with the generation of 1 MWh of electricity in solar and fossil fuel–fired facilities. Fossil energy emissions were estimated on the basis of total annual emissions and the annual power generation for all types of fossil fuel–fired power plants currently in operation in the six-state study area (EPA 2009b). Solar facility emissions were assumed to be negligible. Emissions displaced by a particular solar facility could be bounded by multiplying the facility's

annual output by the factors in Table 5.11-1. The actual magnitude of emissions displaced would depend on many factors influencing the generation and distribution of electricity. Estimates based on the tabulated values approximate the maximum that could be achieved.

TABLE 5.11-1 Annual per MWhr Emissions from Combustion-Related Power Generation

Combustion Emissions (kg/yr per MWhr)[a]			
SO_2	NO_x	Hg	CO_2
0.69	1.0	8.0×10^{-6}	716

[a] Composite emission factors for six-state study area based on individual state composites weighted by the power generated in each state (EPA 2009b).

5.11.2.1 Parabolic Trough and Power Tower

Parabolic trough and power tower solar facilities include a solar field and power block as well as ancillary facilities, such as administration buildings and storage tanks. The power block of these solar facilities containing the STG and other related power-generating and management equipment is virtually identical in both form and function to the power block of fossil fuel and nuclear power plants that also use steam to produce electricity. For solar facilities during normal facility operation, criteria pollutants, VOCs, and HAPs would be emitted from small-scale natural gas–fired boilers used for start-up, HTF freeze protection, space heating, the emergency diesel generator, and fire-water pump engines. The wet-cooling tower, if in use, would emit a small amount of PM as drift, and storage tanks would emit VOCs and a minute amount of HAPs. Because of the relatively low vapor pressure of the HTF and diesel and the low VOC content of the natural gas pipeline (containing mostly non-VOC methane and ethane), fugitive VOC emissions from tanks, pumps, seals, flanges, and valves of the piping would be expected to be negligible.

All combustion sources should meet applicable emission limitations and air pollution control requirements as specified in the permit. For example, each boiler would be equipped with low-NO_x burners for NO_x control, and CO would be controlled by using good combustion practices. Particulate and VOC emissions would be minimized through the use of natural gas as the fuel. For a facility with no TES, power production would occur only during daytime hours when the air dispersion is typically favorable. With TES, a facility could operate during less favorable dispersion conditions (e.g., calm and stable nighttime hours), possibly resulting in pollutant concentrations higher than those during daytime hours at the site fence line. However, air emissions from the power block during normal operation of a parabolic trough or power tower facility would be relatively small and thus would not contribute much to concentrations at the site boundary and the nearest residence. Therefore, potential impacts on ambient air quality associated with the operation of parabolic trough or power tower facilities would be minimal.

A trough or tower facility could displace considerable amounts of criteria pollutants and HAP emissions that would otherwise have been generated from fossil fuel power plants. For this analysis, a production capacity of 400 MW and a capacity factor of 20% were assumed for trough and tower facilities. As a proportion of emissions from other sources of electric power production in the six-state study area, operation of a single 400-MW parabolic trough or tower

facility with a capacity factor of 20% would result in avoided air emissions of 0.21% of SO_2, NO_x, and Hg, by using the factors shown in Table 5.11-1 and the fossil emissions shown in Table 4.4.2-1. When compared with emissions from all sources (not only electricity production), power production from one of these facilities would displace 0.09% and 0.03% of SO_2 and NO_x emissions in the six-state study area, respectively. Fossil fuel–fired power plants in Colorado, Nevada, New Mexico, and Utah account for more than 90% of each state's power generation, while noncombustion power plants (e.g., nuclear, hydro, and/or renewable energy) in Arizona and California account for about 32% and 47%, respectively. Reductions of combustion-associated emissions would occur by siting solar facilities in any of the six states.

5.11.2.2 Dish Engine

The solar dish engine is unique among CSP technologies in that it generates electricity through the action of an external heat engine rather than through the production of steam. However, there are no unique emission sources for criteria pollutants, VOCs, and HAPs from dish engine facilities in comparison with other solar technologies, and the power block, a primary emission source for trough and tower facilities, is eliminated (thus eliminating emissions from boilers and cooling towers). Minor emissions from emergency diesel-fired generators and fire-water pump engines operating on an intermittent basis, fugitive VOCs from piping and tanks, and fugitive dust and engine exhaust emissions of vehicles would occur at dish engine facilities. Air emissions during operations would be small and would not contribute much to concentrations at the site boundary or at the nearest residence; therefore, impacts on ambient air quality would be negligible.

Displaced emissions as a proportion of emissions from other sources of electric power production in the six-state study area would depend on the output of a given dish engine facility and would be proportional on a megawatt-hour basis to those presented above for a 400-MW solar trough or power tower facility.

5.11.2.3 PV Systems

Although PV technology is fundamentally different from the other solar technologies assessed (converting sunlight directly into electricity using solar cells and not using a power block), emission sources and rates from a utility-scale PV facility would be about the same as those from other solar facilities with similar power production capacities, particularly those from solar dish engine facilities, which also do not include a power block. Therefore, potential impacts on ambient air quality associated with operation of a PV facility would be negligible.

Displaced emissions as a proportion of emissions from other sources of electric power production in the six-state study area would depend on the output of a given PV facility and would be proportional on a megawatt-hour basis to those presented above for a 400-MW solar trough or power tower facility.

5.11.2.4 Albedo Effects of Solar Technologies

5.11.2.4.1 PV Systems. The deployment of PV panels would effect a change in the albedo, or the fraction of solar radiation reflected back into space by an area of the earth's surface. On a large scale, such a change could conceivably affect the radiative balance of the earth's surface, and thus contribute to global warming, by slightly reducing the amount of sunlight reflected back to outer space, as the panels absorb more and reflect less solar energy than the underlying ground. Historical changes in earth-surface albedo, both positive and negative, have occurred from a number of other human-induced changes, for example, from the conversion of forests to farmland or from the construction of roads and buildings. The size of the effect from deployment of PV technologies, however, would be small compared to these historical effects and, with respect to global warming, would be more than compensated for by displaced fossil fuel CO_2 emissions, as discussed in the following paragraphs.

Typical surface albedo values range from 0.05 for asphalt to 0.95 for fresh snow, with a global mean planetary albedo of about 0.3 (Jacobson 1999). An albedo for desert, where most solar facilities are located, ranges from 0.2 to 0.4, meaning that 20 to 40% of incident radiation is reflected back into space. Dark-colored sunlight-absorbing photovoltaic panels, by comparison, typically reflect less than about 10% of incident solar radiation (albedo <0.1).

A recent study discussed potential impacts of the Earth's albedo modification on climate change associated with widespread deployment of photovoltaics (Nemet 2009). By 2100, radiative forcing[6] of the albedo effect due to photovoltaics is predicted to range from about 0.003 to 0.029 W/m^2. At the same time, solar energy, including that from PV, would displace a considerable amount of GHG emissions, mainly CO_2, from fossil fuels, such as coal or natural gas. Radiative forcing from displacement of GHG emissions from solar energy is estimated to range from −0.102 to −1.03 W/m^2 (negative values indicate a cooling effect). For comparison, radiative forcing caused by anthropogenic GHG emissions since preindustrial times is about 2.6 W/m^2, and the albedo effect from previous land use changes is estimated at about −0.2 W/m^2. Therefore, climatic benefits resulting from widespread deployment of photovoltaics for fossil fuels far outweigh (more than 30 times larger) the unfavorable effects due to the small change in the Earth's albedo.

5.11.2.4.2 Other Solar Technologies. Reflective surfaces used in other solar technologies have higher albedos than PV, as collectors concentrate reflected solar energy on a secondary surface (i.e., power tower, solar dish engine, or solar trough receivers), while more sunlight is reflected back to the sky than from the original land surface. Deployment of solar technologies other than PV could have small positive effects on climate stability, in addition to benefits from displacement of GHG emissions. However, the total area available for solar energy

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6 Radiative forcing is defined as the radiative imbalance (expressed in watts per square meters or W/m^{-2}) in the climate system at the top of the atmosphere caused by the addition of a GHG (or other change). A positive radiative frequency tends to warm the Earth's surface, while a negative radiative frequency tends to cool the surface.

development on BLM lands is small compared to the areas assumed in the above study (about 0.4 to 3.5%). Thus, radiative forcing effects from solar energy development on BLM lands and any associated effects on climate change would be much smaller than the values estimated in the study.

5.11.3 Potentially Applicable Mitigation Measures

Most solar facilities would be located in desert environments. Fugitive dust emissions from vehicle traffic on unpaved roads and/or from soil-disturbing activities would be the greatest concern with respect to air quality impacts, especially during construction. These fugitive dust emissions and other combustion-related emissions would need to be controlled through stipulations included in the ROW authorization and other permitting processes. The emissions would need to comply with applicable laws, ordinances, regulations, and standards. Many of the mitigation measures recommended below have been adapted from those discussed in the following references: BrightSource Energy, Inc. (2007), Beacon Solar, LLC (2008), and Stirling Energy Systems (SES) Solar Two, LLC (2008).

A project- and location-specific Dust Abatement Plan should be prepared for all solar facilities. Water spraying, which is widely used as a dust control measure, is sometimes not cost-effective, for example, in water-deprived locations. Paving also is not justifiable for low-volume traffic roads within and around a solar facility. Gravel can be used to reduce fugitive dust from roads. Another solution for controlling dust is to apply a dust suppressant, although this is not a permanent solution. Currently, a wide variety of dust suppressants are commercially available. Selection of the proper dust abatement program should be based on road conditions, environmental impacts, and long-term cost. Primary factors for road conditions include number of vehicles, number of wheels, vehicle speed, vehicle weight, particle size distribution of road surface material, degree of road compaction, and meteorological conditions (e.g., wind speed, humidity, and precipitation) (Bolander and Yamada 1999). Dust palliatives could migrate due to careless application, runoff, leaching, resuspension of loose materials after abrasion by vehicles, adhesion to tires, and so on. Environmental concerns associated with the application of dust palliatives include potential impacts on surface water and groundwater quality, the freshwater aquatic environment, and plant communities. Potential environmental impacts on these receptors would depend on soil permeability and depth of groundwater and on the composition, persistency, and toxicity of the chemicals. Bolander and Yamada (1999) discuss in detail the types of dust palliatives, dust palliative selection and application tips, and environmental impacts.

5.11.3.1 Siting and Design

- All heavy equipment should meet emission standards specified in the state code of regulations, and routine preventive maintenance, including tune-ups to meet the manufacturer’s specification, should be implemented to ensure efficient combustion and minimal emissions. Newer and cleaner equipment that meets more stringent emission controls should be leased or purchased.

5.11.3.2 General Multiphase Measures

- Access roads, on-site roads, and parking lots should be surfaced with aggregate with hardness sufficient to prevent vehicles from crushing the aggregate and thus causing dust or compacted soil conditions. Paving could also be used on access roads and parking lots. Alternatively, chemical dust suppressants or durable polymeric soil stabilizers should be used on these locations. The choice of dust suppression measures should consider the potential impacts on wildlife from the windborne dispersal of fugitive dust containing dust suppressants and the potential impact on future reclamation.

- All unpaved roads, disturbed areas (e.g., areas of scraping, excavation, backfilling, grading, and compacting), and loose materials generated during project activities should be watered as frequently as necessary to minimize fugitive dust generation. In water-deprived locations, water spraying should be limited to active disturbance areas only and non-water-based dust control measures should be implemented in areas with intermittent use or use that is not heavy, such as stockpiles or access roads.

- Machinery should use air emission-control devices as required by federal, state, and local regulations or ordinances.

- On-site vehicle use should be reduced to the extent feasible.

- Travel should be limited to stabilized roads.

- The main access road to the main power block and the main maintenance building area should be paved.

- Speed limits (e.g., 10 mph [16 km/h]) within the construction site should be posted with visible signs and enforced to minimize airborne fugitive dust.

- All vehicles that transport loose materials as they travel on public roads should be covered, and their loads should be sufficiently wet and kept below the freeboard of the truck.

- Workers should be trained to comply with the speed limit, use good engineering practices, minimize the drop height of materials, and minimize the number and extent of disturbed areas. The project developer should enforce these requirements.

- Wind fences should be installed around disturbed areas that could affect the area beyond the site boundaries (e.g., nearby residences).

- All soil disturbance activities and travel on unpaved roads should be suspended during periods of high winds. A critical site-specific wind speed

should be established on the basis of soil properties determined during site characterization, and monitoring of the wind speed would be required at the site during construction, operation, and reclamation.

- Any stockpiles created should be kept on-site, with an upslope barrier in place to divert runoff. Stockpiles should be sprayed with water, covered with tarpaulins, and/or treated with appropriate dust suppressants, especially in preparation for high wind or storm conditions. Compatible native vegetative plantings may also be used to limit dust generation from stockpiles that will be inactive for a relatively long period. Chemical dust suppressants that emit VOCs should be avoided within or near ozone nonattainment areas.

- All diesel engines used in the facility should be fueled only with ultra-low-sulfur diesel with a sulfur content of 15 parts per million (ppm) or less.

- The idling time of diesel equipment should be limited to no more than 10 minutes unless idling must be maintained for proper operation (e.g., drilling, hoisting, and trenching).

- Potential environmental impacts from the use of dust palliatives should be minimized by taking all necessary measures to keep the chemicals out of sensitive soil and streams. In addition, the application of dust palliatives should comply with federal, state, and local laws and regulations. Dust palliatives must meet the requirements of the applicable transmission system operator (e.g., Western Area Power Administration construction standards prohibit the use of oil as a dust suppressant [Western 2008]).

5.11.3.3 Construction

- Access to the construction site and staging areas should be limited to authorized vehicles only through the designated treated roads.

- Construction should be staged to limit the exposed area at any time, whenever practical.

- Tires of all construction-related vehicles should be inspected and cleaned as necessary so they are free of dirt before they enter paved public roadways.

- Visible trackout or runoff dirt on public roadways from the construction site should be cleaned (e.g., through street vacuum sweeping).

- Topsoil from all excavations and construction activities should be salvaged and reapplied during reclamation or, where feasible, used for interim reclamation by being reapplied to construction areas not needed for facility operation as soon as activities in that area have ceased.

- Because of low winds and stable atmospheric conditions occurring in the early morning from late fall to early spring, the highest 24-hr concentrations of particulate matter during construction would be attributable to activities occurring during those hours. Thus, soil disturbance activities should be eliminated or minimized under these atmospheric conditions, particularly for construction activities occurring near facility boundaries.

- All soil-disturbing activities and travel on unpaved roads under high-wind events should be limited.

5.11.3.4 Operations

Typically, a utility-scale solar facility would have few emission sources during normal operations, as discussed in Section 5.11.1.3. However, the following mitigation measures are appropriate:

- All combustion sources should comply with state emission standards (e.g., best available control technology requirements).

- For portions of facilities that are maintained to be free of vegetation during operations, the dust control mitigation measures that were used to limit fugitive dust emissions during the construction phase should be implemented to minimize fugitive dust emissions from bare surfaces and unpaved access roads.

- Alternative fuel, electric, or latest-model-year vehicles should be used, when available, as facility service vehicles.

5.11.3.5 Decommissioning/Reclamation

Decommissioning activities are generally the reverse of construction activities, so the mitigation measures applied during construction should also be applied during decommissioning.

5.11.3.6 Transmission Lines and Roads

Most mitigation measures applied to the construction, operation, and decommissioning activities discussed above also should be implemented during the entire life of transmission lines. An additional mitigation measure would include accessing the transmission lines from public roads and designated routes to the maximum extent possible in order to minimize fugitive dust emissions.

5.11.4 Impacts of Greenhouse Gas Emissions

Although the scientific understanding of climate change is evolving, the IPCC's Fourth Assessment Report (IPCC 2007) states that the warming of the earth's climate is unequivocal and that it is very likely attributable to increases in atmospheric GHGs caused by human activities (anthropogenic). This report indicates that changes in many physical and biological systems (e.g., increases in global temperatures, more frequent heat waves, rising sea levels, coastal flooding, loss of wildlife habitat, spread of infectious disease, and other potential environmental impacts) are linked to changes in the climate system and that some changes may be irreversible.

EPA's Mandatory Greenhouse Gases (GHG) Reporting Rule (74 FR 56260, October 20, 2009) mandates the reporting of annual GHG emissions for more than 10,000 facilities that account for about 85% of the national GHG emissions. The rule focuses on large emitters of GHG, including power generation facilities, and other industrial entities. Facilities that emit GHG from certain sources—such as the production of cement, aluminum, and lime—are required to comply with the rule regardless of emission rate. Other GHG sources must report only if the facility's GHG emissions exceed 25,000 metric tons (MT) of carbon dioxide equivalent (CO_2e). Solar energy facilities are expected to have small GHG emissions and would not be required to report under this rule.

A potential benefit from the operation of solar facilities would include the reduction of GHG emissions if a fossil fuel power plant would otherwise be in operation to supply the same amount of electricity. The reduction or displacement of electricity generation in fossil fuel power plants by electricity from solar energy facilities could reduce overall emissions of combustion-related pollutants. The actual magnitude of emissions displaced would depend on many factors determining the generation and distribution of electricity.

As discussed in Section 5.11.1.2, composite emission factors were estimated on the basis of total annual power generation and associated GHG emissions for all types of fossil fuel power plants currently in operation in the six-state study area (EPA 2009b). CO_2 emissions represent the majority of these emissions. On the basis of the composite emission factor for CO_2, an estimated 716 kg (1,578 lb) of CO_2 would be displaced annually per megawatt-hour of solar energy produced (Table 5.11-1). During the period 1996 to 2005, CO_2 emissions accounted for about 83% of the total GHG emissions in terms of CO_2 equivalent (Section 4.4.3). Therefore, total GHG emissions would likely be about 20% more than CO_2 emissions discussed below.

Operation of a hypothetical 400-MW solar energy facility with a capacity factor of 20% could result in avoidance of up to 0.21% of CO_2 emissions from electric power facilities and 0.07% of CO_2 emissions from all source categories in the six-state study area. Fossil fuel power plants in Colorado, Nevada, New Mexico, and Utah account for more than 90% of each of these state's power generation, while noncombustion power plants (e.g., nuclear, hydro, and/or renewable energy) in Arizona and California account for relatively higher amounts of power generation (about 32% and 47%, respectively). Reductions in GHG emissions would result from siting solar facilities in any of the six states.

Recent research indicates that the carbon storage capacity of desert plants and soils could be comparable to that of temperate forests and grasslands (Wohlfahrt et al. 2008). These researchers quantified the net CO_2 consumed by an ecosystem's biomass (i.e., from shrubs and from microscopic organisms living in the soil). The annual removal of GHGs from the atmosphere was about 100 g/m^2 of carbon, with the majority being consumed during spring months. Because this amount of CO_2 is not being stored in desert plants alone, however, they suggested that a significant portion could be stored in the biological crusts, such as in blue-green algae, lichens, and mosses, which cover most desert soils. Their results suggest that arid biomes covering more than 30% of the earth's land surface may be playing a much larger role in global carbon cycling and in modulating atmospheric CO_2 levels than previously thought.

On the basis of this research, an assessment was performed of the potential adverse effect of CO_2 added to the atmosphere due to of loss of desert plants and crustal matter associated with utility-scale solar facilities, compared with the benefit of avoided CO_2 emissions. Potential loss of CO_2 storage capacity associated with clearing of the desert surface for the solar facility was estimated. A land area of about 5 to 9 acres (0.020 to 0.036 km^2) per MW was assumed to be cleared, and a capacity factor of 20% for the solar facilities was assumed. The annual removal of GHGs from the atmosphere by plants and microscopic organisms was assumed to be 100 g/m^2 of carbon (Wohlfahrt et al. 2008).

The resulting loss of CO_2 storage capacity was estimated to be about 1.6 ton/acre/yr (0.37 kg/m^2/yr). This storage loss would be about 0.6 to 1.1% of CO_2 emissions avoided by operation of a solar facility, based on a combustion-related composite CO_2 emission factor averaged over six southwestern states. As a consequence, CO_2 removal from operation of a solar facility would be expected to be far more beneficial than the CO_2 storage capacity lost by clearing of vegetation from the desert, from the standpoint of GHG emission reductions.

The offsets or reductions that would result from the use of solar technology to produce electricity would reduce the contribution to global climate change and the potential environmental impacts described in the opening paragraph of this section.

5.12 VISUAL RESOURCES

Because of the experiential nature of visual resources, the human response to visual changes in the landscape cannot be quantified, even though the visual changes associated with a proposed utility-scale solar energy development can be described (Hankinson 1999). There is, however, some commonality in individuals' experiences of visual resources, and while it may not be possible to quantify subjective experience and values, it is possible to systematically examine and characterize commonly held visual values and to reach consensus about visual impacts and their trade-offs. The BLM's Visual Resource Management (VRM) procedures provide a means of describing visual impacts systematically and of evaluating their impact on the scenic qualities of affected landscapes, so that defensible decisions about the relative worth and disposition of visual resources relative to competing resource demands can be made (BLM 1984). (See the text box for factors that influence individuals' perceptions of visual impacts and that are considered within the BLM's VRM system.)

The BLM is responsible for ensuring that the scenic values of BLM-administered public lands are considered before allowing uses that may have negative visual impacts. BLM accomplishes this through its VRM system. The VRM system includes systematic processes for inventorying scenic values on BLM-administered lands, establishing visual resource management objectives for those values through the Resource Management Plan (RMP) process, and evaluating proposed activities to determine whether they conform with the management objectives. The primary components of BLM's VRM system include visual resource inventory (VRI), VRM class designation, and visual contrast rating.

- *VRI.* BLM's VRI process provides BLM managers with a means for determining visual values for a tract of land. The inventory includes the following three components: scenic quality evaluation, sensitivity level analysis, and delineation of distance zones. These inventory components provide systematic processes for rating the visual appeal of a tract of land, measuring public concern for scenic quality, and determining whether the tract of land is visible from travel routes or observation points. On the basis of the results, BLM-administered lands are placed into one of four visual resource inventory classes. These inventory classes represent the relative value of the visual resources. Class I and II are the most valued; Class III represents a moderate value; and Class IV represents the least relative value. Class I is reserved for specially designated areas, such as national wildernesses and other congressionally and administratively designated areas where decisions have been made to preserve a natural landscape. Class II is the highest rating for lands without special designation. The VRI class values may be affected by visual impacts associated with land management activities, such as utility-scale solar energy development. More information about VRI methodology is available in Section 5.7 and in *Visual Resource Inventory*, BLM Manual Handbook 8410-1 (BLM 1986a).

- *VRM class designation.* The results of the VRI become an important component of BLM's RMP for the area. The RMP establishes how the public lands will be used and allocated for different purposes, and the VRI classes provide the basis for considering visual values in the RMP land use allocation process. When a land use allocation is made, the area's visual resources are then assigned to VRM classes with established management objectives, including the degree of contrast resulting from a project or management activity permissible for that VRM classification. BLM activities must conform to the VRM objectives that apply to the project area as established in the RMP process. The management objectives for the VRM classes are as follows:

  - Class I objective is to preserve the existing character of the landscape. The level of change to the characteristic landscape should be very low and must not attract attention.

  - Class II objective is to retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management

Factors That Influence an Individual's Perception of Visual Impacts

Visibility Factors: Circumstances or activities that eliminate views of the impact area or impacting feature will reduce the level of perceived visual impact. Intervening topography, vegetation, or structures that effectively screen views can greatly reduce impacts of even large visual changes. Conversely, projects placed at higher elevations relative to viewers, particularly along ridgelines, may be conspicuously visible over larger areas, and thus have greater visual impact. Viewer elevation and aspect can also affect impact visibility by increasing or decreasing the viewable area and reducing or increasing screening effectiveness.

View Duration: Impacts that are viewed for a long period of time are generally judged to be more severe than those viewed briefly. For example, a transmission line that closely parallels a hiking trail may be in continuous view of hikers for several hours and would have a greater perceived visual impact than the same transmission line crossed by a perpendicular highway, which would be viewed relatively briefly by drivers and would have a smaller perceived visual impact.

Viewer Distance and Angle: Viewer distance from the affected area is a key factor in determining the level of impact. The BLM's VRM system defines distance zones—foreground-middleground (less than 3 to 5 mi [5 to 8 km]), background (5 to 15 mi [8 to 24 km]), and seldom seen (beyond 15 mi [24 km])—with perceived impact diminishing as distance between the viewer and the impact increases (BLM 1986a). Viewer angle relative to the impact may also affect perceived visual impact; when people view landscapes from angles approaching 90° (e.g., views of canyon walls or steep mountain slopes), the landscapes may be scrutinized more closely than those viewed from low angles (e.g., views of plains and other low-relief areas). An elevated viewpoint, such as when viewing a project located on a valley floor from nearby mountains, can also lead to increased visual impacts, because more surface area of the project is visible from the elevated viewer position.

Landscape Setting: Landscape setting provides the context for judging the degree of contrast in form, line, color, and texture between the proposed project and the existing landscape, as well as the appropriateness of the project to the landscape. Because of their physical properties, some landscapes are perceived by most viewers to have intrinsically higher scenic value than other landscapes, and physical landscape properties also determine the visual absorption capacity of the landscape (i.e., the degree to which the landscape can absorb visual impacts without serious degradation in perceived scenic quality). Scenic integrity describes the degree of "intactness" of a landscape, which is related to the existing amount of visual disturbance present. Landscapes with higher scenic integrity are generally regarded as more sensitive to visual disturbances. A development project in a pristine, high-value scenic landscape with low visual absorption capacity typically is more conspicuous and is perceived as having greater visual impact than if that same project were present in an industrialized landscape of low scenic value where similar projects were already visible. Special landscapes (also called special areas) have special meanings to some viewers because of unique scenic, cultural, or ecological values and are therefore perceived as being more sensitive to visual disturbances. Other landscapes are regarded as more sensitive to visual disturbances, because they are near or adjacent to high-value landscapes, such as national parks, monuments, wildlife refuges, or scenic/historic trails. Rarity of the landscape setting may also affect visual impact assessment; impacts on landscape settings that are relatively rare within a given region may be of greater concern than impacts on a landscape setting that is regionally very common.

Seasonal and Lighting Conditions: Seasonal and lighting conditions that affect contrast may affect perceived visual impact. The presence of snow cover, fall-winter coloration of foliage, and leaf drop may drastically alter color and texture properties of vegetation and soil, thereby altering visual contrasts between a proposed project and the landscape. Sun angle that changes by season and time of day affects shadow casting and color saturation, which, in turn, affect both perceived scenic beauty and contrast.

Number of Viewers: The BLM's VRM system considers impacts to be generally more acceptable in areas that are seldom seen and, conversely, less acceptable in areas that are heavily used and/or viewed.

Continued on next page.

Factors That Influence an Individual's Perception of Visual Impacts (Cont.)

Viewer Activity, Sensitivity, and Cultural Factors: The type of activity a viewer is engaged in when viewing a visual impact may affect his or her perception of impact level. Recreationists, particularly hikers and others who may visit an area with the specific goal of scenic appreciation, are generally more sensitive to visual impacts than workers (e.g., oil and gas workers). Some individuals and groups are also inherently more sensitive to visual impacts than others as a result of educational and social background, life experiences, and other cultural factors.

Sources: BLM (1984, 1986a,b); USFS (1995).

activities may be seen but must not attract the attention of the casual observer. Any changes must repeat the basic elements of form, line, color, and texture found in the predominant natural landscape features.

– Class III objective is to partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention but should not dominate the view of the casual observer. Changes should repeat the basic elements of form, line, color, and texture found in the predominant natural landscape features.

– Class IV objective is to provide for management activities that require major modification of the existing character of the landscape. The level of change to the characteristic landscape can be high.

More information about the BLM VRM program is available in Section 5.7 and in *Visual Resource Management*, BLM Manual Handbook 8400 (BLM 1984).

- *Visual contrast rating.* The BLM's VRM system defines visual impact as the contrast observers perceive between existing landscapes and proposed projects and activities. (See text box for factors that influence an individual's perception of visual impacts and that are considered within the BLM's VRM system.) The BLM's contrast rating system (BLM 1986b) specifies a systematic process for determining the nature and extent of visual contrasts that may result from a proposed land use activity and for determining whether those levels of contrast are consistent with the VRM class destination for the area. Contrasts between an existing landscape and a proposed project or activity are expressed in terms of the landscape elements of form, line, color, and texture. These basic design elements are routinely used by landscape designers to describe and evaluate landscape aesthetics. They have been incorporated into the BLM's VRM system to lend objectivity, integrity, and consistency to the process of assessing visual impacts of proposed projects and activities on BLM-administered lands.

Visual impacts can be either positive or negative, depending on the type and degree of visual contrasts introduced to an existing landscape. Where modifications repeat the general forms, lines, colors, and textures of the existing landscape, the degree of visual contrast is lower, and the impacts are generally perceived less negatively. Where modification introduces pronounced changes in form, line, color, and texture, the degree of contrast is greater, and impacts are often perceived more negatively.

While visual impacts have been identified as a concern for utility-scale solar energy projects (Torres-Sibille et al. 2008; NRC 1996), little scholarly research is available that formally addresses this topic. The following description of visual characteristics of solar facilities indicates that utility-scale solar energy projects introduce a variety of strongly geometric lines and forms and artificial-appearing colors and textures into the landscape that might strongly contrast with most natural-appearing landscapes, depending on viewer location and landscape setting. However, it cannot be assumed that the impacts that might occur would be perceived negatively by all viewers.

In the case of utility-scale wind energy development, studies on visual impacts of offshore and onshore wind energy developments have indicated that wind power enjoys strong support among the public (Global Strategy Group 2007; Warren et al. 2005; SEI 2003), and unlike most large-scale energy facilities, wind turbines are in some cases viewed as a positive visual impact by significant portions of the public (Minnesota Project 2005; Warren et al. 2005; SEI 2003). Surveys have indicated that solar energy is generally viewed favorably by the public, because it is regarded as a nonpolluting, renewable resource (SEIA 2008), and it may be that, similar to wind energy projects, utility-scale solar energy development projects would be viewed less negatively or positively in terms of visual impacts as a result; however, there is no available research to confirm this possibility.

Visual changes associated with utility-scale solar energy development can be produced through a range of direct and indirect actions or activities, including:

- Vegetation and landform alterations;
- Additions of structures, including solar collector/reflector arrays, buildings, and other ancillary facilities;
- Additions or upgrades to roads;
- Additions or upgrades to utilities and/or ROWs, for example, expansion of ROW width, addition of electric transmission lines, or upgrading of transmission voltage rating;
- Vehicular and worker activity;
- Dust, water vapor plumes, and other visible emissions; and
- Light pollution.

Site-specific impact assessment is needed to systematically and thoroughly assess visual impact levels for a particular project. Without precise information about the location of a project, a relatively complete and accurate description of its major components and their layout, and information about the number and types of viewers, it is not possible to assess precisely the visual impacts associated with the facility. However, if the general nature of the facility is known, as well as the general possible location of facilities, a more generalized but still useful assessment of the possible visual impacts can be made by describing the range of expected visual changes and discussing contrasts typically associated with these changes. In addition, a general analysis can be used to identify sensitive resources that may be at risk if a future project is sited in a particular area.

The impact analysis for solar facilities in this PEIS uses distance zones specified by the BLM's VRM system to identify potentially sensitive visual resources that might be affected if they are within view of a solar energy project. The distance between the viewer and the project elements that are the source of visual contrast is a critical element in determining the level of perceived impact. The BLM's VRM system specifies three distance zones in its visual resource inventory process:

- *Foreground-middleground* (0 to 5 mi [0 to 8 km]). This zone includes areas where management activities can be seen in detail. This zone has the highest visibility; visual changes are more noticeable than at farther distances and are more likely to trigger public concern.

- *Background* (5 to 15 mi [8 to 24 km]). This zone includes the area beyond the foreground-middleground up to 15 mi [24 km] and includes the area where some detail beyond the form or outline of the project is visible.

- *Seldom seen* (beyond 15 mi [24 km]). This zone includes areas beyond 15 mi [24 km] or where only the form or outline of the project can be seen or the project cannot be seen at all (BLM 1986a).

The geographical information system- (GIS-) based impact analyses used for this PEIS identified potentially sensitive visual resource areas for which some portions are either within the potential development area under an alternative examined in the PEIS or within 25 mi(40 km) distance from the leasing area. Assuming an unobstructed view of the project, viewers in these areas would be likely to perceive some level of visual impact from the project. It is expected that resources within the foreground-middleground distance would incur more impacts than those areas within the background or seldom-seen distance. Beyond the background distance, individual projects could be visible but would likely occupy a small visual angle and create relatively low levels of visual contrast.

The Summary Level Assessment of Potential Environmental Impacts by Alternative in Chapter 6 of the PEIS did not account for topography; in many cases, intervening terrain might obstruct all or part of the view of a project from a given location (e.g., a canyon or river bottom). The analysis shows areas that might be affected, but the actual number of affected areas is likely less than that indicated by the analysis. A more precise visibility analysis would be conducted

when a site-specific environmental analysis is performed for a particular project, at which point more precise spatial data would be available. The analyses conducted for the PEIS were limited to data available in GIS format at the time of analysis; it is recognized that additional scenic resources exist at the national, state, and local levels. While the GIS is capable of extremely high spatial accuracy, it is limited by the accuracy of the data used in the analysis, which were obtained from many sources and are subject to error.

Detailed visual impact analyses were conducted for the 24 proposed SEZs; the analyses were based on the creation of viewshed maps for each SEZ. A viewshed is an area of landscape that is visible to the human eye from a fixed vantage point. The viewshed analyses determined the potential visibility of the SEZ from the BLM and other lands within 25 mi (40 km) of the SEZs. The viewshed analyses incorporated topographic relief to determine for which areas views of the SEZ would be eliminated or restricted by topographic screening, and multiple viewsheds for each SEZ were created to reflect the varying heights of the different solar technologies analyzed in this PEIS. The viewshed analyses did not account for vegetation height or existing structures that might screen views; however, with few exceptions, the desert lands surrounding the SEZs are devoid of vegetation of sufficient height or density to effectively screen views. These exceptions are noted in the analyses. Viewshed analysis at the site- and project-specific level would include screening vegetation and structures as appropriate.

The SEZ analyses include discussion of potential impacts on BLM and other lands visible within 25 mi (40 km) of the SEZs. The visual impact analysis conducted for this PEIS assumes that the level of project contrast with the existing landscape is a measure of the impact magnitude rather than an assessment or determination of the positive or negative visual quality of the project. As noted by the BLM and the California Energy Commission (BLM and CEC 2009), these two measures are not the same. With respect to visual quality, utility-scale solar energy facilities vary widely in their visual characteristics, individual project layouts, and locational circumstances; however, utility-scale solar receiver fields typically present very large arrays of repeating visual elements with strong regular geometry, and their placement on the landscape usually presents a high degree of visual symmetry. Compared with many other industrial developments (e.g., fossil fuel plants, mines, or manufacturing facilities), solar energy facilities generally exhibit strong visual unity and simplicity, attributes generally associated with positive visual quality, even though they may introduce strong visual contrasts into natural-appearing landscapes. In some cases, some viewers might find some utility-scale solar energy facilities to be attractive or interesting to view because of the facilities' strong visual unity and simplicity or other factors, such as striking and novel light effects from reflections from ambient dust or the polished solar receiver surfaces; however, systematic research studies on this topic are not available. Other elements of a solar facility, such as STGs, roads, substations, and transmission lines, generally do not have the strong visual symmetry and regular geometry of solar collector arrays, and their presence could detract from the project's simplicity, regular geometry, and visual unity, potentially increasing negative perceptions of the facility.

The following impact analysis provides a general description of the visual changes likely to occur as a result of site characterization, construction, operation, and decommissioning/ reclamation of solar energy projects (and associated facilities).

Regardless of the technologies employed for solar energy collection and electricity production, utility-scale solar energy facilities involve substantial amounts of land disturbance. The presence and operation of large-scale facilities and equipment would introduce major visual changes into nonindustrialized landscapes and could create strong visual contrasts in line, form, color, and texture. Where visible to observers within the foreground-middleground distance, facilities would normally be expected to attract attention and in many cases would be expected to dominate the view. Impacts at longer distances could still be substantial, depending on project size and type, viewer location, and other visibility factors. Mitigation measures such as painting the structures in earth tones and using nonreflective surfaces would reduce color contrasts; however, the strong, regular geometry of the solar collector/reflector arrays, combined with the large size of the facilities, and in some instances the presence of glint and glare from reflective surfaces associated with some solar facilities would preclude repeating of the form, color, and texture of the predominant natural landscape features in nonindustrialized landscapes, and strong visual contrast would result. This would be especially true when the facilities were viewed from elevated locations, where the large areal extent of the facilities would be more apparent. While some of the lesser elements of a solar energy project might be compatible with VRM Class III or Class II objectives as viewed from nearby key observation points (KOPs), the siting of the major facility elements would be expected to be compatible with Class IV objectives only, unless careful siting hid them from view. Sensitive visual resource areas close to the major facility components with open lines of sight to the major facilities could be subject to large impacts from the visual contrasts that would result, particularly if the distance to the facilities were short or the viewpoints in the sensitive visual resource areas were elevated with respect to the solar facilities. These impacts might be incompatible with the visual objectives for these areas.

Beyond the impacts of a single solar facility, in some locations viewscapes could include multiple projects with large solar arrays that vary in size, layout, and collector type. Depending on the circumstances, the variety of project sizes, layouts, and associated visual impacts could exceed the visual absorption capability of the landscape, resulting in “visual clutter” that would detract from the scenic qualities of the viewed landscape. There could also be glare visible from multiple facilities simultaneously, which could increase negative perceptions of visual impacts from the facilities, and in some situations could be distracting, or cause visual discomfort that could make portions of the landscape difficult to view for extended periods.

While visual impacts associated with site characterization, construction, operation, and decommissioning/reclamation of solar energy projects considered in this PEIS differ in some important aspects on the basis of the particular solar energy technologies employed, many impacts are common to the technologies and development approaches. Direct visual impacts associated with construction, operation, and decommissioning/reclamation of utility-scale solar energy projects can be divided into generally temporary impacts associated with activities that occur during the construction and decommissioning/reclamation phases of the projects, and longer term impacts that result from the presence of and operation of the facilities themselves. Impacts common to solar energy development regardless of the solar energy technology employed are presented below, followed by impacts specific to each of the utility-scale solar energy technologies analyzed in this PEIS.

5.12.1 Common Impacts

5.12.1.1 Site Characterization

Potential visual impacts that could result from site characterization activities include contrasts in form, line, color, and texture resulting from vegetation clearing, if required for site characterization activities such as meteorological tower construction; the presence of trucks and other vehicles and equipment, with associated occasional, short-duration road traffic and parking, and associated dust; the presence of workers; and the presence of idle or dismantled equipment, and litter, if allowed to remain on the site. Ruts, windblown dust, and visible vegetation damage may occur from cross-country vehicle traffic if existing or new roads are not utilized for site characterization activities. If road upgrading or new road construction is required for site characterization activities, visual contrasts may be introduced, depending on the routes relative to surface contours and the widths, lengths, and surface treatments of the roads. Improper road maintenance could lead to the growth of invasive species or erosion, both of which could introduce undesirable contrasts in line, color, and texture, primarily for foreground and near-middleground views. Site characterization visual impacts are generally temporary; however, impacts due to road construction, erosion, or other landform altering or vegetation clearing in arid environments may be visible for extended periods.

5.12.1.2 Construction

Potential visual impacts that could result from construction activities include contrasts in form, line, color, and texture resulting from vegetation clearing of the solar field and other areas such as building pads (with associated debris); road building/upgrading; construction and use of staging and laydown areas; solar energy collector and support facility construction; vehicle, equipment, and worker presence and activity; and associated vegetation and ground disturbances, dust, and emissions. Construction visual impacts would vary in frequency and duration throughout the course of construction, which for a utility-scale project may last several years.

5.12.1.2.1 Vegetation Clearing. Construction for the solar field requires clearing of vegetation, large rocks, and other objects. The nature and extent of clearing are affected by the requirements of the project, the types of vegetation, and other objects to be cleared. Vegetation clearing and topographic grading would be required for the construction of access roads, maintenance roads, and roads to support facilities (e.g., electric substations). The removal of vegetation would result in contrasts in color and texture, because the varied colors and textures of vegetation would be replaced by the more uniform color and texture of bare soil, and could also introduce contrasts in form and line, depending on the type of vegetation cleared and nature of the cleared surface. Typically, vegetation-clearing activities would create additional visual impacts if refuse materials are not disposed of off-site, mulched, or otherwise concealed.

5.12.1.2.2 Road Building-Upgrading. As noted previously, construction of new temporary and permanent access roads and/or upgrading of existing roads to support project construction and maintenance activities would be required. Road development may introduce strong visual contrasts to the landscape, depending on the routes relative to surface contours and the widths, lengths, and surface treatments of the roads. Construction of access roads would have some associated residual impacts (e.g., vegetation disturbance) that could be evident for some years afterward, with a gradual diminishing of impacts over time.

5.12.1.2.3 Construction Laydown Areas. Construction of new solar energy facilities would require construction laydown areas for stockpiling and storage of equipment and materials needed during construction. Construction laydown areas might be several hundred acres in size. For solar facilities, a construction laydown area would include a staging area with a construction yard that serves as an assembly point for construction crews and includes offices, storage trailers, and fuel tanks. The nature and extent of visual impacts associated with construction laydown areas would depend in part on the size of the laydown area and the nature of required clearing and grading, and on the types and amounts of materials stored at the staging areas. Some newly constructed laydown areas could be converted into permanent facilities for facility maintenance, while others would be reclaimed immediately after completion of construction.

5.12.1.2.4 Solar Energy Collectors and Support Facilities. Construction of solar energy collectors and a variety of support facilities would also be required for utility-scale solar energy facilities, as well as electricity transmission systems. Solar energy collectors and support facilities vary by solar energy technology, and specific descriptions and potential impacts for each technology are discussed in Section 5.12.2. Support facilities include buildings and tanks and may include evaporation ponds, depending on the solar technology employed. Construction activities associated with the collectors and support facilities may include clearing, grading, soil compacting, and surfacing, in addition to constructing the collectors, buildings, and fences.

5.12.1.2.5 Workers, Vehicles, and Equipment. The various construction activities described above require work crews, vehicles, and equipment that would add to visual impacts during construction. Small-vehicle traffic for worker access and large-equipment traffic (e.g., trucks, graders, excavators, and cranes) would be expected for road and building construction, site preparation, and solar collector installation. Both kinds of traffic would produce visible activity and dust in dry soils. Suspension and visibility of dust would be influenced by vehicle speeds, road surface materials, and weather conditions. Temporary parking for vehicles would be needed at or near work locations. Unplanned and unmonitored parking could likely expand these areas, producing visual contrast by suspended dust and loss of vegetation. Construction activities would proceed in phases, with several crews moving through a given area in succession, giving rise to brief periods of intense construction activity (and associated visual impacts) followed by periods of inactivity. Cranes and other construction equipment would produce emissions while in operation and could thus create visible exhaust plumes.

5.12.1.2.6 Other Visual Impacts from Construction. Ground disturbance would result in visual impacts that would produce contrasts of color, form, texture, and line. Any excavating that might be required for building foundations and ancillary structures, trenching to bury pipelines or cables, grading and surfacing roads, clearing and leveling staging areas, and stockpiling soil and spoils (if not removed) would (1) damage or remove vegetation, (2) expose bare soil, and (3) suspend dust. Soil stockpiles could be visible for the duration of construction. Soil scars, exposed slope faces, eroded areas, and areas of compacted soil could result from excavation, leveling, and equipment and vehicle movement. Invasive species may colonize disturbed and stockpiled soils and compacted areas. These species may be introduced naturally; in seeds, plants, or soils introduced for intermediate restoration; or by vehicles. In some situations, the presence of invasive species may introduce contrasts with naturally occurring vegetation, primarily in color and texture. The presence of workers and construction activities could also result in litter and debris that could create negative visual impacts within and around work sites. Site monitoring and restoration activities could reduce many of these impacts.

Other construction activities could include bracing and cutting existing fences and constructing new fences to contain livestock; providing temporary walks, passageways, fences, or other structures to prevent interference with traffic; and providing lighting in areas where work might be conducted at night.

5.12.1.3 Operations

The operation and maintenance of solar energy projects and associated electricity transmission lines, roads, and ROWs would have potentially substantial long-term visual effects. Some impacts are common to utility-scale solar energy projects, regardless of solar technology employed; however, the solar energy collectors and associated structures differ in terms of visual impacts. Power tower projects generally have larger visual impacts than the other technologies analyzed in this PEIS because of the relatively tall and brightly illuminated receiver towers. PV projects generally have lower visual impacts than the other technologies because of the low profile of the collector arrays and the lower reflectivity of the PV panels, when compared to the highly reflective mirrors used by the other technologies. However, all utility-scale solar facilities could create strong visual contrasts for nearby viewers. The following discussion includes impacts common to the various solar energy technologies, while impacts that are significantly different between the technologies are discussed separately in Section 5.12.2. Site operation impacts would generally occur throughout the life of the facility, with some impacts (e.g., impacts resulting from land forming and vegetation clearing) potentially continuing many years beyond the lifetime of the project.

5.12.1.3.1 Solar Field. The dimensions of the cleared area for the solar field for a given project would depend on the solar technology employed and on other project-specific characteristics and would be determined at a project-specific level; in general, however, it would be expected to be in the range of 5 to 9 acres/MW (0.02 to 0.04 km^2/MW). Visual impacts associated with solar field clearing include the potential loss of vegetative screening, which would result in the opening of views; potentially significant changes in form, line, color, and

texture for viewers close to the solar field; and potentially significant changes in line and color for viewers with distant views of the solar field. In general, the impacts would be greater in more heavily vegetated (scrub) areas, where vegetation-clearing impacts are more conspicuous, particularly in areas of strong color contrasts between vegetation and soil; however, in some situations, uncleared vegetation outside the facility might screen views of the cleared areas, reducing visible contrasts. The presence of snow cover might accentuate color contrasts. In sparsely vegetated areas, visual impacts from vegetation clearing would typically be expected to be less, because there would normally be less vegetation removal and there are generally fewer contrast issues associated with vegetation removal in these areas.

While the opening of views for viewers close to a cleared solar field might be a positive visual impact in some circumstances, the introduction of strong linear and color contrasts in middleground and background views as a result of clearing could potentially have large negative visual impacts, particularly in more heavily vegetated areas where the viewer is elevated, so that large portions of the solar field are visible. In worst-case situations, the impacts could be visible for many miles.

In addition to form, line, color, and texture contrasts resulting from the exposure of bare soil, vegetation removal could result in windblown dust that could create visual contrasts and visible movement of dust clouds, obscure views of nearby landscape features, and degrade general visibility of both day and night skies.

In naturally vegetated areas, where bare soils become exposed (generally associated with construction activities), reclamation efforts would include reseeding these areas. Good mitigation practice would dictate reseeding with native plants (or a mix of native and non-native plants where necessary to ensure successful revegetation), which would minimize visual contrasts, but depending on circumstances, in the arid environments included in this PEIS, a number of years might pass before contrasts between reseeded and uncleared areas would no longer be noticeable. If a lack of proper management led to the growth of invasive species in the reseeded areas, noticeable color and texture contrasts might remain indefinitely. The unsuccessful reclamation of cleared areas may also result in soil erosion, ruts, gullies, or blowouts and could cause long-term negative visual impacts.

Other cleared areas would include maintenance roads and facility access roads (e.g., electric substations or pump stations). Some support facilities would be surrounded by cleared areas. Visual impacts associated with these cleared areas would include the potential loss of vegetative screening, which would result in the opening of views and potentially significant changes in form, line, color, and texture for viewers close to the cleared area. Clearing for roads might be subject to some of the linear contrast concerns mentioned above for ROWs. However, impacts would normally be far less severe; mainline facility maintenance roads would generally be within the cleared ROW and, in most cases, would not add substantially to the impact, while access roads would generally be shorter. In both cases, the cleared area would be relatively narrow, especially compared with typical electricity transmission line ROW clearings.

5.12.1.3.2 Solar Collectors and Support Facilities. Solar energy collectors and some support facilities vary by solar energy technology, and specific descriptions and potential impacts for each technology are discussed in Section 5.12.2. Operational activities associated with the collectors and support facilities include routine maintenance, such as washing of solar collector surfaces, road and building maintenance, and repairs.

Buildings common to all solar energy projects regardless of technology include a control-administrative building, a warehouse-shop building, a security building or gatehouse, and a fire-water pump building. These structures would normally be constructed of sheet metal, concrete, or cinder blocks and would be expected to range from approximately 20 to 40 ft (6.1 to 12.2 m) in height.

All utility-scale solar energy facilities would also include various tanks for water and other chemicals (e.g., gasoline or diesel fuel, potable water). Solar energy projects would normally be fenced around the outside perimeter and might include additional fencing around certain support facilities. Landscaping plantings might be included around the control building, or possibly for visual screening in certain situations.

These built structures would introduce complex, rectilinear geometric forms and lines and artificial-looking textures and colors into the landscape that would likely contrast markedly with natural-appearing landscapes. Most buildings and some tanks would be of sufficient height to protrude above the collector arrays as viewed from outside the facility and would likely contrast with the collector arrays in terms of form, line, and color.

Except for PV systems, utility-scale solar energy collectors include highly reflective surfaces that are used to reflect solar radiation. In addition to the collector/reflector arrays, facilities would normally include other components that may have reflective surfaces, such as array support structures, STG components, piping, fencing, transmission towers and lines, etc. Under certain viewing conditions, these reflective surfaces can give rise to specular reflections (glint and glare) that may be visible as spots of intensely bright light on the reflective surface or as flashes of bright light to moving observers. Additionally, power tower receivers can be a source of diffuse reflections. In some situations, these reflections could be visible for long distances, and could constitute a major source of visual impacts from utility-scale solar facilities. PV facilities can also give rise to glinting and glare that can be visible for long distances, but effects for PV facilities would be expected to be lower than those for trough, power tower, and solar dish systems. Specular and diffuse reflections are discussed in more detail in the technology-specific impacts descriptions in Section 5.12.2.

5.12.1.3.3 Roads. In many cases, construction access roads would not be needed during operations and would be reclaimed after construction. In some cases, certain roads would remain, such as the permanent maintenance roads and the permanent facility access roads. Maintenance roads (where needed) would generally be dirt or gravel roads, while some facility access roads might be paved. In addition to being cleared of vegetation, roads may introduce strong visual contrasts to the landscape, depending on the routes relative to surface contours and the widths, lengths, and surface treatments of the roads. Improper road maintenance could lead to the growth

of invasive species or erosion, both of which could introduce undesirable contrasts in line, color, and texture, primarily for foreground and near-middleground views.

5.12.1.3.4 Lighting. Solar energy facilities would include exterior lighting around buildings, parking areas, and other work areas. Security and other lighting around and on support structures (e.g., the control building) could contribute to light pollution. Maintenance activities conducted at night, such as mirror or panel washing, might require vehicle-mounted lights, which could also contribute to light pollution. Light pollution impacts associated with utility-scale solar facilities include skyglow, light trespass, and glare.

Skyglow is a brightening of the night sky caused by both natural and man-made factors. Skyglow decreases a person's ability to see dark night skies and stars, which is an important recreational activity in many parts of the southwestern United States, including BLM- and non-BLM lands within or near the six-state study area. Skyglow effects can be visible for long distances. Outdoor artificial lighting can contribute to skyglow by directing light directly upwards into the night sky and also through reflection of light from the ground and other illuminated surfaces.

Light trespass is the casting of light into areas where it is unneeded or unwanted, such as when light designed to illuminate an industrial facility falls into nearby residential areas. Poorly placed and aimed lighting can result in spill light that falls outside the area needing illumination.

Glare is the visual sensation caused by excessive and uncontrolled brightness and, in the context of outdoor lighting, is generally associated with direct views of a strong light source. Poorly placed and aimed lighting can cause glare, as can the use of excessively bright lighting.

These light pollution impacts from solar facilities could be reduced by shielding and/or other mitigation measures (see Section 5.12.3.1); however, any degree of lighting would produce some off-site light pollution, which might be particularly noticeable in dark nighttime sky conditions typical of the rural/natural settings within the six-state-study area.

For facilities with tall structures and for electric transmission towers associated with solar facilities, FAA guidelines for marking and lighting facilities could require aircraft warning lights that flash white during the day and at twilight and red at night (FAA 2007), or alternatively, red or white strobe lights flashing during the day and/or at night. Daylight lighting might be avoided in some cases by painting the tower orange and white according to FAA guidelines, but this practice could result in large increases in visual contrast for the tower during the day. Terrain, weather, and other location factors allow for adjustments to the manner in which FAA requirements are applied. FAA-compliant aircraft warning lights would be required for power tower receivers (or other structures) 200 ft (61 m) tall or higher and might be required in some circumstances for lower height structures.

The presence of aircraft warning lights could greatly increase visibility of the facilities and associated transmission lines at night in some locations, because the flashing red warning lights or strobes could be visible for long distances. In the dark nighttime sky conditions typical

of the predominantly rural/natural settings within the six-state study area, the warning lights could potentially cause large visual impacts, especially if few similar light sources were present in the area. Because of intermittent operation, however, marker beacons would not likely contribute significantly to skyglow. White lights in daylight conditions would likely be less obtrusive.

AVWSs are all-weather, day and night, low-voltage, radar-based obstacle avoidance systems that activate obstruction lighting and audio signals to alert pilots of potential collisions with obstacles such as power lines, wind turbines, bridges, and towers. The obstruction lights and audio warnings are inactive when there is no air traffic in the area of the obstruction. AVWS systems hold significant promise for reducing the night-sky impacts associated with aircraft warning lights on power towers because they would greatly reduce the duration of lighting use on power towers. Use of AVWS could be particularly effective in remote areas, where dark night skies are particularly valued, and where air traffic would generally be expected to be low in volume.

The FAA announced its approval for the use of AVWS for obstruction lighting on a case-by-case basis in June 2009 (FAA 2009). While AVWS has not yet been utilized for utility-scale solar projects, the deployment of these systems will likely substantially reduce potential night-sky impacts associated with solar power towers (and any other solar facility components requiring aircraft warning lighting) in the future.

5.12.1.4 Decommissioning/Reclamation

During decommissioning/reclamation, the immediate visual impacts would be similar to those encountered during construction but likely of shorter duration. These impacts likely would include road redevelopment, removal of aboveground structures and equipment, the presence of workers and equipment with associated dust and possibly other emissions and litter, and the presence of idle or dismantled equipment, if allowed to remain on-site. Deconstruction activities would involve heavy equipment, support facilities, and lighting. The associated visual impacts would be substantially the same as those in the construction phase but of shorter duration. Decommissioning likely would be an intermittent or phased activity persisting over extended periods of time and would include the presence of workers, vehicles, and temporary fencing at the work site.

Restoring a decommissioned site to pre-project conditions would also entail recontouring, grading, scarifying, seeding, and planting, and perhaps stabilizing disturbed surfaces. This might not be possible in all cases; that is, the contours of restored areas might not always be identical to pre-project conditions. In the arid conditions generally found in the six-state study area where utility-scale solar energy development is likely to occur, newly disturbed soils might create visual contrasts that could persist for many seasons before revegetation would begin to disguise past activity. Invasive species might colonize reclaimed areas, likely producing contrasts of color and texture. If a lack of proper management led to the growth of invasive species in the reseeded areas, noticeable color and texture contrasts might remain indefinitely. The unsuccessful

reclamation of cleared areas could also result in soil erosion, ruts, gullies, or blowouts, which could cause long-term negative visual impacts.

5.12.1.5 Transmission Lines and Roads

Construction and operation of electric transmission lines and upgrades to existing lines would be required for utility-scale solar energy development. However, the projected linear extent of the transmission facilities and voltage rating (and therefore tower size and substation size) would vary by project. Visual impacts associated with construction, operation, and decommissioning of the electric transmission facilities, as well as with line upgrades, would include temporary impacts associated with activities that would occur during the construction and decommissioning phases of the projects, and longer term impacts that would result from construction and operation of the facilities themselves.

Potential visual impacts that could result from construction activities include ROW clearing with associated debris; road building and upgrading; construction and use of staging areas and laydown areas; mainline and support facility construction; blasting of cavities for tower foundations; vehicular, equipment, and worker presence and activity; and associated vegetation and ground disturbances, dust, and emissions. During decommissioning (only to occur if transmission facilities were not still being used to carry other electrical loads), visual impacts would be similar to those encountered during construction but likely of shorter duration and generally occurring in reverse order from construction impacts.

Construction of an ROW typically requires clearing or selective removal of vegetation, large rocks, and other objects. Vegetation clearing and topographic grading would be required for construction of access roads, maintenance roads, and roads to support facilities (e.g., electric substations). Vegetation-clearing activities could cause visual impacts by creating contrasts in form, line, color, and texture with existing natural landscapes, depending on site-specific factors such as existing vegetation. Road development might introduce strong visual contrasts into the landscape depending on the route relative to surface contours and the width, length, and surface treatment of the roads. Construction access roads would be reclaimed after construction ended, but some visual impacts (e.g., vegetation disturbance) associated with them might be evident for some years afterward, gradually diminishing over time. Staging areas and laydown areas would be required for stockpiling and storing equipment and materials needed during construction. These areas may require vegetation clearing, may cover 2 to 30 acres (0.01 to 0.12 km^2), and may be placed at intervals of several miles along an ROW.

Transmission line construction activities include clearing, leveling, and excavation at tower sites as well as assembly and erection of towers followed by cable pulling. These activities would potentially have substantial but temporary visual impacts. Except for substations, because transmission facilities are linear, construction activities would generally proceed as a “rolling assembly line,” with a work crew gradually moving through an area at varying rates depending on circumstances.

The width of cleared area for the permanent ROW for a given project would be determined at a project-specific level. Cleared ROWs might open up landscape views, especially down the length of the ROW, and introduce potentially significant changes in form, line, color, and texture. While the opening of views for viewers close to a cleared ROW might in some circumstances be a positive visual impact, the introduction of strong linear and color contrasts from clearing of ROWs in mid-ground and background views could create large negative visual impacts, particularly in heavily vegetated or forested areas where either the viewer or the ROW is elevated such that long stretches of ROW are visible. Viewing angle could also be an important factor in determining the perceived visual impact in these settings. In worst-case situations, the impacts could be visible for many miles. Various design and mitigation measures could be used to avoid or reduce impacts in these situations.

Where visible, electric transmission and distribution towers could create potentially large visual impacts. Towers for utility-scale solar energy projects would generally range from 70 to 125 ft (21 to 38 m) in height. Towers would be constructed of metal, wood, or concrete and could be monopole or lattice structures. Transmission towers of both monopole and steel lattice construction are shown in Figure 5.12-1. The tower structures, conductors, insulators, aeronautical safety markings, and lights would all create visual impacts. Electric transmission towers would create vertical lines in the landscape, and the conductors would create horizontal lines that would be visible depending on viewing distance and lighting conditions. In the open landscapes present in much of the Southwest and under favorable viewing conditions, the towers and conductors might be easily visible for several miles, especially if skylined, that is, placed along ridgelines. A variety of mitigation measures could be used to reduce impacts from these structures, but because of their size, in many circumstances it is difficult to avoid some level of visual impact except at very long distances. A transmission line's visual presence would last from construction throughout the life of the project.

Electric transmission projects have associated ancillary structures that would contribute to perceived visual impacts. Electrical substations are located at the start and end points of transmission lines and would be required at locations where line voltage is changed. Substations vary in size and configuration but may be several acres in size; they are cleared of vegetation and typically surfaced with gravel. They are normally fenced, may include security lighting, and are reached by a permanent access road. Substations include a variety of visually complex structures, such as conductors, fencing, lighting, and other features, that result in an "industrial" appearance, with generally rectilinear geometry and potentially reflective surfaces. Substation facilities typically introduce strong visual contrasts in line, form, texture, and color where they are located in nonindustrial surroundings, particularly for nearby viewers. The industrial look of a typical substation, together with the substantial height of its structures (up to 40 ft [12 m] or more) and its large areal extent, may result in large negatively perceived visual impacts for nearby viewers.

As noted above, electric transmission towers associated with solar facilities could require aircraft warning lights. The presence of aircraft warning lights could greatly increase visibility of the transmission structures at night in some locations, because the lights could be visible for long distances. In the dark nighttime sky conditions typical of the predominantly rural/natural settings within the six-state study area, the warning lights could potentially cause large visual impacts, especially if few similar light sources were present in the area.

FIGURE 5.12-1 Transmission Towers: Lattice (left) and Monopole (right) (Source: Argonne 2007)

5.12.2 Technology-Specific Impacts

While the solar energy technologies analyzed in this PEIS have many common elements, such as large cleared areas with arrays of solar energy collectors, roads, support facilities, fences, and lighting, there are some important differences among the technologies that affect the potential visual impacts associated with utility-scale development utilizing these technologies. Differences among solar technologies that have the greatest potential to affect visual impacts include the type of solar energy collection equipment employed, and the presence or absence of STGs and associated facilities and processes for steam and water management. The following sections discuss potential visual impacts for parabolic trough systems, CLFR systems, power tower, dish engine, and PV power systems.

5.12.2.1 Parabolic Trough

A utility-scale parabolic trough system would typically occupy about 2,000 acres (8 km^2), depending on the project's power output, with about half of that area occupied by the

solar field, which would be cleared of vegetation and contain numerous rows of parabolic trough solar collectors, with the rows running north to south.

5.12.2.1.1 Solar Collector Arrays. The collectors consist of large curved reflectors; a receiver (in essence a steel tube encased by a glass tube) a few feet above the reflector and oriented parallel to the long axis of the reflector; supporting structures for both the reflector and the receiver; and additional pipes to transport HTF to and from the solar collectors. The height of the trough assembly (including ground clearance) would generally be between 18.2 and 24.5 ft (5.6 and 7.5 m), with taller arrays possible in the future as the technology matures (Moss 2009). A single-axis tracking system would allow the reflectors to tilt from east to west to track the sun's apparent movement across the sky, which would result in changes in orientation of the reflector over the course of a day. Several rows of parabolic trough collectors at a utility-scale solar energy project are shown in Figure 5.12-2.

The reflecting surface of the collector assembly is essentially a mirror and, as such, is highly reflective. Under certain conditions, when viewed from certain angles, specular reflection might result in glint or glare from these surfaces (Ho et al. 2010). The glint and glare can be observed from viewpoints either perpendicular to, or parallel to, the trough arrays. Depending on the angle of mirror tilt, the mirrors may also reflect the sky, clouds, vegetation, soil, and other landscape elements around the facility, which can cause dramatic differences in apparent color of the array (Sullivan et al. 2010). Diffuse and specular reflections from receiver tubes are also potential sources of glint and glare (ALUC 2010), as well as a variety of other visual effects (see discussion below). Other collector array components would primarily be metal and would also reflect light; however, reflectivity of these surfaces could be lessened through mitigation measures specifying low-reflectivity coatings.

As viewed from most ground-level locations outside the solar energy facility, because the facilities are located in flat landscapes, the solar collector array would generally be seen behind fencing and would present a very long, low horizontal profile. If seen from sufficiently far away, the solar collector array might be difficult to see or might appear as a thin line of contrasting color along the horizon. Depending on distance and viewing angle, the visual "line" of collectors might be broken by the buildings, tanks, condensers, and vapor plumes from the cooling tower(s) that would be of sufficient height to be visible above the collector array; in some situations, these elements can contribute substantially to visual contrasts from the facilities.

In flat landscapes and viewed from long distances, the line of collectors would tend to repeat the line of the horizon. This effect is evident in Figure 5.12-3. The viewpoint is slightly elevated relative to the facility; however, the strong horizontal line of the solar collector array is evident. For nearby viewers, the form and visual texture of the collectors would be visible, and the regular geometry of the collectors and their regular spacing, along with the hard reflective surfaces, would contrast with the natural forms, lines, and colors of the landscape. Depending on the colors used for the nonreflective surfaces of the collectors, color contrasts might be apparent as well.

FIGURE 5.12-2 Trough Collectors for the Parabolic Trough Facility, Kramer Junction, California (in addition to CSP, the facility also includes a natural gas–fired turbine located in the facility's power block; see background right) (Source: Hosoya et al. 2008)

FIGURE 5.12-3 Solar Field for Parabolic Trough Facility, Kramer Junction, California (Credit: Argonne National Laboratory)

Where viewers were elevated, more of the facility would be visible, and depending on viewer angle, the very large areal extent of the facility might be apparent, which could increase visual contrasts substantially. The tops of the collectors would be visible, and more glint and glare from reflective surfaces might be seen in certain circumstances. The strong and unnatural-appearing geometry of the rows of collectors could become more apparent, along with any color contrast between the collectors and the ground surface. Proportionally more of the ancillary facilities would be visible as well. Figure 5.12-4, a photograph of a parabolic trough facility from a slightly elevated viewpoint, clearly shows the strong forms, lines, and colors of the solar collector array as well as the buildings, tanks, and other structures of ancillary facilities rising above the collector array in the distance.

The appearance of the parabolic trough collector array would be affected by site- and project-specific factors. For viewers facing the mirrors from long distances on a sunny day, the solar array could visually resemble a lake because the array would be reflecting the blue of the sky. This effect is evident in Figure 5.12-5, a photograph of a distant utility-scale solar trough project. On a cloudy day, the reflections would tend to be grayer. Viewed from behind (facing the backs of the mirror arrays), the highly reflective collector surfaces would not be visible, which would tend to reduce the contrast with the surrounding landscape (Beacon Solar, LLC 2008); however, Sullivan et al. (2010) observed that even the backs of collector arrays can

FIGURE 5.12-4 Parabolic Trough Facility from an Elevated Viewpoint (Credit: Argonne National Laboratory)

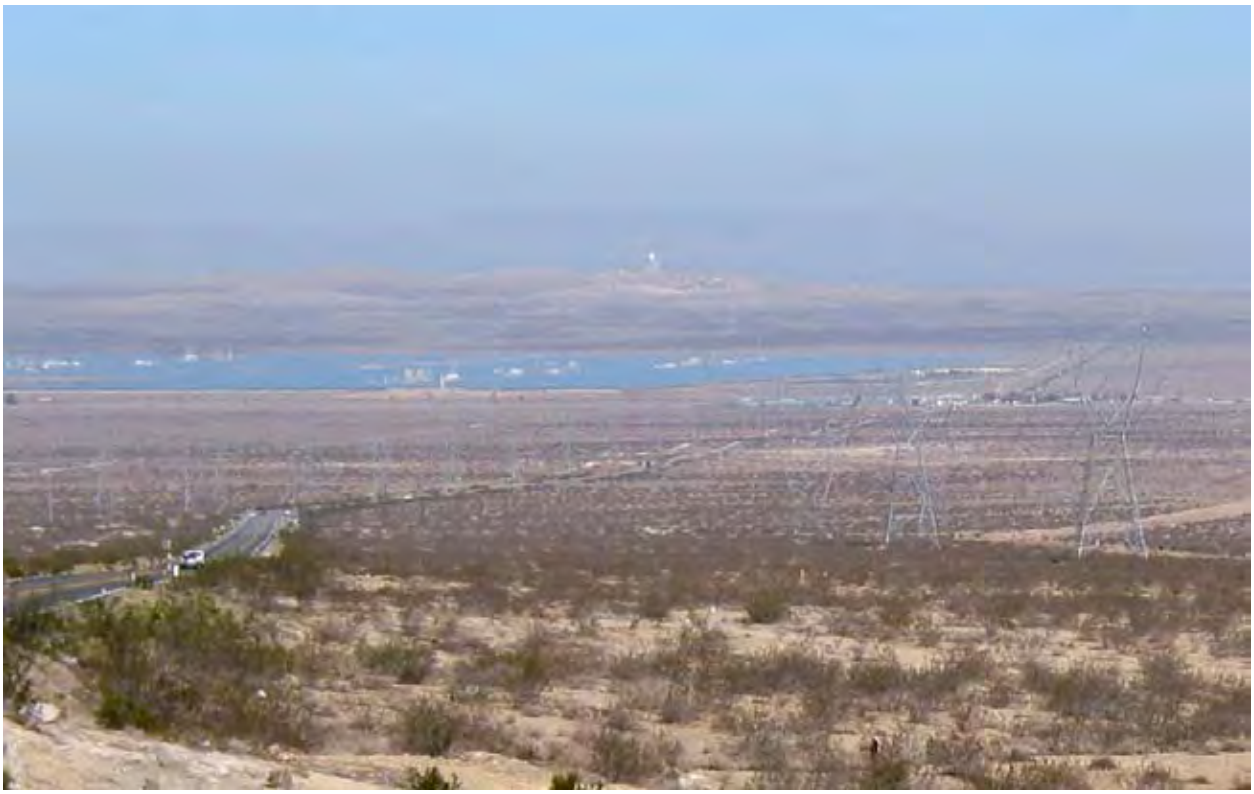

FIGURE 5.12-5 Distant View of Parabolic Trough Facility (Credit: Argonne National Laboratory)

create contrast levels visible for long distances. These contrasts could likely be reduced by painting the support structures to blend with the background, using nonreflective coatings, and by applying similar mitigation measures.

Tracking the apparent movement of the sun across the sky, the collectors would slowly rotate from east to west, and their appearance would change over the course of the day. Reflections from sunlight on the reflective surfaces and other surfaces could give rise to glinting, glare, and other visual effects that would also vary depending on mirror orientation, sun angle, viewing angle, viewer distance, and other visibility factors. Ho et al. (2010) provides methodology for quantitative assessment of glare for parabolic trough facilities. Systematic field-based studies of glare and other visual effects from solar trough facilities are not available, but Sullivan et al. (2010) visited solar trough facilities in Nevada and California to observe their general visual characteristics and found that facilities exhibited highly dynamic visual characteristics, including glare, color changes, geometric patterns of lines and points of light, and scintillations. Environmental studies for current solar trough applications have also discussed glare effects from trough facilities (Beacon Solar, LLC 2008; BLM and CEC 2010a), in some cases based in part on observations from the same facilities observed by Sullivan et al. (2010).

Sullivan et al. (2010) observed strong glare from two solar trough facilities during site visits in April 2010. Glare was observed from the front, sides, and tops of parabolic trough arrays from mid-morning through mid-afternoon, at distances ranging from 0.1 to approximately 3.6 mi

(0.16 to 5.8 km) from the facilities. Glare was observed from viewpoints approximately level with the facilities as well as elevated viewpoints, with the strongest glare observed from an elevated viewpoint at approximately 2.0 mi (3.2 km) distant from the facility, facing the trough array front from the east at mid-afternoon, as shown in Figure 5.12-6. In this instance, glare from the facility was strong enough to cause flash blindness and visual discomfort after a brief glance and prevented viewers from looking directly at the facility for more than a few seconds. Glare effects were highly dependent on precise viewer location, with glare varying widely as viewers moved short distances along the front of the facility.

In addition to glare, Sullivan et al. observed a variety of other visual effects from some viewing locations at various times, including geometric patterns of points of light on the tops and sides of the collector arrays, which sometimes scintillated actively, with or without viewer movement. Other effects observed included prominent bands of light running perpendicular to the trough rows, as shown in Figure 5.12-7. These light sources were believed to be associated with reflections from HTF tubes visible in gaps between adjacent mirrors. The associated scintillations that were observed strongly attracted visual attention, but the light sources were insufficiently bright to cause visual discomfort, and were regarded as novel visual phenomena that could be perceived as positive visual impacts by some viewers.

The apparent color of one facility's trough array ranged from black to silvery white but sometimes appeared gray, blue, or even green, depending in part on mirror orientation. A 400-acre (1.6-km^2) facility was clearly visible at 12 mi (19 km) in particular lighting conditions

FIGURE 5.12-6 Glare from Parabolic Trough Facility at Distance of 2.0 mi (3.2 km) (Credit: Argonne National Laboratory)

FIGURE 5.12-7 Visual Effects from Parabolic Trough Facility (Left and Right Center) (Credit: Argonne National Laboratory)

but nearly indistinguishable from the background from 7 mi (11 km) under different visibility conditions and viewing angle. Strong reflections were also observed from control buildings, STGs, and associated facilities, and plumes from gas boilers and cooling towers also contributed substantially to observed visual impacts in some situations. The power block was plainly visible from slightly elevated positions at approximately 8.5 mi (13.7 km) from the facility.

These results, though not conclusive, suggest that the visual effects associated with parabolic trough solar facilities can be complex, dynamic, and project-specific and that trough facilities may cause strong glare visible for several miles (at least), under a variety of viewing conditions and settings, and at various times of day. These findings might also be applicable to other types of solar facilities with highly polished surfaces, but further studies are needed.

5.12.2.1.2 Power Block and Ancillary Facilities.

STG and Support Equipment

Solar energy projects utilizing parabolic trough technology require the use of STGs and support equipment for generating steam, generating electricity from the steam, steam cooling, recycling, and transporting water and steam. Facilities associated with STGs include a building for housing the STG, a cooling tower, condensers, tanks for water and other chemicals, pipes for steam and water transport, and one or more evaporation ponds. Depending on surface treatment, these structures may cause reflections visible for long distances, but mitigation measures could substantially reduce these impacts.

The STG building (approximately 60 ft [18.3 m] in height), condensers (approximately 115 ft [35 m] in height), and cooling tower (approximately 40 ft [12.2 m] in height) would be sufficiently large and/or tall to be noticeably higher than the collector array, and thus would be visible in most views of the facility. In certain circumstances, a water vapor plume could be visible extending from the cooling tower or from gas boiler stacks; no plume would be present in some viewing situations (Beacon Solar, LLC 2008); generally under hotter and drier conditions. Figure 5.12-8, a photograph of the power plant at a commercial parabolic trough solar energy facility, shows several buildings, a cooling tower with plume, and water tanks. Sullivan et al. (2010) observed that plumes and other power blocks contributed substantially to visual contrasts from solar trough facilities at short distances with low angle views where the facilities projected above the collector array and the plume is clearly visible.

Thermal Energy Storage (TES) Facilities

If the facility included TES, additional structures would be present on-site. These structures would include large vertical (40 to 50 ft [24.4 to 30.5 m]) and horizontal tanks for storage of salts or other HTFs, pumps, heat exchangers, and additional piping for fluid transport.

FIGURE 5.12-8 Power Plant at Commercial-Scale Parabolic Trough Facility (Credit: Sandia National Laboratories; Source: NREL 2009a)

Natural Gas Boilers and Other Facilities

Parabolic trough projects would normally include one or more natural gas boilers and a diesel-fueled generator. The boilers could create visible plumes. In some cases, this equipment might be housed inside buildings and would therefore not be visible from outside the project facility.

5.12.2.2 Compact Linear Fresnel Reflector

Potential visual impacts from solar energy projects utilizing CLFR technology would be very similar to the impacts expected for parabolic trough systems; however, the solar energy collectors differ in some respects, and the system makes steam directly, rather than using HTF, resulting in some reduction in ancillary facilities. The Fresnel reflectors utilized for CLFR systems are typically lower in height than parabolic trough collectors, so that the vertical profile of the reflecting surface array is slightly lower; however, the receiver could be as high or higher than that for a standard parabolic trough system. Figure 5.12-9 is a close-up of a portion of a commercial CLFR array. The lack of HTF would result in fewer fluid storage tanks and related ancillary equipment such as natural gas boilers, which might reduce "visual clutter" associated with these facilities if they would otherwise have been located outside of a building.

5.12.2.3 Power Tower

Like parabolic trough systems, power tower systems utilize HTF to transfer heat to steam that is used to operate an STG to make electricity. Visual impacts associated with the STG and

FIGURE 5.12-9 Commercial CLFR Solar Array (Source: DOE 2009)

support equipment and TES, natural gas boilers, and other facilities are similar for the two systems. However, power tower systems use a significantly different approach to solar energy collection than parabolic trough or CLFR systems, and the visual impacts associated with the power tower solar energy collection facilities are greater than for either the parabolic trough or CLFR systems.

Power tower systems utilize receivers typically positioned at the tops of one or more towers located at the centers of arrays of heliostats, which are large, nearly flat mirrors. Power tower projects would be expected to occupy significantly more land per megawatt of rated power output than parabolic trough or CLFR projects, with utility-scale power tower projects expected to require about 3,600 acres (15 km^2), depending on power output.

5.12.2.3.1 Heliostats. Heliostats can take a variety of shapes and sizes but would generally consist of large, nearly flat mirrors on a pedestal or other support structure. Heliostats could be mounted singly or in arrays. Figure 5.12-10 shows an array of mounted heliostats; however, not all heliostat arrays would necessarily be as large as the one shown in the figure. Large numbers of heliostats or heliostat arrays would be placed in locations around the tower to reflect sunlight onto the receiver. The heliostats would be placed in a more or less geometric pattern (i.e., curved or straight rows), creating a strong horizontal line when viewed from far away and a repeating pattern of structures when viewed close-up.

FIGURE 5.12-10 Heliostats for a Solar Power Tower (Credit: W. Getz; Source: NREL 2009b)

The reflecting surface of the heliostat is essentially a mirror and, as such, is a highly reflective surface. Where visible, mirror faces could display highly variable surface color and brightness. Viewed from certain angles, specular reflection might result in glint or glare from these surfaces, particularly from elevated viewpoints. Heliostats would in most cases surround the power tower receiver on all sides, often in a circular configuration. When this heliostat configuration is used, some portion of the heliostat field would face viewers regardless of their direction of view, which could increase the potential for glinting and glare from the heliostats. The heliostat supports would be primarily metal and would also reflect light; however, reflectivity of these surfaces could be lessened through mitigation measures specifying low-reflectivity coatings.

The Ivanpah Solar Electric Generating System Draft EIS (BLM and CEC 2009) analysis found that solar radiation and light reflected from the proposed project's heliostats could cause a significant human health and safety hazard to observers in vehicles on adjacent roadways or air traffic flying above the site. The analysis also found that the project's heliostats could cause a distraction of drivers, leading to road hazards, and of pilots of aircraft flying over the site.

5.12.2.3.2 Towers. The towers used for power tower solar energy collection are very tall structures with a wide range of possible heights. Tower heights for operational and currently proposed power towers range from approximately 150 to 650 ft (46 to 198 m), and even taller structures are likely in the future as the technology matures (Kolb 2009). At these heights, they would project well above the heliostats and any other facilities on the project site and would be expected to be visible for long distances under normal circumstances. The form, color, and surface treatment would vary by project. The height and strong vertical line of the tower would contrast sharply with the generally horizontal line of the collector array and also with the generally flat landscapes in which utility-scale solar energy projects would be located. Figure 5.12-11 shows a power tower and surrounding heliostats from the Solucar PS10

FIGURE 5.12-11 Solucar (Spain) Solar Power Tower and Heliostats, with Visible Dust Particle "Tent"(Source: Flickr 2009)

commercial solar facility in Sanlúcar la Mayor, near Seville, Spain, and Figure 5.12-12 shows power tower receivers and heliostats for the eSolar Sierra Suntower facility near Lancaster, California.

In addition to visual impacts from the tower structure, the sunlight focused on the tower's receiver by the heliostats during normal operations would cause parts of the receiver to appear to glow with sufficient intensity to be visible for long distances; however, the apparent glow is actually diffuse reflected sunlight. This effect is evident in Figure 5.12-12, and the tower receivers can appear brilliantly white at close distances (Sullivan et al. 2010). The Ivanpah Solar Electric Generating System Draft EIS (BLM and CEC 2009) found that the solar receiver units on the solar power towers for the proposed projects would generate conspicuously bright levels of glare, although they did not constitute a health hazard.

In addition, during certain times of the day from certain angles, the reflection of sunlight on ambient dust particles in the air could sometimes result in the appearance of light streaming down from the tower in a luminous, transparent, tent-like form. This effect is evident in Figure 5.12-11.

Systematic field-based studies of glare and other visual effects from solar power tower facilities are not available, but Sullivan et al. (2010) observed the eSolar Sierra Suntower power tower facility in Lancaster, California, over a period of several days in April 2010. The facility includes two 5-MW power tower receivers atop 175-ft (53.3-m) towers, shown in Figure 5.12-12. The light from the power tower receivers was faintly visible at a distance of 19.5 mi (31.4 km) under very hazy conditions and was visible from a far greater distance than the rest of the facility, though the heliostat field was screened from view by intervening terrain and/or fencing. The receiver light was steady, without twinkling or other scintillations.

FIGURE 5.12-12 Solar Power Towers and Heliostats at the eSolar Sierra Suntower Facility in Lancaster, California (Source: eSolar 2010)

The power towers were judged to strongly attract visual attention at a distance of approximately 7 mi (11 km), with details of tower structures visible at approximately 5 mi (8 km) and some visual discomfort after prolonged viewing at approximately 4 mi (6.4 km). Under cloudy conditions, with unlit receivers, the tower structures were visible at a distance of approximately 13 mi (21 km). Note that power towers could be up to 650 ft (198.1 m) tall and of much higher power output than the Sierra Sun Towers observed in this study. This would cause them to be brighter than the eSolar Sierra Suntowers (Ho 2010) and presumably visible at greater distances than the Sierra Suntowers, potentially substantially greater distances.

For power towers more than 200 ft (61 m) tall, FAA guidelines for marking and lighting facilities could require aircraft warning lights that flash white during the day and at twilight and red at night (FAA 2007) or, alternatively, red or white strobe lights that flash during the day and/or at night. Daylight lighting might be avoided in some cases by painting the power tower orange and white according to FAA guidelines, but this practice could result in large increases in visual contrast for the tower during the day. Terrain, weather, and other location factors allow for adjustments to the manner in which FAA requirements are applied.

At night, the presence of aircraft warning lights could greatly increase visibility of power towers in some locations, as the flashing red warning lights could be visible for long distances. In the dark nighttime sky conditions typical of the predominantly rural/natural settings within the PEIS region of analysis, the warning lights could potentially cause large visual impacts, especially if few similar light sources were present in the area. White lights in daylight conditions would likely be less obtrusive.

5.12.2.4 Dish Engine

Unlike parabolic trough, CLFR, and power tower systems, dish engine systems do not use STGs for steam-powered electricity generation. Thus, they do not require the variety of buildings, tanks, evaporating ponds, and other facilities associated with STGs, HTFs, and cooling water and steam management. The absence of STGs and related facilities would substantially reduce the visual impacts associated with those facilities, including potential water vapor plumes from a cooling tower, which would not be present. Like the other systems, however, a dish engine project would include an administration building, a maintenance building, a component assembly building, guardhouse and other small structures, some tanks for water and other fluids, and electrical components. Except for the larger buildings, few, if any, of these facilities would likely be of sufficient height to be visible from ground level outside of the facility, because they would be screened by the dish engine units.

Solar dish engine units resemble backyard satellite dishes but are much larger. With the support pedestal, dish engine units would be expected to be approximately 38 ft (11.5 m) high and nearly as wide, with larger units possible for future projects as the technology matures (Andraka 2009). Tens of thousands of the units might be used for a utility-scale facility, and a large dish engine project would occupy several thousand acres. Units would be placed in evenly spaced rows, creating a strong horizontal line when viewed from far away and a repeating pattern of structures when viewed close-up. Because of the 38-ft (11.5-m) solar dish height, rows of

solar dishes have greater potential than the other solar technologies discussed in this PEIS for blocking views for nearby viewers. The large surfaces of the dishes may reflect the sky and clouds, potentially creating strong color contrasts with the surrounding landscape, particularly for elevated viewers. This effect is evident in Figure 5.12-13, which shows several solar dish engines.

The reflecting surface of the solar dish engine is essentially a mirror and as such is a highly reflective surface. Viewed from certain angles, reflections from the mirrors might result in glint or glare from these surfaces, particularly from elevated viewpoints. In certain conditions (discussed below) direct specular reflections could be visible from the mirrors, and while direct specular reflections would be blocked by the power conversion units (PCUs) under normal operating conditions, the mirrors could also show very bright reflections in the portions of the mirror visible around the PCUs. In addition, as a result of the intense sunlight focused on it by the mirror, diffuse reflection of sunlight on the PCU itself could be visible from some viewpoints. The Calico Solar Project Draft EIS (BLM and CEC 2010b) found that the SunCatcher solar dish engines proposed for use in that project could in some situations pose a visual hazard to motorists on nearby roadways and travelers on a nearby railway as well.

In a glint and glare study conducted for the proposed Imperial Valley Solar Project, Power Engineers (2010) found that direct specular reflection from the solar dishes (defined in the study as "glint") would not occur when the dishes were in their normal tracking position, but could occur when mirrors were in night stow to operational transitions; moving into wind stow position; malfunctioning; or when performing offset tracking during times with cloud cover. The study noted that in some instances, glint could potentially also be visible for viewers in elevated locations when mirrors were in wind stow position. The study found that a flashing effect could occur for drivers viewing rows of the solar dishes while driving past the facility, but only when the dishes were in offset tracking mode or in night stow to operational transition in the morning,

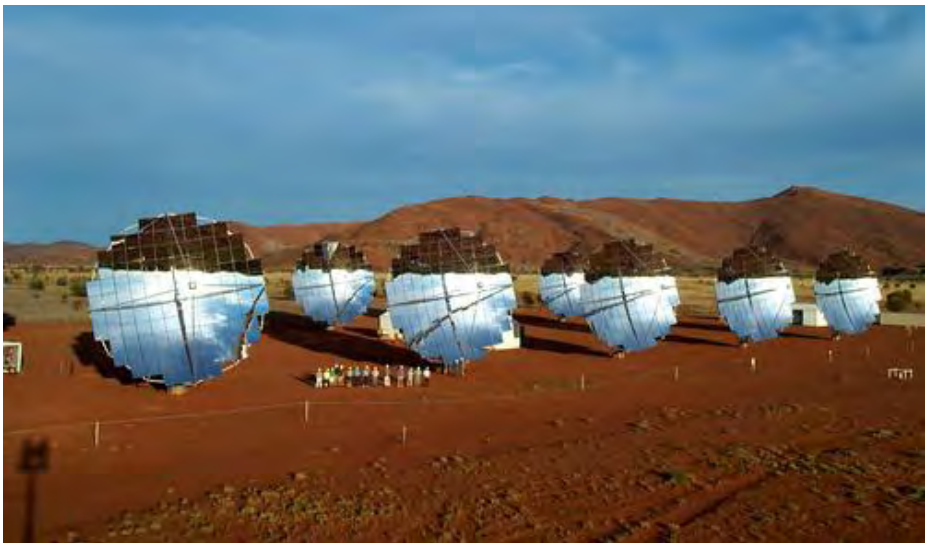

FIGURE 5.12-13 20-kW Solar Dish Engine Units in Alice Springs, Australia (Credit: R. McConnell; Source: NREL 2009c)

and would be a relatively rare occurrence. When glinting occurred, it was visible in the uppermost portion of the dish mirrors.

The study also found that when the dishes were in normal tracking mode, bright diffuse reflections (defined in the study as "glare") could be visible on the PCUs. The reflections could be visible during normal operations when the dishes were viewed from behind or from the side.

The study found that at this facility, a 20-ft (6-m) slatted fence placed around the facility would be ineffective as a mitigation measure for most of the conditions noted above, but that changing the angle of the mirrors during offset tracking mode, as well as adjusting some stow tracking positions could reduce or eliminate glinting effects.

In addition to impacts from mirror reflections, the solar dish pedestals would be primarily metal and would also reflect light; however, reflectivity of these surfaces could be lessened through mitigation measures specifying low-reflectivity coatings.

5.12.2.5 PV Systems

Like solar dish systems, solar PV projects do not use STGs for steam-powered electricity generation, and, therefore, do not require the variety of buildings, tanks, evaporating ponds, and other facilities associated with STGs, HTFs, and cooling water and steam management. The absence of STGs and related facilities would reduce the visual impacts associated with those facilities, including potential water vapor plumes from a cooling tower, which would not be present. Like the other systems, however, a PV project would include an administration building, a maintenance building, a component assembly building, guardhouse and other small structures, some tanks for water and other fluids, and electrical components. Because PV panels are generally low to the ground, usually less than 10 ft (3.0 m), most buildings, some tanks, and possibly other facilities would protrude above the collectors and would be visible from outside the facility. Dual tracking panels or concentrating PV collectors might be somewhat taller (15 ft [4.6 m] or more) and would screen slightly more of the other facilities. Figures 5.12-14 and 5.12-15 show panel arrays; Figure 5.12-15 includes human figures to facilitate scale comparison.

PV facilities contain PV panels in rectangular arrays mounted on either simple fixed mounts that tilt the panels toward the midday sun or more complex sun-tracking systems that might add slightly to the visual impact, depending on the technology employed and its configuration. Concentrating PV collectors are generally larger and taller than conventional PV panels, and because precise tracking of the sun is essential to obtain the best performance, concentrating PV collectors use more advanced tracking systems that, in some cases, may add to the visual complexity of the system. In general, the low profile of the solar panels would reduce their visibility (relative to the other solar technologies analyzed in this PEIS) when viewed from low viewing angles, especially from longer distances. When viewed from elevated positions, more of the facility would be visible, and the regular geometry of the panel arrays would be more apparent, resulting in substantially larger visual impacts.

FIGURE 5.12-14 PV Panels, Nellis Air Force Base, Nevada (Credit: Argonne National Laboratory)

FIGURE 5.12-15 PV Panels, Sacramento Municipal Utility District, Hedge Substation (Credit: Sacramento Municipal Utility District; Source: NREL 2009d)

Unlike the other solar energy systems analyzed in this PEIS, PV panel surfaces are not designed to reflect light, and being significantly less reflective than the mirrored surfaces of the solar collectors for the other technologies, they would likely reduce the potential for glint and glare; however, the panels and other components do reflect light that could result in glinting, glare, and other visual effects that would also vary depending on mirror orientation, sun angle, viewing angle, viewer distance, and other visibility factors. In a manner similar to parabolic trough facilities (see discussion in Section 5.12.2.1.1), PV facilities may vary substantially in their appearance, depending on viewer location and other visibility factors. Chiabrando et al. (2009) discuss glare impacts associated with a hillside PV facility in Italy and provide a methodology for calculating glare from PV panels.

Sullivan et al. (2010) observed glare from a slightly elevated viewpoint at a distance of approximately 2 mi (3.2 km) from panels and ancillary components at a partially built PV facility in Nevada. The observations were made at approximately 6 p.m. from a viewing location east of the facility, during a site visit in April 2010. In addition, the apparent color of the panels varied from black to gray to silvery white, depending on viewer location and other visibility factors.

Vieira (2010) reported repeated instances of short-duration glinting/glare from a small (approximately 100-acre [0.4-km^2]) PV facility in the San Luis Valley in southern Colorado. The viewing location was approximately 20 mi (32 km) east of the facility, and the glare was observed during the morning. Vieira reported that the glare “attracted visual attention and was momentarily annoying.”

5.12.3 Potentially Applicable Mitigation Measures

The nature, extent, and magnitude of visual impacts from utility-scale solar facilities will vary on a site-specific basis and depend on the specific phase of the project (e.g., construction or operation). Similarly, visual impact mitigation measures will vary on a site-specific basis and depend on the specific phase of the project.

The BLM and DOI, as well as other federal agencies such as the USFS, have established mitigation measures for visual impacts of energy production, transmission, roads, and other forms of development on federal lands of the western United States. Several of their publications (BLM 1984, 1985, 1986a,b, 1992, 2006b, 2008b; DOI and USDA 2006; USFS 1975, 1977, 2001) were the primary sources for the mitigation measures listed in this section. Additional mitigation measures were identified in Stirling Energy Systems’ Application for Certification, submitted to the BLM (SES Solar Two, LLC 2008). These publications describe additional mitigation measures and provide related information.

This section presents potential mitigation measures applicable to utility-scale solar energy projects and associated electricity transmission projects and potential mitigation measures specific to electricity transmission projects. Solar energy development and related activities proposed on BLM-administered lands and connected actions should abide by VRM policies and procedures defined in Visual Resource Management Manual M-8400 and handbooks, Visual Resource Inventory H- 8410-1, and Visual Resource Contrast Rating H-8431-1. Other

policy requirements and clarifications are available in Instructional Memorandums 98-164 and 2009-167 (BLM 1998, 2009b).

5.12.3.1 Siting and Design

The greatest potential for visual impact mitigation associated with a utility-scale solar energy project and associated electricity transmission facilities occurs as a result of decisions made during the siting and design of the project. Visual impacts can be substantially reduced or avoided by careful project siting.

The BLM RMPs designate VRM Classes I–IV, which establish objectives for managing allowable levels of visual change to the landscape. Solar development and related activities are required to meet the VRM Class objectives. Project developers should consult the VRM Class designations and associated management objectives during the early phases of project planning, including those related to project due diligence, site selection, planning, and design. It is the developer's responsibility to conduct an early investigation into the respective project's compatibility with the VRM Class objectives, and the potential that these objectives can be met by applying thoughtful and creative design principles. Project developers should document and demonstrate how the visual management objectives were factored into the various phases of project planning and decision rationale.

The BLM Visual Resource Inventory (VRI) class values, including those for Scenic Quality, Sensitivity, and Distance Zones, should also be factored into the project planning, design, and decision making. Project developers should demonstrate how the visual values influence project design and document how impacts on these values are minimized through consideration for the proposed project location and its relationship to the surrounding viewshed. This information should be included as a part of the critical due diligence information considered when determining and selecting solar development sites and ROW boundaries. ROW location, size, and boundary determinations should consider terrain characteristics and opportunities for full or partial project concealment by recessing the project into the landscape terrain.

Project developers should consult with the BLM in the early phases of project planning to help determine the proposed project's potential conformance to the applicable RMP's VRM Class designation and other potential constraints, thus avoiding costly unforeseen planning implications and re-design.

A qualified and licensed professional landscape architect with demonstrated experience with the BLM's VRM policies and procedures should be a part of the developer's and the BLM's respective planning teams evaluating visual resource issues as project siting options are considered. The visual issues should be addressed throughout the planning and design process and the final project plans should reflect intended methods for mitigating visual impacts.

The appropriate BLM field office and locally based public should be consulted to provide input on identifying important visual resources in the project area and on the siting and design process. The public should be involved and informed about the visual site design elements of the

proposed solar energy facilities. Possible approaches include conducting public forums for disseminating information, offering organized tours of operating solar energy development projects, and using computer and visualization simulations in public presentations.

Project developers should also consult on viewshed protection objectives and practices with the respective land management agencies that have been assigned administrative responsibility for landscapes having special designations, such as Wilderness Areas, National Scenic and Historic Trails, Wild and Scenic Rivers, etc., and National Parks and National Wildlife Refuges located within the project's viewshed. Developers should demonstrate a concerted effort to reconcile conflicts while recognizing that the BLM retains authority for final decisions determining project approval and conditions.

The following are specific to National Historic Trails, but possibly pertain to other specially designated lands, such as Wild and Scenic Rivers, Wilderness Areas, National Parks, and National Wildlife Refuges:

- For applications that include artifacts and remnants of a National Historic Trail, are located within the viewshed of a National Historic Trail's designated centerline, or include or are within the viewshed of a trail eligible for listing on the *National Register of Historic Places* (NRHP) by virtue of its important historical or cultural values and integrity of setting, the applicant should evaluate the potential visual impacts on the trail associated with the proposed project; minimize, avoid, or mitigate adverse effects through the Section 106 consultation process; and identify appropriate mitigation measures for inclusion as stipulations in the Plan of Development (POD). This requirement does not supersede or amend National Historic Trails requirements cited in other sections, but is in addition to and supportive of them.

- Because the landscape setting observed from units of the National Park system, national historic sites, national trails, and Tribal cultural resources may be a part of the historic context contributing to the historic significance of the site or trail, project siting should avoid locating facilities that would alter the visual setting in a way that would reduce the historic significance or function, even if compliant with VRM objectives. This requirement does not supersede or amend national historic sites, national trails, and Tribal cultural resources requirements cited in other sections, but is in addition to and supportive of them.

Project developers should obtain engineering-design-quality topographical data and use digital terrain-mapping tools at a landscape-viewshed scale for project location selection, site planning and design, visual impact analysis, and visual impact mitigation planning and design. Visual mitigation planning and design should be performed through field assessments, applied global positioning system (GPS) technology, photo documentation, use of computer-aided design and development software, three-dimensional GIS modeling software, and imaging software to depict visual simulations to reflect a full range of visual resource mitigation measures. The digital terrain-mapping tools should be applied at a resolution and contour interval suitable for

site design and accurate placement of proposed developments into the digital viewshed. Visual simulations should be prepared and evaluated in accordance with *Visual Resource Contrast Rating* in BLM Handbook H-8431-1 (BLM 1986b) and other agency directives, to create spatially accurate depictions of the appearance of proposed facilities. Simulations should depict proposed project facilities from key observation points (KOPs) and other visual resource-sensitive locations.

The siting and design of solar facilities, structures, roads, and other project elements should explore and document design considerations for repeating the natural form, line, color, and texture of the existing landscape in accordance and compliance with the VRM class objectives.

The full range of visual BMPs should be considered, and plans should incorporate all pertinent BMPs. Visual resource monitoring and compliance strategies should be included as a part of the project mitigation plans to cover the construction, operation, and decommissioning phases.

Conformance with VRM objectives should be determined through the use of the BLM contrast rating procedures defined in *Visual Resource Contrast Rating* in BLM Handbook H-8431-1 (BLM 1986b). Visual contrast rating mitigation of visual impacts should abide by the requirements outlined in the handbook and other BLM directives. Plans for facilities determined not to be in conformance with VRM objectives should not be approved or should be redesigned in order to meet the VRM objectives, and updated visual simulations should be prepared. Revised project plans and simulations should be re-evaluated using the Contrast Rating procedures and repeated until the proposed action is found to be in conformance.

KOPs should be selected by first determining the extent of the viewshed by using the viewshed modeling tools previously cited. The viewshed modeling should illustrate the areas from where proposed facilities may be seen out to 25 mi (40 km)—line-of-sight measured from the top elevations of facilities out to 5.5 ft (1.7 m) above the ground terrain. From within the areas, KOPs would then be selected at places where people would be expected—at roads, trails, campgrounds, recreationally active river corridors, residential areas, etc. For the purpose of conducting a visual contrast rating evaluation, the number of KOPs would be reduced to those that serve as the best representations for demonstrating conformance to the respective VRM class objectives. The BLM must approve KOP selections, and the BLM reserves the right to require additional KOPs to further determine the extent of visual impact and conformance to VRM class objectives.

Visual design elements should be integrated into the construction plans, details, shop drawings and specifications; these should include, but not limited to, grubbing and clearing, vegetation thinning and clearing, grading, revegetation, drainage, and structural plans. Visual design elements within the plans should be measureable and monitored while under construction, while operational, and when decommissioned. The plans should include a monitoring and compliance plan that establishes the monitoring requirements and thresholds for acceptable performance. The contrast rating procedures should also be integrated as field-measuring compliance tools during operation and after decommissioning.

The following specific project siting measures can help reduce visual impacts of solar energy development projects and associated, but independent facilities. Project planning and designs should demonstrate the relevance and application of all BLM visual BMPs to the specific project, including, but not limited the following considerations.

Viewshed-Based Site Selection and Siting

- Project developers should exhaust opportunities to minimize visual dominance of projects by siting projects outside the viewsheds of KOPs, or by siting them as far away as possible, diminishing dominance by maximizing visible separation with distance.

- Facility siting should incorporate measures to minimize the profile of all facility-related structures to reduce visibility and visual dominance within the viewshed, particularly for facilities proposed within the foreground/ middleground distance zone (0 to 5 mi [0 to 8 km]) of sensitive viewing locations with extended viewing opportunities and/or moving viewpoints, including, but not limited to National Scenic Byways, All-American Roads, State Scenic Byways and BLM Backcountry Byways, SRMAs, trails, residential areas, etc.

- Siting should take advantage of both topography and vegetation as screening or partial screening devices to interrupt and restrict the views of projects from KOPs and visually sensitive areas.

- Locating of facilities near visually prominent landscape features (e.g., knobs and waterfalls) that naturally draws an observer's attention should be avoided.

- Visual "skylining" should be avoided by placing structures, transmission lines, and other facilities away from ridgelines, summits, or other locations where they would silhouette against the sky from important viewing locations. Siting should take advantage of opportunities to use topography as a backdrop for views of facilities and structures to avoid skylining. Alternatives should be evaluated, and the least visually intrusive option should be selected when linear facilities (e.g., transmission lines) cross over ridgelines.

- Siting of linear features (e.g., ROWs and roads) should follow natural land contours rather than straight lines, particularly up slopes. Fall-line cuts should be avoided. Following natural contours echoes the lines found in the natural landscape and often reduces cut-and-fill requirements; straight lines can introduce conspicuous linear contrasts that appear unnatural.

- Linear developments (e.g., transmission lines, pipelines, and roads) should follow the edges of natural clearings or natural lines of transition between vegetation type, topography, etc. (where they would be less conspicuous), rather than passing through the center of clearings.

Reduction of Surface Disturbance, Grading and Edge Treatments

- In visually sensitive areas, air transport capability shall be used to mobilize equipment and materials for clearing, grading, and erecting transmission towers, thereby preserving the natural landscape conditions between tower locations and reducing the need for permanent and/or temporary access roads.

- Vegetation and ground disturbance should be minimized and take advantage of existing clearings.

- Structures and roads should be designed and located to minimize and balance cuts and fills. Retaining walls, binwalls, half bridges, and tunnels should be used to reduce cut-and-fill.

- Road-cut slopes should be rounded, and the cut-and-fill pitch should be varied to reduce contrasts in form and line; the slope should be varied to preserve specimen trees and nonhazardous rock outcroppings.

- Natural or previously excavated bedrock landforms should be sculpted and shaped when excavation of these landforms is required. Percent backslope, benches and vertical variations should be integrated into a final landform that repeats the natural shapes, forms, textures, and lines of the surrounding landscape. The earthen landform should be integrated and transitioned into the excavated bedrock landform. Sculpted rock face angles, bench formations, and backslopes need to adhere to the natural bedding planes of the natural bedrock geology. Half-case drill traces from presplit blasting should not remain evident in the final rock face. The color contrast from the excavated rock faces should be removed by color treating with a rock stain. Native vegetation (where feasible), or a mix of native and non-native species (if necessary to ensure successful revegetation) should be re-established with the benches and cavities created within the created bedrock formation.

- Where screening topography and vegetation are absent or minimal, natural-looking earthwork landforms, vegetative, or architectural screening should be used to minimize visual impacts. The shape and height of earthwork landforms must be adapted to the surrounding landscape, and must consider distance and viewing angle from KOPs in order to ensure that the earthworks are visually unobtrusive.

- Openings in vegetation for facilities, structures, roads, etc., should be feathered and shaped to repeat the size, shape, and characteristics of naturally occurring openings.

- Topsoil from the site should be stripped, stockpiled, and stabilized before excavating earth for facility construction.

- All electrical collector lines and pipelines should be buried in a manner that minimizes additional surface disturbance (e.g., along roads or other paths of surface disturbance).

5.12.3.2 Building and Structural Materials

Visual impacts associated with solar energy and electricity transmission projects should be mitigated by choosing appropriate building and structural materials and surface treatments (i.e., paints or coatings designed to reduce contrast and reflectivity). A careful study of the site should be performed to identify appropriate colors and textures for materials; both summer and winter appearance should be considered as well as seasons of peak visitor use. Massing and scale of structures and the architectural character appropriate to the region where a solar facility is to be located should be considered (USFS 2001). Architectural character considerations should include integration of vertical and horizontal relief variation to create shadow lines that diminish the overall visual scale and dominance of facilities. The choice of colors should be based on the appearance at typical viewing distances and consider the entire landscape around the proposed development. Appropriate colors for smooth surfaces often need to be two to three shades darker than the background color to compensate for shadows that darken most textured natural surfaces. The BLM Standard Environmental Color Chart CC-001 and guidance should be referenced when selecting colors (BLM 2008d).

Specific mitigation measures include the following:

- Materials and surface treatments should repeat and/or blend with the existing form, line, color, and texture of the landscape.

- Appropriately colored materials should be selected for structures, or appropriate stains/coatings should be applied to blend with the project's backdrop.

- Solar panel backs should be color-treated to reduce visual contrast with the landscape setting.

- Solar towers should be color-treated to reduce visual contrast.

- Materials, coatings, or paints having little or no reflectivity should be used whenever possible.

- Grouped structures should all be painted the same color to reduce visual complexity and color contrast.

- Multiple color camouflage technology applications should be considered for projects within sensitive viewsheds and with visibility distance between 0.25 and 2 mi (0.40 and 3.20 km). BLM guidance on the use of color to mitigate visual impacts should be consulted (BLM 2008d).

- Aboveground pipelines should be painted or coated to match their surroundings.

- Consideration should be given to the appropriate choice of monopoles vs. lattice towers for a given landscape setting. Monopoles may reduce visual impacts more effectively than lattice towers in foreground and midground views within built or partially built environments, while lattice towers tend to be more appropriate for less-developed rural landscapes where the latticework would be more transparent against background textures and colors.

Glint and Glare

- Solar facilities should be sited and designed properly to eliminate glint and glare effects on roadway users, nearby residences, commercial areas, or other highly sensitive viewing locations, or to reduce them to the lowest achievable levels. Regardless of the solar technology proposed, a study to accurately assess and quantify potential glint and glare effects and to determine the potential health, safety, and visual impacts associated with glint and glare should be conducted. The assessment should be conducted by qualified individuals using appropriate and commonly accepted software and procedures. The assessment results must be made available to the BLM in advance of project approval. If the project design is changed during the siting and design process such that substantial changes to glint and glare effects may occur, glint and glare effects should be recalculated, and the study results made available to BLM.

- Mirrors/heliostats should be deployed and operated to avoid high-intensity light (glare) being reflected toward off-site ground receptors. Where off-site glare is unavoidable and project site/off-site spatial relationships favor effective results, fencing with privacy slats or similar screening materials should be employed.

- Electricity transmission-distribution projects should utilize nonspecular conductors and nonreflective coatings on insulators.

Night-Sky Protection

- A lighting plan should be prepared that documents how lighting will be designed and installed to minimize night-sky impacts during facility construction and operations. Lighting for facilities should not exceed the minimum number of lights and brightness required for safety and security, and should not cause excessive reflected glare. Low-pressure sodium light sources should be used to reduce light pollution. Full cut-off luminaires should be used to minimize uplighting. Lights should be directed downward or toward

the area to be illuminated. Light fixtures should not spill light beyond the project boundary. Lights in highly illuminated areas that are not occupied on a continuous basis should have switches, timer switches, or motion detectors so that the lights operate only when the area is occupied. Where feasible, vehicle-mounted lights should be used for night maintenance activities. Wherever feasible, consistent with safety and security, lighting should be kept off when not in use. The lighting plan should include a process for promptly addressing and mitigating complaints about potential lighting impacts.

- To minimize night-sky impacts from hazard navigation lighting associated with solar facilities, the applicant should use AVWS technology for any structures exceeding 200 ft (61 m) in height. If the FAA denies a permit for use of AVWS, the applicant should limit lighting to the minimum required to meet FAA safety requirements. The use of red or white strobe lights should be prohibited unless the BLM approves its use, because of conflicting mitigation requirements.

- The use of signs and project construction signs should be minimized. Necessary signs should be made of non-glare materials and utilize unobtrusive colors. The reverse sides of signs and mounts should be painted or coated using the most suitable color selected from the BLM Standard Environmental Color Chart (BLM 2008d) to reduce color contrasts with the existing landscape; however, placement and design of any signs required by safety regulations must conform to regulatory requirements.

- Commercial symbols or signs and associated lighting on buildings or other structures should be prohibited.

5.12.3.3 General Multiphase Measures

- "Good housekeeping" procedures should be developed to ensure that the site is kept clean of debris, garbage, fugitive trash or waste, and graffiti; to prohibit scrap heaps and dumps; and to minimize storage yards. Mitigation measures for effective waste management should be employed.

5.12.3.4 Construction

A pre-construction meeting with BLM landscape architects or other designated visual/scenic resource specialists should be held before construction begins to coordinate on the VRM mitigation strategy and confirm the compliance-checking schedule and procedures. Final design and construction documents will be reviewed for completeness with regard to the visual mitigation elements, assuring that requirements and commitments are adequately addressed. The construction documents should include, but not be limited to grading, drainage, revegetation, vegetation clearing, and feathering plans, and they must demonstrate how VRM objectives will be met, monitored, and measured for conformance.

Project developers should integrate interim/final reclamation VRM mitigation elements early in the construction process, these may include treatments such as thinning and feathering vegetation along project edges, enhanced contour grading, salvaging landscape materials from within construction areas, special revegetation requirements, etc. Developers should coordinate with BLM in advance to have BLM landscape architects or other designated visual/scenic resource specialists on-site during construction to work on implementing visual resource requirements and BMPs.

Visual impacts associated with construction activities can be partially mitigated by implementing the following mitigation measures, where feasible:

- Project developers should reduce visual impacts during construction by clearly delineating construction boundaries and minimizing areas of surface disturbance; preserving existing, native vegetation to the greatest extent possible; utilizing undulating surface-disturbance edges; stripping, salvaging, and replacing topsoil; using contoured grading; controlling erosion; using dust suppression techniques; and restoring exposed soils to their original contour and vegetation.

- A Decommissioning and Site Reclamation Plan should be in place prior to construction. Reclamation of the construction site should begin immediately after construction to reduce the likelihood of visual contrasts associated with erosion and invasive weed infestation and to reduce the visibility of temporarily disturbed areas as quickly as possible.

- Visual impact mitigation objectives and activities should be discussed with equipment operators before construction activities begin.

- Existing rocks, vegetation, and drainage patterns should be preserved to the maximum extent possible.

- Brush-beating or mowing or using protective surface matting rather than removing vegetation should be employed where feasible.

- Slash from vegetation removal should be mulched and spread to cover fresh soil disturbances as part of the revegetation plan. Slash piles should not be left in sensitive viewing areas.

- All areas of disturbed soil should be reclaimed by using weed-free native grasses, forbs, and shrubs representative of the surrounding and intact native vegetation composition and/or using non-native species, if necessary to ensure successful revegetation.

- The visual color contrast of graveled surfaces should be reduced with approved color treatment practices.

- Horizontal and vertical pipeline bending should be used in place of cut-and-fill activities where feasible.

- Road-cut slopes should be rounded, and the cut-and-fill pitch should be varied to reduce contrasts in form and line. The slope should be varied to preserve specimen trees and nonhazardous rock outcroppings.

- Topsoil from cut-and-fill activities should be segregated and spread on freshly disturbed areas to reduce color contrast and aid rapid revegetation. Topsoil piles should not be left in sensitive viewing areas.

- Excess fill material should not be disposed of downslope to avoid creating color contrast with existing vegetation and soils.

- Excess cut-and-fill materials should be hauled in or out to minimize ground disturbance and impacts from fill piles.

- Natural or previously excavated bedrock landforms should be sculpted and shaped when excavation of these landforms is required, and landforms should conform to the requirements listed and further described under Section A.2.2.13.1, Siting and Design. Half-case drill traces from presplit blasting should not remain evident in the final rock face. The color contrast from the excavated rock faces should be removed by color-treating with a rock stain. Native vegetation (where feasible, or a mix of native and non-native species if necessary to ensure successful revegetation) should be re-established with the benches and cavities created within the created bedrock formation.

- Communication and other local utility cables should be buried where feasible.

- Culvert ends should be painted or coated to reduce color contrasts with the existing landscape.

- No paint or permanent discoloring agents should be applied to rocks or vegetation to indicate surveyor construction activity limits.

- All stakes and flagging should be removed from the construction area and disposed of in an approved facility.

5.12.3.5 Operations

Terms and conditions for VRM mitigation compliance should be maintained and monitored for compliance with visual objectives, adaptive management adjustments, and modifications as necessary and approved by the BLM landscape architect or other designated visual/scenic resource specialist.

Visual impacts associated with operation and maintenance activities could be partially mitigated by implementing the following measures, where applicable:

- The project developer should maintain revegetated surfaces until a self-sustaining stand of vegetation is re-established and visually adapted to the undisturbed surrounding vegetation. No new disturbance should be created during operations without completion of a VRM analysis and approval by the authorized officer.

- Interim restoration should be undertaken during the operating life of the project as soon as possible after disturbances.

- Maintenance activities should include dust abatement (in arid environments) and noxious weed control.

- Road maintenance activities should avoid blading existing forbs and grasses in ditches and adjacent to roads.

- Painted facilities should be kept in good repair and repainted when color fades or flakes.

- Color-treated solar panel/mirror backs/supports should be kept in good repair, and retreated when color fades and flakes.

5.12.3.6 Decommissioning/Reclamation

A Decommissioning and Site Reclamation Plan, covering visual impact mitigation measures, should be in place prior to construction, and reclamation activities should be undertaken as soon as possible after disturbances occur and be maintained throughout the life of the project. The following decommissioning/reclamation activities/practices can partially mitigate visual impacts associated with solar energy development, where feasible:

- Predevelopment visual conditions, and the inventoried visual quality rating (A, B, C) and integrity should be reviewed, and the visual elements of form, line, color, and texture should be restored to pre-development visual compatibility or to that of the surrounding landscape setting conditions, whichever achieves the better visual quality and most ecologically sound outcome.

- A Decommissioning and Site Reclamation Plan should be developed, approved by the BLM, and implemented. The plan should require that all aboveground and near-ground structures be removed. Some structures should only be removed to a level below the ground surface that will allow reclamation/restoration. Topsoil from all decommissioning activities should be salvaged and reapplied during final reclamation. The plan should include

provisions for monitoring and determining compliance with the project's visual mitigation and reclamation objectives.

- Soil borrow areas, cut-and-fill slopes, berms, water bars, and other disturbed areas should be contoured to approximate naturally occurring slopes, thereby avoiding form and line contrasts with the existing landscapes. Contouring to a rough texture would trap seed and discourage off-road travel, thereby reducing associated visual impacts.

- Cut slopes should be randomly scarified and roughened to reduce texture contrasts with existing landscapes and aid in revegetation.

- A combination of seeding, planting of nursery stock, transplanting of local vegetation within the proposed disturbance areas, and staging of construction enabling direct transplanting should be considered. Where feasible, native vegetation should be used for revegetating to establish a composition consistent with the form, line, color, and texture of the surrounding undisturbed landscape.

- Stockpiled topsoil should be reapplied to disturbed areas, and the areas should be revegetated by using a mix of native species selected for visual compatibility with existing vegetation, where applicable, or by using a mix of native and non-native species if necessary to ensure successful revegetation.

- Gravel and other surface treatments should be removed or buried.

- Rocks, brush, and forest debris should be restored whenever possible to approximate pre-existing visual conditions.

- Edges of revegetated areas should be feathered to reduce form and line contrasts with the existing landscapes.

- A decommissioning VRM monitoring and compliance plan should be prepared by the operator and approved by the BLM that establishes the schedule and terms for monitoring and the conditions and methods of measurement for determining compliance.

5.12.3.7 Use of Off-Site Mitigation Measures

- In addition to mitigation measures that directly reduce the visual resource impacts of solar energy and associated facilities, the off-site mitigation of visual impacts may be an option in some situations. Off-site mitigation should be considered in situations where nonconforming proposed actions may lead to changing the VRM Class objectives through an RMP amendment. Unavoidable visual impacts may then be mitigated by a correction or remediation of a nonconforming existing condition resulting from a

different proposed action located within the same viewshed for impacts of approximately equal magnitude, and within the same or a more protective VRM class. The off-site mitigation serves as a means to offset and recover the loss of visual landscape integrity. For example, off-site mitigation could include reclaiming unnecessary roads, removing abandoned buildings, reclaiming abandoned mine sites, putting utility lines underground, rehabilitating and revegetating existing erosion or disturbed areas, or establishing scenic conservation easements. In situations where off-site mitigation opportunities are absent within the same viewshed, then different viewsheds that need mitigation of visual impacts because they could affect highly sensitive visual resources (e.g., along National Scenic and Historic Trails, Wild and Scenic River corridors, Scenic or Backcountry Byways, etc.) may be considered. BLM policy guidance on off-site mitigation procedures is contained in BLM Instruction Memorandum No. 2008-204, *Offsite Mitigation* (BLM 2008f).

5.13 ACOUSTIC ENVIRONMENT (NOISE)

Solar energy facilities could produce noise impacts on nearby residents in the areas where they are built. Construction noise impacts would be short term and distinct from noise impacts from facility operations. The following subsections discuss the common and technology-specific impacts that could occur due to noise from solar development and potentially applicable mitigation measures.

5.13.1 Common Impacts

5.13.1.1 Site Characterization

Typically, potential noise impacts from site characterization activities would be negligible, because these activities are short term and generate minimum noise and can be conducted with a small crew and small equipment. In some instances, deep soil corings to obtain information necessary for the design of substantial structure foundations (e.g., power towers) or extensive drilling for installation of monitoring/sampling wells and piezometers for on-site groundwater characterization may be required. These activities could generate substantial noise, and they also could require larger equipment with larger access road requirements. However, potential noise impacts of these site characterization activities on neighboring communities would be much lower than those of construction activities. Also, developers might elect to delay these types of site characterization activities that would result in more extensive impacts until the construction phase of development, since they may not have a critical role in determining facility design or establishing Power Purchase Agreements (PPAs).

5.13.1.2 Construction

Construction activities would involve a number of separate operations, as described in Section 3.2.2.

Major heavy equipment used in the site preparation phase would include chain saws, chippers, dozers, scrapers, end loaders, trucks, cranes, rock drills, and equipment for blasting if required. The major equipment used in the construction phase would include cranes, end loaders, backhoes, dozers, trucks, and a temporary concrete batch plant if substantial amounts of concrete are needed and/or premixed concrete is unavailable from nearby vendors (e.g., for foundations for a solar power tower or the power block).

Sources of noise would be from a variety of standard construction activities. Noise levels from construction would vary with the level of activity, number of pieces of equipment operating, and the location and type of activity. For typical construction projects, noise levels would be highest during the site preparation phase, that is, the early phase of construction when most of the noisy and heavy equipment would be used for land clearing, grading, and road construction over a short time period. However, the construction of solar facilities generally occurs in desert environments with relatively flat, hard surfaces, and thus minimum site preparation might be needed. Accordingly, noise levels during the site preparation period could be lower than those during the construction period (Beacon Solar, LLC 2008).

During construction, the commuter/delivery/support vehicular traffic around the facility and along the traffic routes would generate intermittent noise. However, the contribution to noise from these sources would be limited to the immediate vicinity of the traffic route and would be minor in comparison with the contribution from continuous noise sources, such as dozers.

In general, the dominant noise source for most construction equipment is the diesel engine if used without sufficient muffling. However, in cases where pile driving and/or pavement breaking would be involved, these noises would dominate. Average noise levels for typical construction equipment range from 74 dBA for a roller to 101 dBA for a pile driver at a distance of 50 ft (15 m) from a source (Hanson et al. 2006). Except for pile drivers and rock drills, most construction equipment has noise levels ranging from 75 to 90 dBA at a distance of 50 ft (15 m).

The highest noise levels would likely occur from construction in the power block area. Noise levels near the construction site would be highest around or at more than 95 dBA. Considering geometric spreading and ground effects, as explained in Section 4.5.1, noise levels would attenuate to about 40 dBA at a distance of 1.2 mi (1.9 km) from the construction site. This noise level is typical of daytime rural background levels. In addition, mid- and high-frequency noises (e.g., those generated from construction activities) are significantly attenuated by atmospheric absorption under high-temperature and low-humidity conditions that would be typical for utility-scale solar facilities; thus, noise attenuation to background levels would occur at distances of less than 1.2 mi (1.9 km) from the construction site. Most construction activities would occur during the day, when noise is better tolerated, than at night because of the masking effects of background noise. Nighttime noise levels would drop to the background levels of a rural environment, because construction activities would cease.

Typically, construction activities would last about 2 to 3 years, or 4 at most, for most solar facilities, and best engineering practices for construction noise control would be implemented in accordance with applicable laws, ordinances, regulations, and standards. Assuming that utility-scale solar facilities would be located in remote and sparsely populated areas, potential noise impacts on surrounding communities would be minor and temporary in nature. Site-specific assessment of noise impacts from construction activities would be required as a part of ROW application processing.

Depending on the equipment and methods employed, varying degrees of ground-borne vibration would occur in the immediate vicinity of construction sites. Except for dish engine facilities, no major vibration-causing construction equipment (e.g., pile drivers or rock drills) would be used in constructing solar facilities (see Section 5.13.2.2 for discussion of potential vibration impacts from pile driver use during construction of dish engine facilities). As a rule, for solar energy facilities located in relatively remote areas far from vibration-sensitive structures, potential vibration impacts on surrounding communities and vibration-sensitive structures would likely be negligible. For example, the vibration level at receptors beyond 230 ft (70 m) from a vibratory roller (94 VdB at 25 ft [7.6 m]) would diminish below the threshold of perception of 65 VdB for humans, as discussed in Section 4.5.2 (Hanson et al. 2006). A site-specific assessment of vibration impacts from construction activities would be required as a part of ROW application processing.

5.13.1.3 Operations

Noise-generating activities common to all types of solar facilities include those from site inspection; maintenance and repair (e.g., mirror washing, replacement of broken mirrors) at the solar field; commuter/support/delivery vehicles within and around the solar facility; and control/administrative buildings, warehouses, other auxiliary buildings/structures. Diesel-fired emergency power generators and fire-water pump engines would be another source of noise, but their operations would be limited to several hours per month.

Noise sources from the solar field of solar facilities would include those from solar tracking devices and vehicular traffic for inspection, maintenance, and repair. Typically, tracking devices make little noise and are relatively unobtrusive. The individual dish engines are an additional source of noise that should be considered with the Stirling solar dish engine technology. Electricity is generated in situ; this source is discussed further in Section 5.13.2.2. In general, the noise-generating activities in the solar field area of solar facilities are usually minimal, with the possible exception of the Stirling solar dish engine technology.

Noise sources in common regardless of solar technology are transformers, which are typically located in the power block area or near the site boundary. The primary transformer noise is a constant low-frequency humming tone with a fundamental frequency of 120 Hz and even harmonics of line frequency of 60 Hz, such as 240 Hz, 360 Hz, and up to 1,200 Hz or higher, primarily because of the vibration of its core (Wood 1992). The core's tonal noise should be uniform in all directions and continuous when in operation. In addition, cooling fans and oil pumps at large transformers produce broadband noise from the cooling system fan and pump when in operation; however, this noise is usually less noticeable than tonal noise. The number

and capacity of transformer(s) and their configurations could vary by many factors (e.g., solar technology, facility design, redundancy, and PPA). The following analysis shows the distance at which noise from a transformer for a solar facility with the largest capacity would be reduced to the background level. The average A-weighted core sound level at a distance of 150 m (492 ft) from a transformer would be about 51 dBA for 938 million volt-amperes (MVA), assuming a power factor of 0.8 for a solar plant of 750 MW (Wood 1992), which is the upper limit of power generation being analyzed. For geometric spreading only, the noise level at a distance of about 1,800 ft (550 m) would be about 40 dBA, typical of the daytime rural background level. For other attenuation mechanisms, such as ground effects and air absorption and/or for facilities with capacities of less than 750 MW, daytime rural background levels would occur at distances of less than 1,800 ft (550 m) from the site.

In general, the primary noise sources for a solar facility are located in the power block area, which is typically located at the center of the facility. Stationary and steady noise sources from a power block (limited to parabolic trough and solar power tower technologies only) would include STGs, various pumps for circulating water and HTFs, small-scale boilers to maintain a minimum temperature of HTF during power downtime, and a heat-rejection system such as wet-cooling towers or air-cooled condensers. Periodic short-term noise increases would occur during start-up or shutdown, load transition, or opening of steam relief valves. Noise levels from the power block would be attenuated considerably at the site boundaries, to about 30 to 40 dBA, and much more at the nearest communities (Beacon Solar, LLC 2008). These noises would be limited to daytime hours only for “solar only” facilities, when noise is better tolerated than at night. Therefore, potential noise impacts on neighboring communities associated with the power block areas of parabolic trough and power tower facilities would be expected to be minor. TES systems, when used, could provide up to 6 more hours of power after sundown and extend the duration of above-background noise levels during that time due to low background levels and/or downward bending of noise to the surface caused by temperature inversion on a clear, calm day. A site-specific assessment of noise impacts from operations would be required as a part of ROW application processing.

During operation, no major equipment that can cause ground vibration would be used. All equipment would be designed to minimize the vibrations caused by the imbalance of moving parts. If needed, vibration-monitoring systems, which are designed to ensure that the equipment remains balanced, would be installed in the equipment. In addition, no sensitive structures are typically located close enough to sustain physical damage, considering that the locations of most solar facilities are in remote, sparsely populated desert environments. Therefore, potential vibration impacts on surrounding communities and vibration-sensitive structures during operation of any solar facility would be minimal.

5.13.1.4 Decommissioning/Reclamation

Decommissioning requires many of the same procedures and equipment used in traditional construction. Decommissioning would include dismantling of solar facilities and support facilities such as buildings/structures and mechanical/electrical installations, disposal of debris, grading, and revegetation as needed. Activities for decommissioning would be similar to those for construction but on a more limited scale. Potential noise impacts on

surrounding communities would be correspondingly less than those for construction activities. Decommissioning activities would last for a short period, and their potential impacts would be minor and temporary in nature. The same mitigation measures adopted during the construction phase could also be implemented during the decommissioning phase.

As for noise, potential vibration impacts on surrounding communities and vibration-sensitive structures during decommissioning of any solar facility would be less than those during construction and thus minimal.

5.13.1.5 Transmission Lines and Roads

The general sequence of construction activities for electric transmission lines is described in Section 3.2.5. Potential noise impacts during construction of transmission corridors and during line upgrade activities would occur during ground disturbance and excavation to clear the ROWs, from installation of access roads and structures (e.g., transmission line towers, substations, or pipelines), and from installation of the support structures and lines. As in construction of a solar facility, major noise sources would be heavy equipment, such as dozers or graders to level the foundation area, and vehicular traffic, such as heavy trucks. Depending on environmental and/or logistical factors (e.g., rugged, mountainous terrain), helicopters could be used for transport and erection of steel lattice towers and/or poles. This helicopter operation could significantly reduce the construction period and total noise exposure, although short-term noise levels would be higher when in operation.

Most construction activities would occur during the day, when noise is better tolerated, than at night because of the masking effects of background noise. Nighttime noise levels would drop to background levels. Since most new facilities would be located within a few miles and some up to 25 mi (40 km) of existing transmission lines, transmission line construction could be performed in a short time period. In addition, construction sites along the transmission line ROWs would move continuously, and no particular area would be exposed to noise for a prolonged period. Thus the potential noise impacts on surrounding communities along the transmission line ROW, if any, would be minor and temporary.

During operation of the transmission lines, there is a potential for noise impacts from corona discharge, which relates to the electrical breakdown of air into charged particles caused by the electrical field at the surface of conductors. Corona discharge is affected by ambient weather conditions, such as humidity, air density, wind, and precipitation, and by irregularities on the energized surfaces. Corona-generated audible and high-frequency noise from transmission lines is generally characterized as having a crackling, popping, or hissing noise but does not have any significant adverse effects on humans, except for potential annoyance. Modern transmission lines are designed, constructed, and maintained so that they operate below the corona-inception voltage during dry conditions, meaning that the lines generate a minimum of corona-related noise. During rainfall events (when corona discharge is highest), the noise level at 100 ft (30 m) from the center of a 250-kV and a 500-kV transmission line tower would be about 36 and 47 dBA, respectively (Lee et al. 1996). The noise level at a distance of 300 ft (91 m) would be about 31 and 42 dBA, respectively. However, noise from corona discharge during fair

weather conditions may be generally indistinguishable from background noise when the background noise levels are similar or higher.

A preliminary study by Pearsons et al. (1979) indicated that corona noise needed to be 10 dBA lower in intensity than other environmental noises judged equally as annoying because of its more annoying high-frequency components. However, at long distances, noise attenuation by air absorption is significant, especially at high frequencies, thus corona noise decreases faster than other environmental noise sources that are dominated by lower frequencies. Accordingly, corona noise is easily lost in background noise within short distances from transmission lines.

Proposed sites for solar facilities in the six-state study area are in arid, desert environments and thus corona-generated audible noise would occur infrequently. Most of the areas adjacent to the proposed sites are undeveloped and sparsely populated. Except for very quiet locations, corona noise would likely not be discernable beyond 0.25 mi (0.4 km) from a transmission line.

As discussed in Section 5.13.1.4, activities for decommissioning would be similar to those for construction but on a more limited scale and duration. Decommissioning activities would last for a short period, and their potential impacts would be minor and temporary.

During the life of transmission lines (i.e., construction, operation, and decommissioning), no major equipment that can cause ground vibration would be used, as discussed in Section 5.13.1.2. In addition, no sensitive structures are typically close enough to sustain physical damage, because most solar facilities are in remote, sparsely populated, desert environment. Therefore, potential vibration impacts on surrounding communities and vibration-sensitive structures during the life of transmission lines would be minimal.

5.13.2 Technology-Specific Impacts

General construction activities and heavy equipment used would be similar among the solar technologies. Potential noise impacts of facility construction on nearby communities would vary depending not only on the technology used but also on many other variables—power generation capacity, land area of a facility, construction period, topographic features (including terrain and vegetation), soil characteristics (including crustiness and soil strength), length of required transmission lines to the nearest grid and natural gas supply pipeline, local meteorological conditions (ambient temperature, relative humidity, and vertical wind and temperature profiles), distance to the site boundaries, and nearest sensitive human receptors.

In the following sections, potential technology-specific noise impacts for four solar technologies are discussed, including those associated with construction of a solar dish engine facility and operation of four types of solar facilities.

5.13.2.1 Parabolic Trough and Power Tower

As discussed in Section 5.13.1.3, noise levels around the solar field of parabolic trough and power tower facilities would typically be negligible, but the power block area where steam is generated and converted to electricity would have the highest noise levels. Typical continuous noise sources from the power block of these facilities would include the STG, small-scale boilers to maintain a minimum temperature of the HTF during power downtime, various pumps for circulating water and HTF, and a heat-rejection system such as a wet-cooling tower or air-cooled condenser. Typically, the STG is enclosed, and boilers with inlet fan silencers and pumps are relatively low noise emission sources.

Wet-cooling towers are outdoors and would generate the highest noise levels, more than 25 dBA higher than any other noise sources at these types of facilities (Beacon Solar, LLC 2008). The sound is generated by the impact of cascading water over a series of horizontal slats by the movement of air by fans, the fan blades moving in the structure, and the motors, gearboxes, or drive belts. The fans and water splash are the major noise sources of induced draft cooling towers (Wang 1979). The fan and water noise can be characterized as relatively low frequency and comparatively high frequency, respectively. Noise levels for dry-cooling systems (i.e., radiators) are somewhat higher than those for wet systems because of the larger fans required, although the water splash noise is eliminated.

Typically, the solar block area would be located in the center of the solar facility a few thousand feet from the site boundary; thus noise levels would attenuate by about 30 to 40 dBA, to 50 dBA or less, before reaching the site boundaries (Beacon Solar, LLC 2008). Parabolic trough and power tower facilities without TES would be operating during daytime hours only, when noise is tolerated better than at night, because of the masking effects of background noise. Accordingly, significant noise impacts associated with operation of these facilities would typically not be expected at the site boundaries. Noise levels would be expected to be barely discernable or completely inaudible at the nearest neighboring community. For facilities with TES, power generation could continue up to about 6 hours after sundown, possibly resulting in noise levels higher than background levels in neighboring communities due to low background levels and/or downward bending of noise to the surface caused by temperature inversion on a clear, calm day. Potential noise impacts would be evaluated in site-specific environmental assessments for facilities planning to incorporate TES that are located near residential communities and other sensitive human or wildlife receptors.

5.13.2.2 Dish Engine

The Stirling solar dish engine is unique among CSP technologies, because it generates electricity in situ through the action of an external heat engine rather than the production of steam. This type of facility does not need a power block. The major parts of the system are the solar concentrator and the power conversion unit. A large solar dish engine facility would consist of tens of thousands of dish engines, several hundred step-up transformers embedded in the solar field, and a substation.

The individual dish engines are not very heavy but need to be supported against wind loadings. Typically, dish engines would be installed on a concrete foundation. However, if the subsoil is soft or sandy, the support leg for each of the dish engines would be installed with the use of pile drivers. The drilling depth would typically be shallow, less than 10 ft (3 m). Although pile driving, which occurs periodically and intermittently, can have high noise impacts due to high intensity, in the case of pile driving for dish engine foundations, the impacts would be expected to be at least partially mitigated because of the shallow drilling depth and soft soils. Also, if hydraulic pile drivers, which generate lower noise and vibration levels, are used, the noise impacts would be further mitigated. A site-specific assessment of noise and vibration impacts from construction of dish engine facilities would be required as a part of ROW application processing.

The major noise source during operation of dish engine facilities would be from up to tens of thousands of Stirling dish engines. Sound levels from a power transformer and a collector step-up transformer are about 17 and 32 dBA lower than that from a dish engine, respectively (SES Solar Two, LLC 2008). Noise sources from a dish engine would include the engine itself, electric generator, cooling system, and air compressor. High-efficiency Stirling engines are often equipped with cooling devices, either an air-cooled fan or a glycol-based, closed-loop coolant/external radiator system functionally identical to the cooling system used in an automobile. The composite noise level of a dish engine would be about 88 to 89 dBA at a distance of 3 ft (0.9 m) (SES Solar Two, LLC 2008). This noise level would be attenuated to about 40 dBA (typical of the rural daytime environment) within 330 ft (100 m) of the dish engine. Dish engines would operate only during daytime hours. The combined noise level from tens of thousands of dish engines operating simultaneously would be significantly high in the immediate vicinity of the facility. Noise levels could be higher than typical rural background levels at considerable distances from the facility. Accordingly, potential noise impacts could be substantial if the nearest community and other sensitive human or wildlife receptors are close to the facility, and thus noise considerations are far more important for siting of a dish engine facility than for other solar facilities.

5.13.2.3 PV Systems

Compared with other solar technologies, PV facilities would have a minimal number of noise sources and low-level noises. For example, PV facilities generate electricity without producing steam; thus there is no power block.

To dissipate heat from solar module assemblies, passive convection cooling systems or active air- or liquid-cooling systems would be applied. Noise sources for active air-cooling systems would be electric fans, while sources for active liquid-cooling systems would be electrically powered pumps. Other noise sources would include pad-mounted inverters, which convert direct current into alternating current, and transformers serving each PV block, usually consisting of 12 PV modules.

The audible noise level of an inverter (attributable to the cooling fan) with a rated capacity of 10 kW would be as low as 35 to 40 dBA or lower at a distance of about 3 ft (1 m),

but would exceed 50 dBA for some inverters with rated capacities greater than 10 kW (Ishikawa 2002). However, the noise level from these higher capacity inverters would be less than 30 dBA at a distance of 50 ft (15 m). Many inverters would be embedded in the modules of a PV facility. The combined noise level from these inverters is not expected to result in adverse noise impacts at the site boundary or at the nearest residential locations.

Because of minimal noise-generating activities, noise from a PV facility would be typically expected to be inaudible or barely perceptible at the site boundaries. No configuration for a TES option is practically available for this technology; thus PV facilities would be operating during daytime only.

5.13.3 Potentially Applicable Mitigation Measures

The following mitigation measures during construction, operation, and decommissioning are recommended as ways to reduce potential noise impacts on the neighboring communities. Many of the mitigation measures recommended below have been adapted from those discussed in the following references: Beacon Solar, LLC (2008); BrightSource Energy, Inc. (2007); DOI and USDA (2007); SES Solar Two, LLC (2008); Wang (1979); and Wood (1992).

5.13.3.1 Siting and Design

- Project developers should take measurements to assess the existing background ambient sound levels both within and outside the project site and compare them with the anticipated noise levels associated with the proposed facility. The ambient measurement protocols of all affected land management agencies should be considered and utilized. Nearby residences and likely sensitive human and wildlife receptor locations should be identified at this time.

- Siting of stationary construction equipment (e.g., compressors and generators) should be as far from nearby residences and other sensitive receptors as the specific project configuration allows.

- Permanent sound-generating facilities (e.g., compressors, pumps) should be sited away from residences and other sensitive receptors. In areas of known conflicts, consideration should be given to the installation of acoustic screening.

- Where feasible, low-noise systems (e.g., for ventilation systems, pumps, generators, compressors, and fans) should be incorporated, and equipment that has no prominent discrete tones should be selected.

- If a wet-cooling tower is to be used, the louvered side should be sited to face away from sensitive human receptors. The cooling tower should be located

such that nearby equipment can act as a barrier and further reduce noise. Quieter fans should be selected in the facility design, and fans should be operated at a lower speed, particularly if they are to operate at night. If a high degree of reduction in noise is required, silencers should be used on the fan stacks.

- Noise reduction measures that should be considered include siting noise sources to take advantage of topography and distance and constructing engineered sound barriers and/or berms or sound-insulated buildings, if needed, to reduce potential noise impacts at the locations of nearby sensitive receptors. As an alternative, solar facilities generating higher operational noise (e.g., a solar dish engine facility) could take advantage of higher background noise. For example, they could be sited within an existing noisy area, such as close to a well-traveled highway, where the ambient sounds partially mask the noise from the facility.

5.13.3.2 General Multiphase Measures

- All equipment should be maintained in good working order in accordance with manufacturers' specifications. For example, suitable mufflers and/or air-inlet silencers should be installed on all internal combustion engines (ICEs) and certain compressor components.

- If residences or sensitive receptors are nearby, noisy equipment, such as turbines and motors, should be placed in enclosures.

- All vehicles traveling within and around the project area should be operated in accordance with posted speed limits to reduce vehicle noise levels.

- Warning signs should be posted in high-noise areas, and a hearing protection program should be implemented for work areas with noise in excess of 85 dBA.

- Project developers should realize that complaints about noise may still occur, even when the noise levels from the facility do not exceed regulatory levels. Accordingly, a noise complaint process and hotline for the surrounding communities should be implemented, including documentation, investigation, evaluation, and resolution of all legitimate project-related noise complaints.

5.13.3.3 Construction and Decommissioning/Reclamation

- Construction and decommissioning activities and construction traffic should be scheduled to minimize disruption to nearby residents and existing operations surrounding the project areas.

- If residences or sensitive receptors are nearby, noisy construction and decommissioning activities should be limited to the least noise-sensitive times of day (daytime between 7 a.m. and 7 p.m.) and weekdays. Quieter activities, such as instrumentation or interior installation, could be conducted at any time.

- Whenever feasible, different noisy activities should be scheduled to occur at the same time, since additional sources of noise generally do not increase noise levels at the site boundary by much. That is, less-frequent but noisy activities would generally be less annoying than lower level noise occurring more frequently.

- Noise control measures (e.g., erection of temporary wooden noise barriers) should be implemented if noisy activities are expected near sensitive receptors.

- If noisy activities, such as blasting or pile driving, are required during the construction or decommissioning period, nearby residents should be notified in advance.

5.13.3.4 Operations

- If noise from a transformer becomes an issue, a new transformer with reduced flux density, which generates noise levels as much as 10 to 20 dB lower than National Electrical Manufacturers Association (NEMA) standard values, could be installed. Alternatively, barrier walls, partial enclosures, or full enclosures could be adopted to shield or contain the transformer noise, depending on the degree of noise control needed.

5.13.3.5 Transmission Lines and Roads

Most mitigation measures applied to the construction, operation, and decommissioning activities discussed above should also be implemented during the entire life of transmission lines. An additional mitigation measure in the case of helicopter use, typically of short duration but with high-level noise, is the following:

- Helicopter flights at low altitude (under 1,500 ft [457 m]) near noise-sensitive receptors should be minimized except at locations where only helicopter activities can perform the task.

5.14 PALEONTOLOGICAL RESOURCES

Solar energy facilities could produce impacts on paleontological resources in and around the areas where they are built. Impacts would occur primarily during facility construction due to

surface disturbance, but indirect impacts from facility operations could also occur. The following subsections discuss the common and technology-specific impacts on such resources from solar development and potentially applicable mitigation measures.

5.14.1 Common Impacts

Significant paleontological resources could be affected by utility-scale solar energy development. The potential for impacts on paleontological resources from solar energy development, including ancillary facilities, such as access roads and transmission lines, is directly related to the location of the project regardless of the technology employed and the amount of land disturbance in areas where paleontological resources could be present. Indirect effects, such as impacts resulting from the erosion of disturbed land surfaces and from increased accessibility to possible site locations, are also considered.

Impacts on paleontological resources could result in several ways, as described below.

- Complete destruction of the resource and loss of valuable scientific information could result from the clearing, grading, and excavation of the project area and from construction of facilities and associated infrastructure if paleontological resources are located within the development area.

- Degradation and/or destruction of near-surface paleontological resources and their stratigraphic context could result from the alteration of topography; alteration of hydrologic patterns; removal of soils; erosion of soils; runoff into and sedimentation of adjacent areas; and oil or other contaminant spills if near-surface paleontological resources are located on or near the project area. Such degradation could occur both within the project footprint and in areas downslope or downstream. While the erosion of soils could negatively affect near-surface paleontological localities downstream of the project area by potentially eroding materials and portions of sites, the accumulation of sediment could serve to remove from scientific access, but otherwise protect, some localities by increasing the amount of protective cover. Agents of erosion and sedimentation include wind, water, downslope movements, and both human and wildlife activities.

- Increases in human access and subsequent disturbance (e.g., looting and vandalism) of near-surface paleontological resources could result from the establishment of corridors or facilities in otherwise intact and inaccessible areas. Increased human access (including OHV use) exposes paleontological sites to a greater probability of impact from a variety of stressors.

Paleontological resources are nonrenewable and, once damaged or destroyed, cannot be recovered. Therefore, if a paleontological resource (specimen, assemblage, or site) is damaged or destroyed during utility-scale solar energy development, this scientific resource would become irretrievable. Data recovery and resource removal are ways in which at least some information

can be salvaged should a paleontological site be affected, but certain contextual data would be invariably lost. The discovery of otherwise unknown fossils would be beneficial to science and the public good, but only as long as sufficient data can be recorded.

5.14.2 Technology-Specific Impacts

The technology-specific factor that could have a possible impact on the paleontological resources assessment is the difference in land requirements of the technologies (see Section 3.1.5 for the differences in land requirements per megawatt). However, because all potential impacts on paleontological resources would be determined by site-specific conditions, differences in land requirements would not directly correspond to differences in impacts on paleontological resources at the programmatic level. The magnitude or level of impact would depend on whether the specific location of a proposed utility-scale solar facility contains significant paleontological resources, regardless of the overall size of the facility.

Differences in water requirements (i.e., water use and discharge) among the technologies are not likely to be a factor in determining levels of impact of surface runoff and possible effects on paleontological resources. However, depending on the source of water for solar technologies using cooling towers or steam generators, drawdown of surface water levels could increase the potential for erosion in some localities and inadvertently expose paleontological resources. Again, these issues would be addressed at a site-specific level of analysis.

5.14.3 Potentially Applicable Mitigation Measures

For all potential impacts, the application of mitigation measures developed in consultation with the BLM could reduce or eliminate (if avoidance of the resource is chosen) the potential for adverse impacts on significant paleontological resources. Coordination between the project developer and the managing agency would be required for all projects before areas are developed. The use of management practices, such as training/education programs to reduce the amount of inadvertent destruction to paleontological sites, could also reduce the occurrences of human-related disturbances to nearby sites. The specifics of these management practices would be established in project-specific coordination between the project developer and the managing agency. BLM Instruction Memorandum (IM) 2009-011 provides guidance for assessing potential impacts on paleontological resources and determining mitigation measures.

Mitigation measures to reduce impacts on paleontological resources would be required and could include the following, as applicable:

- Project developers should determine whether paleontological resources exist in a project area on the basis of the following: the sedimentary context of the area and its potential to contain paleontological resources (PFYC [potential fossil yield classification] Class, if it is available); a records search of published and unpublished literature for past paleontological finds in the area; coordination with paleontological researchers working locally in potentially

affected geographic areas and geologic strata; and/or depending on the extent of existing information, the completion of a paleontological survey.

- If paleontological resources are present at the site or if areas with a high potential to contain paleontological material have been identified, a paleontological resources management plan should be developed. This should include a mitigation plan; mitigation may include avoidance, removal of fossils (data recovery), stabilization, monitoring, use of protective barriers and signs, or use of other physical or administrative protection measures. The paleontological resources management plan should also identify measures to prevent potential looting, vandalism, or erosion impacts and address the education of workers and the public to make them aware of the consequences of unauthorized collection of fossils on public land.

- If an area has a high potential but no fossils are observed during survey, monitoring by a qualified paleontologist may be required by the managing agency during all excavation and earthmoving activities in the sensitive area. Development of a monitoring plan is recommended.

- If fossils are discovered during construction, the managing agency should be notified immediately. Work should be halted at the fossil site and continued elsewhere until a qualified paleontologist can visit the site and make site-specific recommendations for collection or other resource protection. The area of the discovery should be protected to ensure that the fossils are not removed, handled, altered, or damaged.

If these types of mitigation measures are implemented during the initial project design and planning phases and are adhered to throughout the course of development, the potential impacts on paleontological resources discussed under the Section 5.14.1 would be mitigated to the fullest extent possible. Adopting this approach does not mean that there would be no impacts on paleontological resources. The exact nature and magnitude of the impacts would vary from project to project and would need to be examined in detail in future NEPA reviews of site-specific projects.

5.15 CULTURAL RESOURCES

Solar energy facilities could produce diverse impacts on cultural resources in and around the areas where they are built. Impacts could occur during both facility construction and operations. The following subsections discuss the common and technology-specific impacts on cultural resources that could occur from solar development and potentially applicable mitigation measures.

5.15.1 Common Impacts

Significant cultural resources, including historic properties listed or eligible for listing on the NRHP, could be affected by utility-scale solar energy development regardless of the technology employed.

The potential for impacts on cultural resources from solar energy development, including ancillary facilities, such as access roads and transmission lines, is directly related to the amount of land disturbance and the location of the project. Indirect effects, such as impacts on the cultural landscape resulting from the erosion of disturbed land surfaces and from increased accessibility to possible site locations, are also considered.

Impacts on cultural resources could result in several ways, as described below.

- Complete destruction of historic properties could result from the clearing, grading, and excavation of the project area and from construction of facilities and associated infrastructure if archaeological sites, historic structures, or traditional cultural properties are located within the footprint of the project.

- Degradation and/or destruction of historic properties could result from the alteration of topography, alteration of hydrologic patterns, removal of soils, erosion of soils, runoff into and sedimentation of adjacent areas, and oil or other contaminant spills if sites are located on or near the project area. Such degradation could occur both within the project footprint and in areas downslope or downstream. While the erosion of soils could negatively affect historic properties downstream of the project area by potentially eroding materials and portions of downstream archaeological sites, the accumulation of sediment could serve to protect some downstream sites by increasing the amount of protective cover. Erosion can also destabilize historic structures. Agents of erosion and sedimentation include wind, water, downslope movements, and both human and wildlife activities. Contaminants could affect the ability to conduct an analysis of material present at the site and thus the ability to interpret site components.

- Increases in human access and subsequent disturbance (e.g., looting, vandalism, and trampling) of cultural resources could result from the establishment of corridors or facilities in otherwise intact and inaccessible areas. Increased human access (including OHV use) exposes archaeological sites and historic structures and features to greater probability of impact from a variety of stressors.

- Visual degradation of settings associated with significant cultural resources could result from the presence of a utility-scale solar energy development and associated land disturbances and ancillary facilities. This could affect significant cultural resources for which visual integrity is a component of sites' significance, such as sacred sites and landscapes, historic structures, trails, and historic landscapes.

Cultural resources are nonrenewable and, once damaged or destroyed, are not recoverable. Therefore, if a cultural resource is damaged or destroyed during solar energy development, this particular cultural location, resource, or object would be irretrievable. For cultural resources that are significant for their scientific value, data recovery is one way in which some information can be salvaged should a cultural resource site be adversely affected by development activity. Certain contextual data would be invariably lost, but new cultural resources information would be made available to the scientific community. Loss of value for education, heritage tourism, or traditional uses is less easily mitigated.

5.15.2 Technology-Specific Impacts

The technology-specific factor that could have a possible impact on the cultural resources assessment is the difference in land requirements of the technologies (see Section 3.1.5 for the differences in land requirements per MW). Differences in land requirements, however, would not directly correspond to differences in impacts on cultural resources at the programmatic level. The magnitude or level of impact would depend on whether the specific location of a proposed solar facility contains significant cultural resources, regardless of the overall size of the facility. Programmatic impacts could occur if specific classes of cultural resources are affected. All areas available for solar development are flat valley floors, and aside from trails or other linear features that might cross these valleys, the areas of potential cultural significance, whether prehistoric or historic, will most likely be near dry lake beds, in dune areas, or along washes. Those technologies that can be adjusted to avoid specific areas are less likely to result in an adverse effect on historic properties (e.g., dish engine technology is less position-driven with respect to individual units than some of the other linear technologies or the power tower).

The different technologies also result in different viewsheds based on facility height differences. For cultural resources with a visual component, such as a historic trail, where integrity of setting is an important aspect of the resource's significance, technology choice could be a factor in determining whether a resource is adversely affected (see Section 5.12.2).

Differences in water requirements (i.e., water use and discharge) among the technologies are not likely to be a factor in determining levels of impact of surface runoff and possible effects on cultural resources. However, depending on the source of water for solar technologies using cooling towers or steam generators, drawdown of surface water levels could increase the potential for erosion in some localities and inadvertently expose cultural resources present along stream banks or lakeshores. These issues would be addressed at the site-specific level of analysis.

5.15.3 Potentially Applicable Mitigation Measures

For all potential impacts, the application of mitigation measures developed in consultation under Section 106 of the National Historic Preservation Act (NHPA) would avoid, reduce, or mitigate the potential for adverse impacts on significant cultural resources. Section 106 consultations between the BLM and the State Historic Preservation Officers (SHPOs), appropriate Tribes, and other consulting parties would be required. Thresholds for the

involvement of and review by the Advisory Council on Historic Preservation (ACHP) include non-routine interstate and/or interagency programs; undertakings directly and adversely affecting National Historic Landmarks or National Register eligible properties of national significance; and/or highly controversial undertakings, when ACHP review is requested by the managing agency, SHPO, Indian Tribe, local government, or the applicant for a BLM authorization. Ongoing Tribal consultation, in accordance with the NHPA, would help determine areas of sensitivity, appropriate survey and mitigation needs, and other issues of concern, such as access rights or disruption of cultural practices (see Section 5.16.3), and to take those concerns into consideration during project development. The following describes the process the BLM follows to address impacts on historic properties for individual projects.

Site-specific NEPA analyses and a Section 106 review would be conducted on individual projects. The BLM would require the completion of comprehensive identification (e.g., field inventory), evaluation, protection, and resolution of adverse effects (mitigation) following the policies and procedures contained in the 1997 BLM National Programmatic Agreement (PA) (BLM 1997) and under state protocols.[7] If significant cultural resources are present at the project location or if there is a high potential for the project area to contain significant cultural resources that could be adversely affected, a formalized agreement may be required to address management and mitigation options (e.g., avoidance, data recovery, monitoring, preventive measures for looting, vandalism, and erosion, and worker education) in the form of various planning documents (e.g., cultural resources monitoring and mitigation plan, cultural data recovery plan, historic properties treatment plan). The agreement should be developed in consultation with the SHPO, appropriate federally recognized Tribes, and any consulting parties. Also, the BLM would continue to implement government-to-government consultation with Tribes and state and local governments on a case-by-case basis.

The BLM does not approve any ground-disturbing activities that may affect any historic properties, sacred sites or landscapes, and/or resources protected under the NHPA; the American Indian Religious Freedom Act; the Native American Graves Protection and Repatriation Act (NAGPRA); E.O. 13007, "Indian Sacred Sites" (*Federal Register*, Volume 61, page 26771, May 24, 1996); or other statutes and E.O.s until it completes its obligations under applicable requirements of the NHPA and other authorities. The BLM may require modification to development proposals to protect such properties, or it may disapprove any activity that is likely to result in adverse effects that cannot be successfully avoided, minimized, or otherwise mitigated.

The BLM develops specific mitigation measures on a project-by-project basis. Avoidance of the resource is the preferred option. Data recovery is a common option for addressing adverse effects, but it does not eliminate the adverse effect. Mitigation of adverse effects can include many other options, such as monitoring and surveillance to protect sites from looting or vandalism; off-site mitigation; education and interpretive programs, including the use of volunteers; and funding of historic preservation efforts proportionate to the anticipated effects.

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[7] A PA specific to solar development on BLM-administered lands is under development by the BLM, National Council of SHPOs, and ACHP. This paragraph will be replaced with a summary of relevant information from the Solar PA once it is completed.

Several mitigation measures for other disciplines (soils, air quality, vegetation, hydrology) to encourage use of previously disturbed lands, prevent erosion, and require use of designated routes only to prevent off-road damage are also appropriate for protecting historic properties, but are not all repeated here (access roads and water control structures would be considered part of the area of potential effects and would require a survey). To protect sacred sites and portions of historic trails that are potentially eligible for listing on the NRHP from visual intrusion and to maintain the integrity of the historic cultural setting, the managing agency could require that surface disturbance be restricted or prohibited within the viewshed of a sacred site or within the viewshed of the trail along those portions of the trail for which eligibility is tied to the visual setting. Mitigation for the demolition of historic structures typically entails detailed architectural records and historical documentation; for the impacts on settings of historic structures, measures such as those for historic trails and sacred sites are appropriate. Ultimately, mitigation strategies would be determined during project-specific consultation.

Specific mitigation measures to reduce impacts on cultural resources should be required and include the following, as applicable.

5.15.3.1 Siting and Design

- The use of previously disturbed lands, rather than pristine lands, should be encouraged.

- The managing agency would consult with the appropriate SHPOs, the ACHP, and affected Native American governments and notify the public early in the planning process to identify issues and areas of concern regarding any proposed solar energy project. Such consultation is required by the NHPA and other authorities.

- Project developers should conduct a records search of published and unpublished literature for past cultural resource finds in the area; coordinate with researchers working locally in the area, and, depending on the extent of existing information, develop a survey design in coordination with the managing agency and SHPO, and complete a Class III cultural resources inventory. The inventory should be conducted according to the standards set forth in the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation (48 FR 44716), BLM Handbook H-8110: *Guidelines for Identifying Cultural Resources* (BLM 2002), and revised BLM Manual 8110 (BLM 2004). All inventory data should be provided to the managing agency in digitized format that meets applicable accuracy standards, including shape files for surveyed areas.

- A phased sampling strategy, beginning with a Class II inventory to assess various alternative development areas, is recommended prior to the selection of individual project locations. The Class II inventory should meet the standards set forth in the Secretary of Interior's Standards and

Guidelines for Archaeology and Historic Preservation (48 FR 44716), BLM Handbook H-8110: *Guidelines for Identifying Cultural Resources* (BLM 2002), and revised BLM Manual 8110 (BLM 2004a).

- If significant or NRHP-eligible cultural resources are present at the site and would be adversely affected or if areas with a high potential to contain additional cultural material have been identified, a formalized agreement should be required to address management and mitigation options in the form of various planning documents (such as a monitoring and mitigation plan, data recovery plan, historic treatment plan, etc.). The agreement should be developed in consultation with the SHPO, appropriate federally recognized Tribes, and any consulting parties. The agreement also should identify measures to prevent potential looting/vandalism or erosion impacts and address the education of workers and the public to make them aware of the consequences of unauthorized collection of cultural resources on public land.

- To protect historic properties, sacred sites, and portions of historic trails that are eligible for listing in the NRHP from visual intrusion and to maintain the integrity of the historic cultural setting, the managing agency could require that surface disturbance be restricted or prohibited within the viewshed of a historic property, sacred site, or trail segment for which eligibility is tied to the visual setting. These types of adverse effects will be minimized, avoided, or otherwise resolved (mitigated) through the Section 106 consultation process.

5.15.3.2 Construction, Operation, and Decommissioning/Reclamation

- In cases where there is a probability of encountering cultural resources during construction that could not be fully detected during a Class III inventory, cultural field monitors (appropriate for the resource anticipated) should be employed to monitor ground disturbing activities. Development of a monitoring plan is recommended.

- The unexpected discovery of cultural resources during construction should be brought to the attention of the responsible authorized officer immediately. Work should be halted in the vicinity of the find. The area of the find should be protected to ensure that resources are not removed, handled, altered, or damaged while they are being evaluated and to ensure that appropriate mitigation measures are being developed.

- The use of management practices, such as training/education programs for workers and the public, should be implemented to reduce occurrences of human-related disturbances to nearby cultural sites. The specifics of these management practices should be established in project-specific consultations between the applicant and the BLM as well as with the SHPO and Tribes, as appropriate.

5.16 NATIVE AMERICAN CONCERNS

Solar energy facilities could affect resources of Native American concern in and around the areas where they are built. Impacts could occur from land disturbance during construction and from the location of facilities. The following subsections discuss the common and technology-specific impacts from solar development that could affect such concerns and potentially applicable mitigation measures.

5.16.1 Common Impacts

Native American concerns include trust assets and resources, traditional cultural properties, burial remains, sacred sites or landscapes, ecological balance and environmental protection, water quality and use, human health and safety, economic development and employment, and access to energy resources. As discussed in Section 4.16, these issues and concerns should be viewed and evaluated by using an integrated, holistic approach. Any of these resources can be affected by utility-scale solar energy development, and many of these issues are described in other sections of this PEIS, such as Cultural Resources, Visual Resources, Vegetation, Wildlife and Aquatic Biota, Special Status Species, Water Resources, Socioeconomics, and Environmental Justice. Consultation on this PEIS between the BLM and the potentially affected Tribes is ongoing and is described more fully in Chapter 14; consultation letters and responses are provided in Appendix K.

The potential for impacts on resources of significance to Native American from solar energy development, including ancillary facilities, such as access roads and transmission lines, in many instances is directly related to the amount of land disturbance and the location of the project. Indirect effects—for example, impacts on water quality and use, the ecosystem in general, and the cultural landscape resulting from the erosion of disturbed land surfaces—are also considered. Impacts on social services, economic development, employment, environmental justice, and human health and safety are discussed elsewhere in this PEIS (Sections 5.17, 5.18, and 5.21).

Impacts on Native American resources could result in several ways, as described below.

- Complete destruction of an important location or habitat type could result from the clearing, grading, and excavation of the project area and from construction of facilities and associated infrastructure if archaeological sites, sacred sites, burials, traditional cultural properties, specific habitat for culturally important plants and wildlife species, and the like are located within the footprint of the project.

- Degradation and/or destruction of an important location could result from the alteration of topography, alteration of hydrologic patterns, removal of soils, erosion of soils, runoff into and sedimentation of adjacent areas, and oil or other contaminant spills if important sites or habitats are located on or near the project area. Such degradation could occur both within the project footprint

and in areas downslope or downstream. While the erosion of soils could negatively affect areas downstream of the project area by potentially eroding materials and portions of sites, the accumulation of sediment could serve to protect some sites by increasing the amount of protective cover.

- Modifications of natural flow systems, including effects on floodplains, wetlands, and riparian areas and possible degradation of surface water quality could occur as a result of construction activities and water withdrawals for a solar energy development project (see Section 5.9).

- Increases in human access and subsequent disturbance (e.g., looting, vandalism, and trampling) of resources of significance to Native Americans could result from the establishment of corridors or facilities in otherwise intact and inaccessible areas. Increased human access (including OHV use) exposes plants, animals, archaeological sites, historic structures and features, and other culturally significant natural features to greater probability of impact from a variety of stressors.

- Visual degradation of settings associated with significant cultural resources and sacred landscapes could result from the presence of a utility-scale solar energy development and associated land disturbances and ancillary facilities. This could affect significant resources for which visual integrity is a component of the sites' significance to the Tribes, such as sacred sites, landscapes, and trails.

- Noise degradation of settings associated with significant cultural resources and sacred landscapes also could result from the presence of a utility-scale solar energy development and associated land disturbances and ancillary facilities. This could affect the pristine nature and peacefulness of a culturally significant location.

5.16.2 Technology-Specific Impacts

The difference in land requirements is one technology-specific factor that could have a possible impact on resources of concern to Native Americans. (See Section 3.1.5 for the land requirements per megawatt output of various solar technologies.) However, because all potential impacts on tribally sensitive resources would be determined by site-specific conditions, differences in land requirements would not directly correspond to differences in impacts on these resources at the programmatic level. The magnitude or level of impact would depend on whether the specific location of a proposed solar facility contains significant resources, regardless of the overall size of the facility.

In addition, the different solar technologies result in different viewsheds based on facility height differences. For sacred landscapes, trails, and some traditional cultural properties,

technology choice could be a factor in determining whether a significant resource is adversely affected (see Section 5.12.2).

Differences in water requirements of various solar technologies also could be a factor as water use, quality, and availability are important issues of Native American concern (see Section 5.9.2). For example, reduction of spring flows would be of concern.

5.16.3 Potentially Applicable Mitigation Measures

Government-to-government consultations among the managing agency and the directly and substantially affected Tribes is required under Executive Order 13175 *(Federal Register*, Volume 65, page 67249). In addition, Section 106 of the NHPA requires federal agencies to consult with Indian Tribes for undertakings on Tribal lands and for historic properties of significance to the Tribes that may be affected by an undertaking (CFR 36 800.2 (c)(2)). BLM Manual 8120 (BLM 2004b) and Handbook H-8120-1 (BLM 2004c) provide guidance for Native American consultations. For impacts on Native American resources, such as traditional cultural properties, that constitute historic properties under the NHPA, the application of mitigation measures developed in consultation under Section 106 of the NHPA would avoid, reduce, or mitigate the potential for adverse impacts. The use of management practices, such as training/education programs for workers and the public, could reduce occurrences of human-related disturbances to nearby cultural sites. The specifics of these management practices should be established in project-specific consultations among the applicant and the managing agency, Tribes, and SHPOs, as appropriate. See Section 5.15.3 for additional potential mitigation measures for historic properties.

For those resources not considered historic properties under the NHPA, ongoing Tribal consultation would help determine other issues of concern, including but not limited to access rights, disruption of cultural practices, impacts on visual resources important to the Tribes, and impacts on subsistence resources. Ecological issues and potential mitigation measures are discussed in Section 5.10. Impacts on water use and quality and potential mitigation measures are discussed in Section 5.9. It should be noted that even when consultation and an extensive inventory or data collection occur, not all impacts on tribally sensitive resources can be fully mitigated.

Some specific mitigation measures are listed below (all mitigation measures listed in Section 5.15.3 for cultural resources would also apply to historic properties of concern to Native Americans):

- The managing agency will consult with Native American governments early in the planning process to identify issues and areas of concern for any proposed solar energy project. Such consultation is required by the NHPA and other authorities and is necessary to determine whether construction and operation of the project are likely to disturb Tribally sensitive resources, impede access to culturally important locations, disrupt traditional cultural practices, affect movements of animals important to Tribes, or visually affect

culturally important landscapes. It may be possible to negotiate a mutually acceptable means of minimizing adverse effects on resources important to Tribes.

- The importance of any Native American archaeological or other culturally important site identified in archaeological inventories in project areas should be determined and validated through consultation with appropriate Native American governments and cultural authorities. Appropriate mitigation steps, such as avoidance, removal, repatriation of Native American human remains and associated items of cultural patrimony, or curation, should be determined during this consultation.

- Visual intrusion on sacred areas should be avoided to the extent practical through the selection of the solar facility location and solar technology. When avoidance is not possible, timely and meaningful consultation with the affected Tribe(s) should be conducted to formulate a mutually acceptable plan to mitigate or reduce the adverse effect.

- Tribal burial sites should be avoided. A contingency plan for encountering unanticipated burials and funerary goods during construction, maintenance, or operation of a solar facility should be developed as part of a formalized agreement to address management and mitigation options for significant cultural resources (see Section 5.15.3) in consultation with the appropriate Tribal governments and cultural authorities well in advance of any ground disturbances. The contingency plan should include consultation with the lineal descendants or Tribal affiliates of the deceased, and human remains and objects of cultural patrimony should be protected and repatriated according to NAGPRA statutory procedures and regulations.

- Springs and other water sources that are or may be sacred or culturally important should be avoided whenever possible. If construction, maintenance, or operational activities must occur in proximity to springs or other water sources, appropriate measures, such as the use of geotextiles or silt fencing, should be taken to prevent silt from degrading water sources. The effectiveness of these mitigating barriers should be monitored. Measures for preventing water depletion impacts on spring flows should also be employed. Particular mitigations should be determined in consultation with the appropriate Native American Tribe(s).

- Culturally important plant species should be avoided when possible. When it is not possible to avoid these plant resources, consultations should be undertaken with the affected Tribe(s). If the species is available elsewhere on agency-managed lands, guaranteeing access may suffice. For rare or less common species, establishing (transplanting) an equal amount of the plant resource elsewhere on agency-managed land accessible to the affected Tribe may be acceptable.

- Culturally important wildlife species and their habitats should be avoided. When it is not possible to avoid these habitats, solar facilities should be designed to minimize impacts on game trails, migration routes, and nesting and breeding areas of Tribally important species. Mitigation and monitoring procedures should be developed in consultation with the affected Tribe(s).

- Archaeological sites created by ancestral Native American populations should be avoided whenever possible. However, when archaeological excavations are necessary, affiliated Tribe(s) should be consulted, and the concerns of the affected descendant Native American population taken into account when developing a data recovery strategy. Possible mitigations include scientific excavation; monitoring or participation in excavations by Tribal representatives; and repatriation or approved curation of artifacts.

- Rock art (panels of petroglyphs and/or pictographs) should be avoided whenever possible. These panels may be just one component of a larger sacred landscape, in which avoidance of all impacts may not be possible. Mitigation plans for eliminating or reducing (minimizing) potential impacts on rock art should be formulated in consultation with the appropriate Tribal cultural authorities.

- Standard noise mitigation measures (see Section 5.13.3) should be employed when solar facilities would be located near sacred sites to minimize the impacts of noise on culturally significant areas.

- Health and safety mitigation measures for the general public (see Section 5.21.3) should be employed when solar facilities are located near to Native American traditional use areas in order to minimize potential health and safety impacts to Native Americans.

- Prior to construction, consideration should be given to training contractor personnel whose activities or responsibilities could affect resources of significance to Native Americans during construction.

- When there is a reasonable expectation of encountering previously unidentified cultural resources during construction, monitoring of construction by a qualified cultural resource specialist should be considered to minimize impacts on resources of significance to Tribes to the extent possible.

5.17 SOCIOECONOMICS

Solar energy development would produce diverse socioeconomic impacts in the affected area around the development, nominally a 50-mi (80-km) radius. Distinct impacts would occur during facility construction and operations. The following subsections discuss the common and

technology-specific socioeconomic impacts that could occur from solar development and potentially applicable mitigation measures.

5.17.1 Common Impacts

Construction and operation of utility-scale solar energy facilities and construction of or upgrades to transmission lines in the six-state study area would produce direct and indirect economic impacts. Direct impacts would occur as a result of expenditures on wages and salaries, procurement of goods and services required for project construction and operation, and the collection of state sales and income taxes. Indirect impacts would occur as project wages and salaries, procurement expenditures, and tax revenues subsequently circulate through the economy of each state, creating additional employment, income, and tax revenues. Facility construction and operation would also require in-migration of workers and their families into each state, which would affect rental housing, public services, and local government employment. Technology-specific impacts are described in Section 5.17.2. The following sections describe the impact of solar facilities on recreation, property values, and transmission lines—impacts that would occur regardless of the solar technology developed in any of the six states.

5.17.1.1 Construction and Operations

5.17.1.1.1 Recreation Impacts. Estimating the impact of solar facilities on recreation is problematic, because it is not clear how solar development in each state would affect recreational visitation and nonmarket values (the value of recreational resources for potential or future visits; see Appendix M). While it is clear that some land in each state would be no longer accessible for recreation, the majority of popular wilderness locations would be precluded from solar development. It is also possible that solar development in each state would be visible from popular recreation locations, thus reducing visitation and consequently affecting the economy of each state.

A simple way to estimate the economic impact of recreation in each state as a whole is to identify sectors in the state economy in which expenditures on recreational activities occur, and assume solar development would affect some portion of the activity in each of these sectors. Not all activities in these sectors are directly related to recreation on federal lands; some expenditures would be made by business visitors, oil and gas workers, and interstate travelers, and some activity would occur on private land (e.g., dude ranches, golf courses, bowling alleys, and movie theaters). This section presents two simple scenarios to indicate the magnitude of the economic impact of solar development on recreation—the impact of a 0.5% and a 1% reduction in recreation activity in each state. Impact estimates include direct effects, that is, loss of recreation employment in recreation sectors, and indirect effects, that is, the impact on the remainder of the economy in each state as a result of declining recreation employee wage and salary spending and declining recreation expenditures on materials, equipment, and services. Impacts were estimated by using IMPLAN data for each state (MIG, Inc. 2005), an input-output modeling framework

designed to capture spending flows among all economic sectors and households in each state economy.

Construction and operation of solar facilities could produce the socioeconomic impacts shown in Table 5.17-1 resulting from a 0.5% and a 1% decline in recreation activity. In California, the total (direct plus indirect) impact would be the loss of 12,114 jobs statewide with a 0.5% reduction in recreation activity and 24,229 jobs with a 1% reduction in recreation activity. Income lost would be $298 million as a result of a 0.5% contraction in recreational activity and $597 million for a 1% contraction. Elsewhere in the six states, a 0.5% reduction in recreational activity would mean the loss of 1,967 jobs and $42 million in income in Colorado, 1,879 jobs and $39.3 million in income in Arizona, and 1,827 jobs and $48.2 million in income in Nevada. Table 5.17-1 indicates that a larger reduction in recreational activity of 1% would affect each state in the same proportion as would a 0.5% reduction.

5.17.1.1.2 Property Value Impacts. There is concern that solar facilities and associated transmission lines might affect property values in nearby communities. Property values might decline in some locations as a result of the deterioration in aesthetic quality, increases in noise, real or perceived health effects, congestion, or social disruption. In other locations, property values might increase because of access to employment opportunities associated with solar development.

In general, potentially hazardous facilities can directly affect property values in two ways (Clark et al. 1997; Clark and Allison 1999). First, negative imagery associated with these

TABLE 5.17-1 Estimates of State Economic Impacts of Assumed Reductions in Recreation Sector Activity[a]

	0.5% Reduction		1% Reduction	
State	Employment	Income ($ million 2006)	Employment	Income ($ million 2006)
Arizona	1,879	39.3	3,758	78.6
California	12,114	298.4	24,229	596.9
Colorado	1,967	42.3	3,933	84.7
Nevada	1,827	48.2	3,653	96.4
New Mexico	627	10.4	1,253	20.8
Utah	809	13.9	1,617	27.8

[a] The recreation sector includes amusement and recreation services, automotive rental, eating and drinking establishments, hotels and other lodging, museums and historic sites, RV parks and campsites, scenic tours, and sporting goods retailers. These results are based on assumed levels of reduced recreation and use IMPLAN data (MIG Inc. 2005) to estimate the corresponding employment and income reductions.

facilities could reduce property values if potential buyers believed that any given facility might produce an adverse environmental impact. Negative imagery could be based on individual perceptions of risk associated with proximity to these facilities or on perceptions at the community level that the presence of such a facility might adversely affect local economic development prospects. Even though a potential buyer might not personally fear a potentially hazardous facility, the buyer might still offer less for a property in the vicinity of a facility if there was fear that the facility would reduce the rate of appreciation of housing in the area. Second, there could be a positive influence on property values associated with accessibility to the workplace for workers at the facility, with workers offering more for property close to the facility to minimize commuting times. Workers directly associated with a solar facility would probably also have much less fear of the technology and operations at the facility than would the population as a whole. The importance of this influence on property values would likely vary with the size of the workforce involved.

Although there is no evidence of the impact of solar facilities on local property values, there is limited evidence of the impact of energy development on property values. In western Colorado communities adjacent to oil and gas drilling activities, property values declined with the announcement of drilling, and during the first stages of extraction, the values rebounded, at least partly, once production was fully under way (BBC Research and Consulting 2006). Other studies have assessed the impact of other potentially hazardous facilities—such as nuclear power plants and waste facilities (Clark and Nieves 1994; Clark et al. 1997; Clark and Allison 1999) and hazardous material and municipal waste incinerators and landfills (Kohlhase 1991; Kiel and McClain 1995)—on, for example, local property markets. Many of these studies used a hedonic modeling approach to take into account the wide range of spatial influences, including noxious facilities, crime (Thaler 1978), fiscal factors (Stull and Stull 1991), and noise and air quality (Nelson 1979), on property values.

The general conclusion from these studies is that while there may be a small negative effect on property values in the immediate vicinity of noxious facilities (i.e., less than 1 mi [1.6 km]), this effect is often temporary and associated with announcements related to specific project phases, such as site selection, the start of construction, or the start of operations. At larger distances or over longer project durations, no significant, enduring, negative property value effects have been found. Depending on the importance of the employment effect associated with the development of the various activities analyzed in these studies, a positive impact on property values was found to be associated with increases in demand for local housing.

Under conditions of moderate population growth and housing demand, it appears that property values could increase with the expansion in local employment opportunities resulting from solar development. However, with larger scale construction in each state, increases in population and associated congestion (in the absence of adequate private-sector real estate investment and appropriate local community planning) might adversely affect property values. Various energy development studies have suggested that once the annual growth in population is between 5 and 15% in smaller rural communities, a breakdown in social structures would occur, alcoholism, depression, suicide, social conflict, divorce, and delinquency would increase, and levels of community satisfaction would deteriorate (BLM 1980, 1983, 1996); the resulting deterioration in local quality of life would adversely affect property values.

5.17.1.1.3 Environmental Amenities and Economic Development. Solar development may affect environmental amenities, including environmental quality, stable rural community values, or cultural values, near solar facilities. Consequently, some local communities may have difficulty in attracting businesses that are highly sensitive to actual or perceived changes in environmental amenities. Over recent decades, many areas of the western United States have been able to diversify their economies away from largely extractive industries toward knowledge-based industries; the professional and service sector; and retirement, recreation, and tourism (Bennett and McBeth 1998). It is apparent, therefore, that growth in some parts of the economy has become highly sensitive to changes in environmental amenities. Although other factors, including cost and availability of labor resources and the prevailing relative cost of doing business, may be more important than environmental amenities to some sectors, extensive literature indicates that perceived deterioration in the natural environment and in amenities in particular locations may have an important impact on the ability of communities in adjacent areas to foster sustainable economic growth (Rudzitis and Johansen 1989; Johnson and Rasker 1995; Rasker 1994; Power, 1996; Rudzitis 1999; Rasker et al. 2004; Chipeniuk 2004; Holmes and Hecox 2005; Reeder and Brown 2005).

Since the 1980s, many rural areas in the six-state study area have diversified their economies toward tourism and recreation, much of which is based on natural amenities, notably hunting, fishing, bird watching, and skiing. To the extent that existing and potential new economic activities are sensitive to changes in environmental quality and the amenity-based activities they support in each state, solar energy development may create conflicts with the ability of adjacent areas in each state to attract future economic growth in economic activities that are sensitive to environmental amenities. In addition to amenity values, however, various other economic and demographic factors would have to be favorable in any given solar development area for additional economic growth to occur, in particular, the economic development potential of infrastructure and human resources in the area and the cost of doing business relative to that in other comparable locations. Given the limited economic base of the areas in which proposed solar facilities would be located, it is unlikely that high amenity values alone would be sufficient to encourage local economic growth or that businesses, once established in a given location, would necessarily relocate because of changes in amenity values.

5.17.1.1.4 Social Change and Social Disruption. 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 development projects in small rural communities are still unclear (see Appendix M). 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 affected, 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). Accordingly, because of the lack of adequate social baseline data, it has been suggested that social disruption is likely to occur once an arbitrary population growth rate associated with solar energy development projects has been reached, with an annual rate of between 5 and 10% growth in population assumed to result in a breakdown in social structures, an increase

in alcoholism, depression, suicide, social conflict, divorce, and delinquency, and deterioration in levels of community satisfaction (BLM 1980, 1983).

In overall terms, the in-migration of workers and their families into each state would represent a relatively small increase in state population during construction of the trough technology, with smaller increases for the power tower, dish engine and PV technologies, and during the operation of each technology. While it is possible that some construction and operations workers will choose to locate in communities closer to each solar development, because of the lack of available housing in smaller rural communities in the region of influence (ROI) of each solar development to accommodate all in-migrating workers and families and the insufficient range of housing choices to suit all solar occupations, many workers are likely to commute to the solar development from larger communities elsewhere, reducing the potential impact of solar development projects on social change. Regardless of the pace of population growth associated with the commercial development of solar resources, the number of new residents from outside the ROI is likely to lead to some demographic and social change in small rural communities. Communities hosting these development projects are likely to be required to adapt to a different quality of life, with a transition away from a more traditional lifestyle of ranching in small, isolated, close-knit, homogenous communities with a strong orientation toward personal and family relationships, toward a more urban lifestyle with increasing cultural and ethnic diversity and increasing dependence on formal social relationships within the community.

5.17.1.2 Transmission Lines

To capture the range of possible impacts of the construction and operation of transmission lines, two line sizes, 230 kV and 500 kV, were assessed for a 25-mi (40-km) length of line. The assessment is also conservatively assumed to apply to transmission line upgrades of a similar length. Impacts were assessed for a representative peak year of construction, assumed to be 2021, and a representative first year of operations, assumed to be 2023 (see Section 5.17.2). Expenditure data associated with the construction and operation of transmission lines were derived from Buchanan et al. (2005) and Idaho Power (2004), which provided the relevant construction and operating cost data for labor and materials in various general cost categories. These data were used to calculate the direct economic and fiscal impacts of transmission lines. IMPLAN economic data (MIG, Inc. 2005) were then used to calculate the indirect impacts associated with project wage and salary spending, material procurement spending, and expenditures of sales and income tax revenues. Direct employment data were used to estimate the number of in-migrants into each state during construction and the impacts on the rental housing market and on local government expenditures and employment.

5.17.1.2.1 Construction. Total employment impacts (including direct and indirect impacts) of construction of a transmission line in the peak year of construction for related solar facilities would be largest in Utah, where a 230-kV line would create 57 jobs and a 500-kV line would produce 131 jobs (Table 5.17-2). Smaller impacts would occur in New Mexico, where 55 jobs would be created for a 230-kV line and 128 jobs for a 500-kV line, and in Colorado

TABLE 5.17-2 Socioeconomic Impacts of Construction and Operations of 25-mi (40-km) Transmission Lines[a]

	Arizona		California		Colorado		Nevada		New Mexico		Utah	
Parameter	230 kV	500 kV	230 kV	500 kV	230 kV	500 kV	230 kV	500 kV	230 kV	500 kV	230 kV	500 kV
Construction												
Employment (no.)												
Direct	22	50	22	50	22	50	22	50	22	50	22	50
Total	47	108	51	117	52	120	46	107	55	128	57	131
Income[b]												
Total	2.3	5.4	2.5	5.12	2.4	5.5	2.2	5.2	2.2	5.1	2.3	5.4
State direct taxes[b]												
Sales	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Income	0.1	0.1	0.1	0.1	0.1	0.1	NA[c]	NA	0.1	0.1	0.1	0.1
In-migrants (no.)	4	9	4	9	4	9	4	9	4	9	4	9
Vacant rental housing (no.)	2	5	2	5	2	5	2	5	2	5	2	5
Local government												
Expenditures[b]	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1
Employment (no.)	0	0	0	0	0	0	0	0	0	1	0	0
Operations												
Employment (no.)												
Direct	0	1	0	1	0	1	0	1	0	1	0	1
Total	1	2	1	3	1	3	1	2	1	3	1	3
Income[b]												
Total	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1
State direct taxes[b]												
Sales	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Income	0.0	0.0	0.0	0.0	0.0	0.0	NA	NA	0.0	0.0	0.0	0.0

[a] Impacts were assessed for a representative peak year of construction of solar facilities, 2021, and for a representative first year of operations, 2023.

[b] Unless indicated otherwise, values are reported in $ million 2008.

[c] NA = not applicable.

(52 and 120 jobs). Transmission line construction activities would constitute less than 1% of total state employment for a 25-mi (40-km) 230-kV and 500-kV line in each of the six states. Transmission line construction would produce larger income impacts in California (between $2.5 million and $5.12 million), Colorado ($2.4 million to $5.5 million), and Arizona and Utah ($2.3 million to $5.4 million). Fiscal impacts of transmission line construction would include state sales and income taxes. Direct sales taxes and direct income taxes would be less than $0.1 million for both line sizes.

The likelihood of local worker availability in the required occupational categories during construction of a transmission line would mean that some in-migration of workers and their families from outside each state would be required, with between 4 and 9 persons in-migrating into each of the six states during construction. Although in-migration may potentially affect local housing markets, the relatively small number of in-migrants and the availability of temporary accommodations (hotels, motels, and mobile home parks) mean that the impact of transmission line construction on the number of vacant rental housing units would not be expected to be large, with between 2 and 5 rental units occupied in each of the states. These occupancy rates would represent less than 0.1% of the vacant rental units expected to be available in each of the states.

In addition to the potential impact on housing markets, in-migration would affect state and local government expenditures and employment. Transmission line construction would require less than $0.1 million in expenditures for a 230-kV line and $0.1 million for a 500-kV line in each of the states to meet existing levels of state and local government services. These increases would represent an increase of less than 0.1% over expenditures expected in each of these states. Slight increases in employment would also be expected with transmission line construction in New Mexico to maintain levels of service.

5.17.1.2.2 Operations. Total employment impacts (including direct and indirect impacts) in the first year of operation of a transmission line would be similar in each of the six states, with slightly larger impacts in California, Colorado, New Mexico, and Utah. Income impacts would also be similar in each of the six states, with small state sales and income tax revenues produced during operation of a 25-mi (40-km) line.

With a relatively small local labor force required to maintain and operate a transmission line, no in-migrants are expected with either facility size. No impacts are likely in the rental housing market or in local government expenditures or employment.

5.17.1.2.3 Recreation and Property Values. Transmission lines associated with solar facilities would have impacts on recreation, although it is not clear how transmission lines in each state would affect recreational visitation and nonmarket values (the value of recreational resources for potential or future visits). While some land in each state would no longer be accessible for recreation, the majority of popular wilderness locations would be precluded from transmission line development. It is also possible that transmission lines associated with solar facilities in each state would be visible from popular recreation locations, thus reducing visitation and consequently affecting the economy of each state.

Energy transmission lines could also affect property values in communities located on land adjacent to solar facilities, primarily as a result of the visibility of electricity transmission structures; health and safety issues (in particular, EMF concerns), and noise; traffic congestion associated with transmission lines would likely be less important. Although various studies have attempted to measure the impact of transmission lines on property values, significant data and methodological problems are associated with many of the studies, and the results are often inconclusive (Kroll and Priestley 1992; Grover Elliot and Company 2005).

5.17.2 Technology-Specific Impacts

The economic impact of solar energy development was assessed at the state level for the six-state study area. Impacts were measured in terms of employment, income and state tax revenues (sales and income), BLM acreage rental and capacity fees, population in-migration, vacant rental housing, and local government expenditures and employment. More information on the data and methods used in the analysis can be found in Appendix M.

To capture the range of possible impacts of the construction and operation of each technology, a minimum and a maximum facility size were assessed; 100 to 400 MW for trough and power tower and 10 to 750 MW for dish engine and PV. Impacts were assessed for a representative peak year of construction, assumed to be 2021 for each technology, and a representative first year of operations, assumed to be 2023 for trough and power tower, 2022 for the minimum facility size for dish engine and PV, and 2023 for the maximum facility size for these technologies. The years of construction and operations were selected as representative of the entire 20-year study period, because they are the approximate midpoint; construction and operations could begin earlier.

5.17.2.1 Parabolic Trough

5.17.2.1.1 Construction. Total employment impacts (including direct and indirect impacts) in the peak year of construction of a trough facility would be the largest in California, where a minimum size facility would create 1,935 jobs and a maximum size facility, 7,740 jobs (Table 5.17-3). Smaller impacts would occur in Nevada, where between 909 and 3,635 jobs would be created, and in Arizona, between 894 and 3,577 jobs. Solar development using trough technology would also produce between 833 and 3,377 jobs in Colorado and Utah, and between 682 and 2,728 jobs in New Mexico. Peak year construction activities would constitute less than 1% of total state employment for both the minimum and maximum facility size in each of the six states. A trough development would produce larger income impacts in California (between $115.5 million and $462.2 million), Nevada ($53.6 million to $214.5 million), and Arizona ($52.3 million to $209.4 million), and smaller impacts in Colorado, Utah, and New Mexico. Fiscal impacts of a trough facility include state sales and income taxes. Direct sales taxes would vary between $5.9 million and $23.6 million in the peak year of construction in California; and smaller impacts in Arizona (between $1.9 million and $7.7 million) and the other five states. Direct income taxes would range between $1.3 million and $5.0 million in each of the six states.

TABLE 5.17-3 Socioeconomic Impacts of Construction and Operations of Parabolic Trough Facilities[a]

	Arizona		California		Colorado		Nevada		New Mexico		Utah	
Parameter	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Construction												
Employment (no.)												
Direct	350	1,399	350	1,399	350	1,399	350	1,399	350	1,399	350	1,399
Total	894	3,577	1,935	7,740	833	3,332	909	3,635	682	2,728	844	3,377
Income[b]												
Total	52.3	209.4	115.5	462.2	47.5	190.6	53.6	214.5	37.5	150.1	47.4	173.6
State direct taxes[b]												
Sales	1.9	7.7	5.9	23.6	1.5	6.1	1.4	5.12	1.0	3.9	1.4	5.12
Income	1.3	5.0	1.3	5.0	1.3	5.0	NA[c]	NA	1.3	5.0	1.3	5.0
In-migrants (no.)	68	272	68	272	68	272	68	272	68	272	68	272
Vacant rental housing (no.)	34	136	34	136	34	136	34	136	34	136	34	136
Local government												
Expenditures[b]	0.5	2.1	0.7	3.0	0.6	2.4	0.6	2.4	0.6	2.4	0.3	1.3
Employment (no.)	3	13	3	14	4	15	3	12	5	18	4	14
Operations												
Employment (no.)												
Direct	43	172	43	172	43	172	43	172	43	172	43	172
Total	73	293	80	321	72	290	69	275	77	307	79	317
Income[b]												
Total	2.5	10.1	3.1	12.5	2.5	10.0	2.3	9.3	2.3	9.3	2.5	9.8
State direct taxes[b]												
Sales	0.0	0.2	0.0	0.2	0.0	0.2	0.0	0.2	0.0	0.2	0.0	0.2
Income	0.1	0.3	0.1	0.3	0.1	0.3	NA	NA	0.1	0.3	0.1	0.3

TABLE 5.17-3 (Cont.)

Parameter	Arizona		California		Colorado		Nevada		New Mexico		Utah	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Operations (Cont.)												
BLM payments[b]												
Acreage-related fee	<0.1	0.1	0.1	0.3	<0.1	0.1	<0.1	0.1	<0.1	0.2	0.1	0.3
Capacity fee[d]	0.7	2.6	0.7	2.6	0.7	2.6	0.7	2.6	0.7	2.6	0.7	2.6

[a] The minimum facility size for the trough was assumed to be 100 MW; the maximum facility size, 400 MW. Impacts were assessed for a representative peak year of construction, 2021, and a representative first year of operations, 2023.

[b] Unless indicated otherwise, values are reported in $ million 2008.

[c] NA = not applicable.

[d] The BLM annual capacity payment was based on a fee of $6,570 per MW, established by the BLM in its Solar Energy Interim Rental Policy (BLM 2010c), assuming a solar facility with no storage capability. Projects with three or more hours of storage would generate higher payments, based on a fee of $7,884 per MW.

Given the scale of construction activities and the likelihood of local worker availability in the required occupational categories, construction of a trough facility would mean that some in-migration of workers and their families from outside each state would be required, with between 68 and 272 persons in-migrating into each of the six states during construction. Although in-migration may potentially affect local housing markets, the relatively small number of in-migrants and the availability of temporary accommodations (hotels, motels, and mobile home parks) mean that the impact of trough facility construction on the number of vacant rental housing units would not be expected to be large, with between 34 and 136 rental units expected to be occupied in each of the states. These occupancy rates would represent less than 0.1% of the vacant rental units expected to be available in each of the states.

In addition to the potential impact on housing markets, in-migration would affect state and local government expenditures and employment. Trough construction would require an additional $0.7 million to $3.0 million in expenditures in California, and $0.6 million and $2.4 million in Colorado, Nevada, and New Mexico, to meet existing levels of state and local government services. These increases would represent an increase of less than 0.1% over expenditures expected in each of these states. Smaller increases would be expected elsewhere in the six-state study area. Employment increases would also be expected in association with solar development to maintain levels of service; 5 to 18 new employees would likely be required in New Mexico, 4 to 15 in Colorado, and 4 to 14 in Utah. These increases would represent less than 0.1% of state and local employment expected in these states. Smaller increases would be expected elsewhere in the six-state study area.

5.17.2.1.2 Operations. Total employment impacts (including direct and indirect impacts) in the first year of operation of a trough facility would be largest in California, where between 80 and 321 jobs would be created. Slightly smaller impacts would occur in Utah, where between 79 and 317 jobs would be created, and in New Mexico, between 77 and 307 jobs. A trough development would produce larger income impacts in California ($3.1 million to $12.5 million), Arizona ($2.5 million to $10.1 million), and Colorado ($2.5 million to $10.0 million), with smaller impacts in Utah, Nevada, and New Mexico. The direct fiscal impacts of a trough facility would include state sales and income taxes. Sales taxes would be up to $0.2 million in the first year of operations, while income taxes would vary between $0.1 million and $0.3 million. Based on fees established by the BLM in its Solar Energy Interim Rental Policy (BLM 2010c), acreage-related payments would vary between less than $0.1 million in Arizona, Colorado, Nevada, and New Mexico and $0.3 million in California and Utah. Solar generating capacity payments would vary between $0.7 million and $2.6 million in each of the states.

With a relatively small local labor force required to maintain and operate trough facilities, no in-migrants are expected with either facility size. No impacts are likely in the rental housing market or in local government expenditures or employment.

5.17.2.2 Power Tower

5.17.2.2.1 Construction. Total employment impacts (including direct and indirect impacts) in the peak year of construction of a power tower facility would be largest in California, where a minimum size facility would create 977 jobs and a maximum size facility, 3,748 jobs (Table 5.17-4). Smaller impacts would occur in Arizona, where 433 to 1,732 jobs would be created. Solar development using power tower technology would also produce 403 to 1,625 jobs in Colorado, Nevada, and Utah, and 330 to 1,321 jobs in New Mexico. Peak year construction activities would constitute less than 1% of total state employment for both the minimum and maximum facility size in each of the six states. A power tower development would produce larger income impacts in California ($56.0 million to $223.8 million), Arizona ($25.3 million to $101.4 million), and Nevada ($24.3 million to $97.3 million), with smaller impacts in Colorado, Utah, and New Mexico. Direct sales taxes would vary from $2.9 million to $11.5 million in the peak year of construction in California, with smaller impacts in Arizona (from $0.9 to $3.7 million) and the other four states. Direct income taxes would vary from $0.6 million to $2.4 million in each of the six states.

Given the scale of construction activities and the likelihood of local worker availability in the required occupational categories, construction of a power tower facility means that some in-migration of workers and their families from outside each state would be required, with between 33 and 132 persons in-migrating into each of the six states during construction. Although in-migration may potentially affect local housing markets, the relatively small number of in-migrants and the availability of temporary accommodations (hotels, motels, and mobile home parks) mean that the impact of power tower facility construction on the number of vacant rental housing units would not be expected to be large, with between 16 and 66 rental units expected to be occupied in each of the states. These occupancy rates would represent less than 0.1% of the vacant rental units expected to be available in each of the states.

In addition to the potential impact on housing markets, in-migration would also affect state and local government expenditures and employment. Power tower construction would require an additional $0.3 million to $1.4 million in expenditures in California and $0.3 million and $1.2 million in Colorado, Nevada, and New Mexico to meet existing levels of state and local government services. These increases would represent an increase of less than 0.1% over expenditures expected in each of these states. Smaller increases would be expected elsewhere in the six-state study area. Employment increases would also be expected in association with solar development to maintain levels of service, with 2 to 9 new employees likely to be required in New Mexico and 2 to 7 in California, Colorado, and Utah; smaller numbers would be required in the other states. These increases would represent less than 0.1% of state and local employment expected in these states.

5.17.2.2.2 Operations. Total employment impacts (including direct and indirect impacts) in the first year of operation of a power tower facility would be largest in California, where 48 to 192 jobs would be created. Slightly smaller impacts would occur in Utah, where 42 to 170 jobs would be created, and in New Mexico, 41 to 166 jobs. A power tower

TABLE 5.17-4 Socioeconomic Impacts of Construction and Operations of Power Tower Facilities[a]

	Arizona		California		Colorado		Nevada		New Mexico		Utah	
Parameter	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Construction												
Employment (no.)												
Direct	169	677	169	677	169	677	169	677	169	677	169	677
Total	433	1,732	977	3,748	403	1,614	404	1,616	330	1,321	409	1,625
Income[b]												
Total	25.3	101.4	56.0	223.8	23.1	92.3	24.3	97.3	18.2	72.7	21.0	84.0
State direct taxes[b]												
Sales	0.9	3.7	2.9	11.5	0.7	2.9	0.7	2.8	0.5	1.9	0.7	2.8
Income	0.6	2.4	0.6	2.4	0.6	2.4	NA[c]	NA	0.6	2.4	0.6	2.4
In-migrants (no.)	33	132	33	132	33	132	33	132	33	132	33	132
Vacant rental housing (no.)	16	66	16	66	16	66	16	66	16	66	16	66
Local government												
Expenditures[b]	0.3	1.0	0.3	1.4	0.3	1.2	0.3	1.2	0.3	1.2	0.2	0.6
Employment (no.)	2	6	2	7	2	7	1	6	2	9	2	7
Operations												
Employment (no.)												
Direct	20	79	20	79	20	79	20	79	20	79	20	79
Total	33	131	48	192	38	154	37	147	41	166	42	170
Income[b]												
Total	1.1	4.5	1.5	5.9	1.1	4.6	1.1	4.3	1.1	4.2	1.1	4.5
State direct taxes[b]												
Sales	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1
Income	0.0	0.1	0.0	0.1	0.0	0.1	NA	NA	0.0	0.1	0.0	0.1

TABLE 5.17-4 (Cont.)

Parameter	Arizona		California		Colorado		Nevada		New Mexico		Utah	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Operations (Cont.)												
BLM payments[b]												
Acreage-related fee	0.1	0.2	0.1	0.5	0.1	0.2	0.1	0.2	0.1	0.3	0.1	0.5
Capacity fee[d]	0.7	2.6	0.7	2.6	0.7	2.6	0.7	2.6	0.7	2.6	0.7	2.6

[a] The minimum facility size for the power tower was assumed to be 100 MW; the maximum facility size, 400 MW. Impacts were assessed for a representative peak year of construction, 2021, and for a representative first year of operations, 2023.

[b] Unless indicated otherwise, values are reported in $ million 2008.

[c] NA = not applicable.

[d] The BLM annual capacity payment was based on a fee of $6,570 per MW, established by the BLM in its Solar Energy Interim Rental Policy (BLM 2010c), assuming a solar facility with no storage capability. Projects with 3 or more hours of storage would generate higher payments, based on a fee of $7,884 per MW.

development would produce larger income impacts in California ($1.5 million to $5.9 million), Colorado ($1.1 million to $4.6 million), and Arizona and Utah ($1.1 million to $4.5 million), with smaller impacts in Nevada and New Mexico. The direct fiscal impacts of a power tower facility would include state sales and income taxes. Both sales taxes and income taxes would be less than $0.1 million in the first year of operations for both facility sizes. Based on fees established by the BLM in its Solar Energy Interim Rental Policy (BLM 2010c), acreage-related payments would vary from $0.1 million in each of the six states to $0.5 million in California and Utah. Solar generating capacity payments would vary from $0.7 million to $2.9 million in each of the six states.

With a relatively small local labor force required to maintain and operate power tower facilities, no in-migrants are expected with either facility size. No impacts are likely in the rental housing market or in local government expenditures or employment.

5.17.2.3 Dish Engine

5.17.2.3.1 Construction. Total employment impacts (including direct and indirect impacts) in the peak year of construction of a dish engine facility would be largest in California, where a minimum size facility would create 38 jobs and a maximum size facility, 2,855 jobs (Table 5.17-5). Smaller impacts would occur in Arizona, where 18 to 1,319 jobs would be created, and in Colorado, Nevada, and Utah, 16 to 1,244 jobs. Solar development using dish engine technology would produce 13 to 1,004 jobs in New Mexico. Peak year construction activities would constitute less than 1% of total state employment for both the minimum and maximum facility size in each of the six states. A dish engine development would produce larger income impacts in California ($2.3 million to $170.5 million), Arizona ($1.0 million to $77.2 million), and Nevada ($1.0 million to $74.1 million), with smaller impacts in Colorado, Utah, and New Mexico. Fiscal impacts of a dish engine facility would include state sales and income taxes. Direct sales taxes would vary from $1.0 million to $8.7 million in the peak year of construction in California, with smaller impacts in Arizona (up to $2.8 million) and the other five states. Direct income taxes would be up to $1.8 million in each of the six states.

Given the scale of construction activities and the likelihood of local worker availability in the required occupational categories, construction of a dish engine facility means that some in-migration of workers and their families from outside each state would be required, with 1 to 100 persons in-migrating into each of the six states during construction. Although in-migration may potentially affect local housing markets, the relatively small number of in-migrants and the availability of temporary accommodations (hotels, motels, and mobile home parks) mean that the impact of dish engine facility construction on the number of vacant rental housing units would not be expected to be large, with 1 to 50 rental units expected to be occupied in each of the states. These occupancy rates would represent less than 0.1% of the vacant rental units expected to be available in each of the states.

In addition to the potential impact on housing markets, in-migration would also affect state and local government expenditures and employment. Dish engine construction would

TABLE 5.17-5 Socioeconomic Impacts of Construction and Operations of Dish Engine Facilities[a]

	Arizona		California		Colorado		Nevada		New Mexico		Utah	
Parameter	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Construction												
Employment (no.)												
Direct	7	516	7	516	7	516	7	516	7	516	7	516
Total	18	1,319	38	2,855	16	1,228	16	1,230	13	1,004	17	1,244
Income[b]												
Total	1.0	77.2	2.3	170.5	0.9	70.2	1.0	74.1	0.7	55.3	0.9	64.0
State direct taxes[b]												
Sales	0.0	2.8	1.0	8.7	0.0	2.2	0.0	2.1	0.0	1.5	0.0	2.1
Income	0.0	1.8	0.0	1.8	0.0	1.8	NA[c]	NA	0.0	1.8	0.0	1.8
In-migrants (no.)	1	100	1	100	1	100	1	100	1	100	1	100
Vacant rental housing (no.)	1	50	1	50	1	50	1	50	1	50	1	50
Local government												
Expenditures[b]	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0
Employment (no.)	0	5	0	5	0	5	0	4	0	7	0	5
Operations												
Employment (no.)												
Direct	2	144	2	144	2	144	2	144	2	144	2	144
Total	3	238	4	275	3	243	3	229	3	255	4	263
Income[b]												
Total	0.1	8.2	0.1	10.7	0.1	8.3	0.1	7.8	0.1	7.7	0.1	8.2
State direct taxes[b]												
Sales	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0	0.1
Income	0.0	0.2	0.0	0.2	0.0	0.2	NA	NA	0.0	0.2	0.0	0.2

TABLE 5.17-5 (Cont.)

Parameter	Arizona		California		Colorado		Nevada		New Mexico		Utah	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Operations (Cont.)												
BLM payments[b]												
Acreage-related fee	<0.1	0.4	<0.1	0.8	<0.1	0.4	<0.1	0.4	<0.1	0.6	<0.1	0.8
Capacity fee[d]	0.1	4.9	0.1	4.9	0.1	4.9	0.1	4.9	0.1	4.9	0.1	4.9

[a] The minimum facility size for the dish engine was assumed to be 10 MW; the maximum facility size, 750 MW. Impacts were assessed for a representative peak year of construction, 2021, and for a representative first year of operations, 2022 for the minimum facility size and 2023 for the maximum facility size.

[b] Unless indicated otherwise, values are reported in $ million 2008.

[c] NA = not applicable.

[d] The BLM annual capacity payment was based on a fee of $6,570 per MW, established by the BLM in its Solar Energy Interim Rental Policy (BLM 2010c), assuming a solar facility with no storage capability. Projects with 3 or more hours of storage would generate higher payments, based on a fee of $7,884 per MW.

require less than $0.1 million in each of the six states to meet existing levels of service. These increases would represent an increase of less than 0.1% over expenditures expected in each of these states. Employment increases would also be expected in association with solar development to maintain levels of service, with up to 7 new employees likely to be required in New Mexico; up to 5 in Arizona, California, Colorado, and Utah; and up to 4 in Nevada. These increases would represent less than 0.1% of state and local employment expected in these states.

5.17.2.3.2 Operations. Total employment impacts (including direct and indirect impacts) in the first year of operation of a dish engine facility would be largest in California, where 4 to 275 jobs would be created. Slightly smaller impacts would occur in Utah, where 4 to 263 jobs would be produced, and in New Mexico (3 to 255 jobs). A dish engine development would produce larger income impacts in California ($0.1 million to $10.7 million), Colorado ($0.1 million to $8.2 million), and Arizona and Utah ($0.1 million to $8.2 million) and smaller impacts in Nevada and New Mexico. The direct fiscal impacts of a dish engine facility include state sales and income taxes. Sales taxes would be less than $0.1 million in the first year of operations in each of the states, while income taxes would be less than $0.2 million in each of the states. Based on fees established by the BLM in its Solar Energy Interim Rental Policy (BLM 2010), acreage-related payments would vary from less than $0.1 million in each of the six states to $0.8 million in California and Utah. Solar generating capacity payments would vary from $0.1 million to $4.9 million in each of the six states.

With a relatively small local labor force required to maintain and operate dish engine facilities, no in-migrants are expected with either facility size. No impacts are likely in the rental housing market or in local government expenditures or employment.

5.17.2.4 PV Systems

5.17.2.4.1 Construction. Total employment impacts (including direct and indirect impacts) in the peak year of construction of a PV facility would be largest in California, where a minimum size facility would create 18 jobs and a maximum size facility, 1,331 jobs (Table 5.17-6). Smaller impacts would occur in Arizona, where 8 to 615 jobs would be created, in Utah (8 to 580 jobs), and in Colorado and Nevada (8 to 573 jobs). Solar development using PV technology would also produce 6 to 468 jobs in New Mexico. Peak year construction activities would constitute less than 1% of total state employment for both the minimum and maximum facility size in each of the six states. A PV development would produce larger income impacts in California ($1.1 million to $79.5 million), Arizona ($0.5 million to $36.0 million), and Nevada ($0.5 million to $34.6 million) and smaller impacts in Colorado, Utah, and New Mexico. Fiscal impacts of a PV facility would include state sales and income taxes. Direct sales taxes would range from $0.1 million to $4.1 million in the peak year of construction in California, with smaller impacts in the other five states. Direct income taxes would be less than $0.8 million in each of the six states.

TABLE 5.17-6 Socioeconomic Impacts of Construction and Operations of PV Facilities[a]

Parameter	Arizona		California		Colorado		Nevada		New Mexico		Utah	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Construction												
Employment (no.)												
Direct	3	241	3	241	3	241	3	241	3	241	3	241
Total	8	615	18	1,331	8	573	8	573	6	468	8	580
Income[b]												
Total	0.5	36.0	1.1	79.5	0.4	32.8	0.5	34.6	0.3	25.8	0.4	29.8
State direct taxes[b]												
Sales	0.0	1.3	0.1	4.1	0.0	1.0	0.0	1.0	0.0	0.1	0.0	1.0
Income	0.0	0.8	0.0	0.8	0.0	0.8	NA[c]	NA	0.0	0.8	0.0	0.8
In-migrants (no.)	1	47	1	47	1	47	1	47	1	47	1	47
Vacant rental housing (no.)	0	23	0	23	0	23	0	23	0	23	0	23
Local government												
Expenditures[b]	0.0	0.4	0.0	0.5	0.0	0.4	0.0	0.4	0.0	0.4	0.0	0.2
Employment (no.)	0	2	0	2	0	3	0	2	0	3	0	2
Operations												
Employment (no.)												
Direct	0	14	0	14	0	14	0	14	0	14	0	14
Total	0	24	0	27	0	24	0	23	0	25	0	26
Income[b]												
Total	0.0	0.8	0.0	1.1	0.0	0.8	0.0	0.8	0.0	0.8	0.0	0.8
State direct taxes[b]												
Sales	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Income	0.0	0.0	0.0	0.0	0.0	0.0	NA	NA	0.0	0.0	0.0	0.0

TABLE 5.17-6 (Cont.)

Parameter	Arizona		California		Colorado		Nevada		New Mexico		Utah	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
BLM payments[b]												
Acreage-related fee	<0.1	0.4	<0.1	0.8	<0.1	0.4	<0.1	0.4	<0.1	0.6	<0.1	0.8
Capacity fee[d]	0.1	3.9	0.1	3.9	0.1	3.9	0.1	3.9	0.1	3.9	0.1	3.9

[a] The minimum facility size for the PV facility was assumed to be 10 MW; the maximum facility size, 750 MW. Impacts were assessed for a representative peak year of construction, 2021, and for a representative first year of operations, 2022 for the minimum facility size and 2023 for the maximum facility size.

[b] Unless indicated otherwise, values are reported in $ million 2008.

[c] NA = not applicable.

[d] The BLM annual capacity payment was based on a fee of $5,256 per MW, established by the BLM in its Solar Energy Interim Rental Policy (BLM 2010c).

Given the scale of construction activities and the likelihood of local worker availability in the required occupational categories, construction of a PV facility would mean that some in-migration of workers and their families from outside each state would be required, with 1 and 47 persons in-migrating into each of the six states during construction. Although in-migration may potentially affect local housing markets, the relatively small number of in-migrants and the availability of temporary accommodations (hotels, motels, and mobile home parks) would mean that the impact of PV facility construction on the number of vacant rental housing units is not expected to be large, with up to 23 rental units expected to be occupied in each of the six states. These occupancy rates would represent less than 0.1% of the vacant rental units expected to be available in each of the six states.

In addition to the potential impact on housing markets, in-migration would also affect state and local government expenditures and employment. PV construction would require $0.0 million to $0.5 million in expenditures in California, and $0.0 million to $1.4 million in Arizona, Colorado, Nevada, and New Mexico to meet existing levels of service. These increases would represent an increase of less than 0.1% over expenditures expected in each of these states. Smaller increases would be expected elsewhere in the six-state region. Employment increases would also be expected in association with solar development to maintain levels of service, with up to 3 new employees likely to be required in Colorado and New Mexico and up to 2 in the other states. These increases would represent less than 0.1% of state and local employment expected in these states.

5.17.2.4.2 Operations. Total employment impacts (including direct and indirect impacts) in the first year of operation of a PV facility would be largest in California, where less than 1 to 27 jobs would be created. Slightly smaller impacts would occur in Utah, where less than 1 and 26 jobs would be produced, and in New Mexico, up to 25 jobs. A PV development would produce larger income impacts in California, less than $0.1 million to $1.1 million, and less than $0.1 million to $0.8 million in the five other states. The direct fiscal impacts of a PV facility would include state sales and income taxes. State taxes would amount to less than $0.1 million in each of the six states. Based on fees established by the BLM in its Solar Energy Interim Rental Policy (BLM 2010c), acreage-related payments would vary from less than $0.1 million in each of the six states to $0.8 million in California and Utah. Solar generating capacity payments would vary from $0.1 million to $3.9 million in each of the six states

With a relatively small local labor force required to maintain and operate PV facilities, no in-migrants are expected with either facility size. No impacts are likely in the rental housing market or in local government expenditures or employment.

5.17.3 Potentially Applicable Mitigation Measures

The economic effects of solar energy projects can be positive, with increases in employment, income, and state tax revenues; thus, few, if any, mitigation measures may be necessary. On the basis of the potential magnitude of employment impacts of each solar technology, however, it is possible that the socioeconomic impacts of solar development

projects, notably the impacts of in-migrating workers on local housing markets and on local government expenditures and employment, would require mitigation measures. A large in-migrant labor force has the potential to produce some degree of social disruption, whereby the cultural and social values of in-migrants conflict with those of the resident population, potentially creating alienation, crime, alcoholism, drug use, mental health problems, and the disruption of family life.

The following mitigation measures may be applicable to avoid or reduce these impacts, depending on site- and project-specific conditions.

- To address impacts on local issues, the BLM may include stipulations in the ROW authorization or require solar developers to enter into mitigation agreements with individual local jurisdictions and county agencies, as necessary.

- Project developers should collect and evaluate available information describing the socioeconomic conditions in the vicinity of the proposed project, as needed, to predict potential impacts of the project.

- If the managing agency concluded that the project is likely to have a substantial impact on the economic or social conditions of local communities, project developers should work with state, local and Tribal agencies and governments to develop community monitoring programs that would be sufficient to identify and evaluate socioeconomic impacts resulting from solar energy development. Monitoring programs should collect data reflecting the economic, fiscal, and social impacts of development at the state, local, and Tribal levels. Parameters to be evaluated could include impacts on local labor and housing markets, local consumer product prices and availability, local public services (police, fire, and public health), and educational services. Programs also could monitor indicators of social disruption (e.g., crime, alcoholism, drug use, and mental health) and the effectiveness of community welfare programs in addressing these problems.

- If the managing agency concludes that the project is likely to have a substantial impact on the economic or social conditions of local communities, the agency may include stipulations in the ROW authorization (if BLM) or require solar developers to enter into mitigation agreements with individual local jurisdictions and county agencies, as necessary, to address local issues. Also, project developers should work with state, local, and Tribal agencies to develop community outreach programs that would help communities adjust to changes triggered by solar energy development. Such programs could include any of the following activities:

  – Establishing vocational training programs for the local workforce to promote development of skills required by the solar energy industry;

- Developing instructional materials for use in area schools to educate the local communities on the solar energy industry;

- Supporting community health screenings; and

- Providing financial support to local libraries for the development of information repositories on solar energy, including materials on the hazards and benefits of commercial development. Electronic repositories established by the operators could also be of great value.

5.18 ENVIRONMENTAL JUSTICE

Solar energy development could raise environmental justice concerns in the affected area around the development, nominally a 50-mi (80 km) radius, if minority or low-income populations are present. Such concerns would result from potential impacts on many of the environmental resources discussed above. The following subsections discuss the common and technology-specific impacts on environmental justice concerns that could occur from solar development and potentially applicable mitigation measures.

5.18.1 Common Impacts

The areas of concern that might potentially affect low-income or minority populations are noise and dust during the construction of utility-scale solar facilities and the associated access roads; visual impacts of solar generation and auxiliary facilities, including transmission lines; noise and EMF effects associated with solar project operations; access to land used for economic, cultural, or religious significance; and property values. The impact analyses for these areas of concern are presented in previous sections of this chapter.

Because impacts resulting from the construction and operation of solar facilities with the potential to affect low-income and minority populations are likely to be small and there are no low-income or minority populations, as defined by Council on Environmental Quality (CEQ) guidelines (see Section 4.18.1), in the six-state study area (with the exception of New Mexico, where there is a minority population), impacts of solar projects would not disproportionately affect low-income or minority populations. However, since population composition could change with the coming census, a brief description of the kinds of impacts that could affect minority and low-income populations is provided below.

Noise and dust impacts during construction of solar generation and other facilities would be minor and temporary, even given the amount of land typically disturbed, and the relative remoteness of locations used for solar facilities would mitigate some of the impacts. Access roads required during construction for the delivery of equipment and materials to energy project sites could affect low-income or minority populations, depending on the terrain across which these roads would be constructed, access road length, the length of time they would be used for construction traffic, and the proximity to these populations.

Visual impacts from generation and auxiliary facilities associated with each solar technology may also affect low-income or minority populations. Although preliminary screening excludes development on BLM-administered lands designated as being of scenic quality or interest, solar development may potentially alter the scenic quality in areas of traditional or cultural significance to these populations.

Although likely to be minor, noise and EMF impacts from project operation could also create impacts affecting low-income or minority populations. The extent to which these effects are issues would depend on the size of the energy facilities and related transmission lines and on their proximity to these populations.

Access to lands that contain animals or vegetation of cultural or religious significance to certain population groups or that form the basis for subsistence agriculture may be restricted because of the development of solar facilities. The curtailment of various economic uses of federal lands due to solar energy facility development, such as leasing for mineral, energy, and forestry resource development, may also affect low-income or minority populations if individuals involved in specific resource developments are concentrated in affected local communities.

Property value impacts on private land in the vicinity of solar facilities may affect low-income or minority populations, depending on the extent to which these population groups are concentrated in affected local communities. The precise nature of the impact would depend on current property values and the perceived value of costs (visual impacts, traffic congestion, noise and dust pollution, and EMF effects) and benefits (infrastructure upgrades, utility hookups, cheap and reliable energy supplies, and local tax revenues) of a property's proximity to a solar facility.

5.18.2 Technology-Specific Impacts

Potential environmental justice impacts are not dependent on the type of technology used at solar facilities. Any solar facility has the potential for the common impacts discussed in Section 5.18.1.

5.18.3 Potentially Applicable Mitigation Measures

Mitigation of environmental justice impacts, specifically those associated with visual impacts of solar generation facilities, may be required. Mitigation of visual impacts would include the siting of facilities to minimize contrast with scenic views, the appropriate use of construction materials that minimize scenic contrast, and the avoidance of traditional and cultural sites important to low-income and minority populations. Noise and dust impacts during construction of solar facilities, particularly those associated with the construction of access roads, would be reduced by using standard mitigation methods, while noise and any EMF effects during project operation would be minimal due to the remote locations of the majority of solar facilities in each of the six states and would be unlikely to require any mitigation.

Although the environmental impacts of solar development on low-income and minority populations are likely to be small, where such environmental justice impacts occur, the developer should make a plan to implement a number of mitigation measures to mitigate the potential environmental, economic, cultural, and health impacts on low-income and minority populations. These mitigation measures may include any or all of the following:

- Focused public information campaigns could be developed and implemented to provide technical and environmental health information directly to low-income and minority groups or to local agencies and representative groups. Key information would include the extent of any likely impact on air quality, drinking water supplies, subsistence resources, public services, and the relevant preventive measures that may be taken.

- Community health screenings for low-income and minority groups.

- Financial support to local libraries in low-income and minority communities could be provided for the development of information repositories on solar energy, including materials on the hazards and benefits of commercial development.

In addition to the environmental impacts that may affect low-income and minority populations, there are various economic impacts that may require mitigation, including lack of access to construction and operations employment. Mitigation measures might include the following:

- Vocational training for the local low-income and minority workforce could be established to promote development of skills required by the solar energy industry, and

- Instructional materials could be developed for use in area schools to educate the local communities on the solar energy industry.

The likelihood of rapid population growth following the in-migration of workers in communities with low-income and minority populations could lead to overstressing of local community social structures. Beliefs and value systems among the local population and in-migrants would likely contrast and, consequently, could lead to a range of changes in social and community life, including increases in crime, alcoholism, and drug use. In anticipation of these impacts, mitigation measures might include the following:

- Key information could be provided to local governments and directly to low-income and minority populations on the scale and timeline of expected solar projects and on the experience of other low-income and minority communities that have followed the same energy development path. In addition, information on planning activities that may be initiated to provide local infrastructure, public services, education, and housing could be made available.

5.19 TRANSPORTATION

Transportation requirements for construction, operation, and decommissioning of a typical utility-scale solar energy facility are discussed in Section 3.4. Potential impacts are related to the project location; the project size; the delivery of equipment, materials, and supplies; and the daily commute of workers, as discussed in the following sections.

5.19.1 Common Impacts

Primary impacts on transportation are expected for the road network. Workers are expected to commute to work over local roads, and shipments to and from the solar energy facilities are expected to be by truck, although rail transport to the closest intermodal facility for materials could be used. As discussed in Section 3.4, the major, projected transportation-related impact is the potential degradation of the level of service of local roads around a solar energy facility as a result of increased traffic volumes.

5.19.1.1 Siting

The location of large solar energy facilities can have direct impacts on the local road network. At sizes exceeding 1,000 acres (4.05 km^2), these facilities could pose an impediment to travel from off-site locations on one side to destinations on another. Additional travel times and added traffic congestion could result.

The proximity of the site to major roads will determine to some extent the traffic congestion problems anticipated from construction worker commuters, as discussed in Section 5.19.1.2. Some of the best solar resources are located in remote areas that may be served by only one major road (e.g., a state highway) providing access from two directions, while other locations may have multiple access routes. Limited access can lead to more significant impacts should delays occur due to inclement weather, road maintenance or construction, higher vehicle volumes, or traffic accidents.

The location of the site with respect to the electric grid will determine where the electric transmission line from the site will connect to the grid and the route and length of the transmission line. Likewise, gas and water utility lines must also be determined if required by the solar energy plant design. The construction and operation of the transmission, water, and gas lines would not be expected to result in any significant transportation impacts, but the addition of any construction workers associated with them could increase impacts coupled with the construction workers associated with the solar energy facility itself, as discussed in Section 5.19.1.2.

Utility-scale solar energy projects are expected to have an insignificant impact on railroad operations. However, potential conflicts could arise if there are rail crossings near roads heavily involved with site traffic, especially during the construction period, as covered in Section 5.19.1.2. An increased risk of a collision between a train and a vehicle could occur,

most notably from drivers trying to beat a train because of frustration with site-related traffic congestion.

With respect to air traffic, electric transmission lines, with heights up to about 150 ft (45 m),[8] could pose a hazard to low-flying aircraft. Installation of a new transmission line to connect the site to the electric grid would need to take civil and military considerations into account to avoid runway approach patterns, low-altitude flight corridors, and military exercise areas.

5.19.1.2 Site Construction

In general, the heavy equipment and materials needed for site access, site preparation, and solar array footing or foundation construction are typical of road construction projects and do not pose unique transportation considerations. However, local road improvements may be necessary if access routes are not built to support heavy truck traffic up to the federal limit of 80,000 lb (36,280 kg) gross vehicle weight for the National Network (23 CFR Part 658). In addition, it is likely that a small number of one-time oversized and/or overweight shipments may be required for the larger earthmoving equipment required for site preparation. In cases of previously disturbed areas, demolition of existing structures might be necessary prior to grading and project construction. Any resulting debris would be required to be shipped off-site to an appropriate disposal facility.

Shipments of overweight and/or oversized loads can be expected to cause temporary disruptions on the secondary and primary roads used to access a construction site. It is possible that local roads might require fortification of bridges and removal of obstructions to accommodate overweight or oversized shipments. The need for such actions must be determined on a site-specific basis. Moreover, the solar energy facility access road must be constructed to accommodate such shipments. Overweight and oversized loads typically require tractor-trailer combinations with multiple axles, special local/county/state permits, advance and trailing warning vehicles, and possible police escorts. Travel during off-peak hours and/or temporary road closures may also be necessary. Most of the construction equipment (e.g., heavy earthmoving equipment, cranes) would remain at the site for the duration of construction activities. Because such construction equipment is routinely moved on U.S. roads and there will be only a limited number of one-time shipments, no significant impact is expected from these movements to and from the construction site.

The movement of other equipment and materials to the site during construction would cause a small increase in the level of service of local roadways during the construction period. Shipments of materials, such as gravel, concrete, water, and solar components, would not be expected to significantly affect local primary and secondary road networks. For larger projects (e.g., >200 MW), the average number of deliveries could be on the order of 20 to 30 per day (BrightSource Energy, Inc. 2007; Beacon Solar, LLC 2008; SES Solar Two, LLC 2008) or

[8] For a potential range of typical high-voltage transmission line towers and their height ranges, see Great River Energy (2008).

higher (Carrizo Energy, LLC 2007) and could go as high as approximately 85 per day (Topaz Solar Farms, LLC 2008) during peak construction activities. Deliveries are more likely to occur during morning work hours but could occur anytime during the day. Assuming that all deliveries occur during the morning between 8:00 a.m. and noon, the average traffic volume on local roads would increase by about 20 vehicles per hour during peak construction periods. This increase is not enough to change a route's level of service and thus is considered to be an insignificant impact.

On the other hand, significant impacts could arise from workers commuting to the construction site for larger projects. Peak construction workforces have been estimated to range from about 400 to 1,400 daily workers (see Section 5.17; also BrightSource Energy, Inc. 2007; Carrizo Energy, LLC 2008; Beacon Solar, LLC 2008), with averages from about 100 to 400 or more workers (Beacon Solar, LLC 2008; Topaz Solar Farms, LLC 2008) over construction periods ranging from 2 to 4 years. In the worst case, if workers were to drive individually to the project site during peak construction periods, 700 or more additional vehicles per hour (1,400 workers arriving on-site between 7:00 and 9:00 a.m.) could severely degrade an access route's level of service.

5.19.1.3 Operations

Transportation activities during solar energy production would involve commuting workers, material shipments to and from the facility, and on-site work and travel. Operations crews may number more than 150 for larger projects but are anticipated to number on the order of 10 to 50 workers during daytime hours (see Section 5.17; also Carrizo Energy, LLC 2008; Topaz Solar Farms, LLC 2008; SES Solar Two, LLC 2008), with a minimal crew of a few personnel during the nighttime in most cases. At most, a few daily truck shipments to or from a site are expected. Deliveries of materials during operations could include hazardous materials such as fuels for backup generators or maintenance vehicles. Section 3.5 provides more information on the hazardous materials used in the different solar energy technologies. Delivery of technology-specific hazardous materials is noted in Section 5.19.2. Shipments of hazardous materials require proper route selection as well as appropriate operator training and qualifications. However, all types of hazardous materials transported for use at solar energy facilities are routinely shipped in the United States for other applications and pose no unusual hazards. Thus, no significant impacts are expected from hazardous material shipments. Shipments from facilities would also include wastes for disposal.

With some facility sizes on the order of thousands of acres, on-site operations would include travel to various locations for repairs and maintenance, including dust suppression and cleaning operations. If on-site water is not available for these latter operations, shipments of water to the facility location would be required as well.

Consequently, transportation activities during operations would be limited to a small number of daily trips by personal vehicles and a few truck shipments at most. It is possible that large components may be required for equipment replacement in the event of a major equipment malfunction. However, such shipments would be expected to be infrequent. The level of

transportation activity during operations is expected to have an insignificant impact on the local transportation network.

The electrical interference of transmission lines or solar array control systems with aircraft operations is remote but should be evaluated for any new installation. Interactions with low-altitude aircraft avionics or communications have the potential to occur if corona discharges from the transmission lines are not minimized and if specific electric frequencies are not avoided. Also, the potential for glare from solar energy facilities (reflection of the sun off of mirrors or PV panels) to interfere with pilot vision is not expected to be a significant impact. Aircraft flying over these facilities receive diffuse reflections as they are well away from the focal point of any parabolic mirrors or trough reflectors. Past experience with flights over solar facilities likens the visual impact to the reflection of the sun off large ponds or lakes (Carrizo Energy, LLC 2007; Beacon Solar, LLC 2008). In the case of heavily traveled air routes, such as airport approach routes, the solar array patterns could be adjusted to minimize interference.

5.19.1.4 Decommissioning/Reclamation

With some exceptions, transportation activities during site decommissioning/reclamation would be similar to those during site development and construction. Heavy equipment and cranes would be required for dismantling solar arrays, breaking up array foundations if necessary, and regrading and recontouring the site to the original grade. Aside from any construction equipment, oversized and/or overweight shipments are not expected during decommissioning activities, because any major components can be disassembled, segmented, or reduced in size prior to shipment.

5.19.2 Technology-Specific Impacts

The major potential transportation impacts from utility-scale solar energy projects are similar for all the technologies considered in this PEIS, as presented in Section 5.19.1. There are a few differences, as noted below. However, these technology-specific impacts are not expected to be significant if properly mitigated.

Electric transmission lines, used for all technologies, pose a physical low-altitude flight hazard to aircraft, as discussed in Section 5.19.1.1. Power towers could pose greater height hazards to aircraft; for example, the Ivanpah power tower facility proposed in California includes power towers with heights reaching 459 ft (140 m) (BrightSource Energy, LLC 2007). The Crescent Dunes Solar Energy Project proposed by Tonopah Solar Energy, LLC for a location in Nye County, Nevada, has a proposed central tower height of 633 ft (192 m) (Tonopah Solar Energy 2009). Thus, the siting of power tower–based facilities needs to take civil and military considerations into account to avoid runway approach patterns, low-altitude flight corridors, and military exercise areas.

Oversize shipments would be necessary for the delivery of STGs and main transformers used for the trough and power tower technologies. Such equipment is typically shipped by rail to

the nearest intermodal facility where transfer to specially designed tractor trailers would occur for transport to the project location. Special considerations for oversize loads are discussed in Section 5.19.1.2. Because such shipments are one-time events and would be similar to those needed for some construction equipment, no significant transportation impacts are expected.

Truck deliveries of materials and supplies during solar energy facility operations would include hazardous materials specific to the solar technology in use. Section 3.5 summarizes the materials and their applications. No significant impacts are anticipated, as discussed in Section 5.19.1.3.

5.19.3 Potentially Applicable Mitigation Measures

Depending on site-specific characteristics, a number of mitigation measures may be required for transportation impacts. Appropriate measures should be determined during the siting and design phase through the development of a Transportation Plan and a Traffic Management Plan. Measures appropriate to implement include the following:

- Easements could be required for public roadway corridors through a site to maintain proper traffic flows and retain more direct routing for the local population.

- To mitigate impacts related to the daily commutes of construction workers, the operator may be required to implement local road improvements, provide multiple site access locations and routes, stagger work schedules for different work functions (e.g., site preparation, array foundation installation, array assembly, and electrical connections), shift work hours to facilitate off-peak commuting times to minimize impact on local commuters, and/or implement a ride-sharing or shuttle program.

- To reduce hazards for incoming and outgoing traffic, as well as to expedite traffic flow, the operator may be required to implement traffic control measures, such as intersection realignment coupled with speed limit reduction; the installation of traffic lights and/or other signage; and the addition of acceleration, deceleration, and turn lanes on routes with site entrances. These types of measures can be considered during the siting and design phase through development of the following plans:

  – Transportation Plan, particularly for oversized or overweight components specific to a solar energy development (STGs). The plan should consider component sizes, weights, origin, destination, and unique handling requirements. It should also evaluate alternate transportation approaches (barge, rail).

  – Traffic Management Plan for site access roads and for the use of main public roads. The plan should include road design, construction, and

management standards. It also should incorporate consultation with local planning authorities regarding traffic in general and specific issues such as school bus routes and stops.

5.20 HAZARDOUS MATERIALS AND WASTE

Section 3.5 provides a discussion of the amounts and types of hazardous materials that would be present at a solar facility during its construction, operation, and decommissioning phases. Wastes expected to be generated during those phases and the likely management and disposal strategies that would be employed are also discussed. The following sections discuss the possible adverse impacts resulting from the presence and use of hazardous materials and the generation, management, and disposal of wastes. Appropriate mitigation strategies are also presented.

5.20.1 Common Impacts

5.20.1.1 Construction

Despite the fundamental differences in the manner in which CSP (i.e., parabolic trough, power tower, and dish engine) and PV solar technologies generate electricity, the array of hazardous materials used in facility construction is generally the same for all solar technologies and also quite similar to hazardous materials used in the construction of any industrial facility. Likewise, the wastes expected to be generated are common to such construction projects, and various mitigation measures exist for their safe management and disposal. Impacts from the hazardous materials present during construction include increased risks of fires and contamination of environmental media from improper storage and handling, leading to spills or leaks. However, as suggested previously, there is considerable experience in the use of such hazardous materials to support industrial construction, and the construction industry has established appropriate management practices, worker training, personal protective equipment (PPE), and contingency planning to address such potentially adverse impacts. Section 5.20.3 provides a comprehensive list of appropriate mitigation measures for hazardous materials used during construction.

Construction-related wastes include various fluids from the on-site maintenance of construction vehicles and equipment (used lubricating oils, hydraulic fluids, glycol-based coolants, and spent lead-acid storage batteries); incidental chemical wastes from the maintenance of equipment and the application of corrosion-control protective coatings (solvents, paints, and coatings); construction-related debris (e.g., dimension lumber, stone, and brick); and dunnage and packaging materials (primarily wood and paper). All such materials are expected to be initially accumulated on-site and ultimately disposed of or recycled through off-site facilities. Some construction-related waste (e.g., spent solvents and corrosion control coatings that are applied in the field) may qualify as characteristic hazardous waste or state- or federal-listed hazardous waste. Short-term accumulation and storage of hazardous waste on-site would be

subject to the generator regulations in 40 CFR Part 261 promulgated under the authority of the Resource Conservation and Recovery Act (RCRA). However, any hazardous waste is likely to be transported to off-site RCRA-permitted treatment, storage and disposal facilities (TSDF) prior to the time when the RCRA regulations would require a permit for their on-site management.

Potential impacts from the generation of such wastes include potential contamination of environmental media from improper collection, containerization, storage, and disposal. As with hazardous materials, appropriate waste management strategies, supported by the availability of appropriate waste containers and properly designed storage areas and implemented by worker training and adherence to established and disseminated waste management policies and appropriate in-house spill response capabilities,[9] can be expected to successfully avert adverse impacts while the wastes are being accumulated on-site and during delivery to off-site disposal or recycling facilities. A comprehensive list of appropriate mitigation measures for on-site management and off-site transport of construction-related wastes is provided in Section 5.20.3.

5.20.1.2 Operations

Unlike the construction phase, there are substantial differences among the solar technologies in the types of hazardous materials needed to support their operational phases. All solar technologies can be expected to have substantial quantities of dielectric fluids contained in various electrical devices such as switches, transformers, and capacitors, as well as several types of common industrial cleaning agents. All solar facilities also can be expected to engage in some degree of noxious weed and vegetation management that would result in approved and registered herbicides being applied on the site and some wastes generated as a result of such activities. Beyond these factors, PV facilities can be expected to have a relatively small complement of hazardous materials present to support equipment cleaning, repair, and maintenance. Conversely, the amount and variety of hazardous materials needed to support CSP facilities is substantially greater. Section 5.20.3 presents specific mitigation measures to avert adverse impacts.

Wastes common to all solar technologies include (1) domestic solid wastes and sanitary wastewaters from workforce support and (2) industrial solid and liquid wastes resulting from routine cleaning and equipment maintenance and repair. Volumes of domestic solid wastes and sanitary wastewaters would be limited and proportional to the expected relatively small size of the operating workforce. Various options would be available for the management and disposal of domestic solid waste and sanitary waste. In all instances, solid wastes can be expected to be accumulated on-site for short periods until they are delivered to permitted off-site disposal facilities, typically by commercial waste disposal services. Options for sanitary wastewaters range from on-site disposal in septic systems, when circumstances allow, to off-site treatment and disposal in publically owned treatment works. All such treatment or disposal options, properly implemented, would preclude adverse environmental impacts. Some industrial wastes (e.g., spent cleaning solvents) may exhibit hazardous character, but well-established procedures

[9] Because of the expected remoteness of some facilities, responses by external resources may not be immediate and in-house spill/emergency response capabilities sufficient to stabilize the upset condition are considered essential.

for the management, disposal, and/or recycling of all industrial wastes should be readily available and would keep adverse impacts to a minimum. Wastes from herbicide applications would likely include empty containers and possibly some herbicide rinsates.[10]

Unless major malfunctions occur, dielectric fluids can be expected to remain in their devices throughout the active life of the facility, and no dielectric wastes are expected except as a result of unplanned spills or leaks. Adverse impacts would include potential worker exposure to hazardous materials and wastes and contamination of environmental media resulting from spills or leaks of hazardous materials or from improper waste management techniques. Well-developed management programs involving proper facility design, worker training, PPE, well-developed and well-understood management strategies, and appropriate spill contingency plans can be expected to largely preempt adverse impacts. Section 5.20.3 provides a comprehensive list of possible mitigation measures.

5.20.1.3 Decommissioning/Reclamation

During decommissioning, virtually the identical complement of hazardous materials would be present to support vehicles and equipment as was present during facility construction. However, the decommissioning period would likely be shorter than that of initial construction.

Wastes generated during decommissioning would largely be derived from the maintenance of vehicles and equipment and can expected to be managed in very much the same manner as during construction, with the same potential for adverse impacts. However, in addition to wastes generated in support of vehicles and equipment, other large-volume wastes would be generated as a result of draining and purging of plant systems. Spent HTF, dielectric fluids, TES salts, and steam amendment chemicals would be produced in large quantities. Much of this volume of waste would have recycling options, but subsequent flushing (with water or appropriate organic solvents) and cleaning of the systems from which they were removed would generate wastes in need of disposal. Impacts during facility dismantlement and draining would include spills and leaks and releases to the environment from improper temporary on-site storage of recovered fluids.

Substantial quantities of solid materials would also be produced during facility dismantlement. Some would need to be managed as solid waste (e.g., broken concrete and masonry from on-site buildings and foundations); however, much of the material produced

[10] Pesticide application is likely to be a contracted service. Typically, pesticide contractors will be responsible for removing any wastes from the operation to off-site treatment or disposal facilities. Use of proper techniques in developing field-strength solutions from pesticide concentrates typically results in a triple-rinsed container that can be disposed of as solid waste and rinsates that will have been incorporated into the solution to be applied. Application equipment is typically cleaned at the contractor's off-site location.

(e.g., steel and aluminum infrastructures, reflecting mirrors, power cables, pipes, and pumps) is likely to be recyclable after short-term on-site storage.[11]

Finally, for PV facilities using high-performance solar cells, special handling of solar panels containing toxic metals would be required to prevent their accidental breakage and to preserve any opportunities for the recycling of the solar cell materials (at off-site facilities).

5.20.2 Technology-Specific Impacts

5.20.2.1 Parabolic Trough and Power Tower

Parabolic trough and power tower facilities would have substantial quantities of HTFs circulating in pipes throughout the solar field and connecting the solar field to the power block facility. The amounts would be proportional to the power rating and size of the solar field, but also greatly dependent on facility configurations and the sizes of supporting reservoirs (if any) used to address thermal inertia and shorter cold start-up times. Although these materials are expected to remain in their respective systems throughout the facility's operating life, adverse impacts may include environmental media contamination from spills or leaks in the HTF system. Parabolic trough and power tower facilities would also have substantial quantities of hazardous chemicals on hand to provide water treatment in support of the steam cycle. Handling and transfers of these chemicals could also result in spills or leaks. However, because most of these chemicals would likely be stored in bulk tanks within a power block building, proper building design would likely prevent spills and leaks from immediately or inevitably becoming a release to the environment; such events would nevertheless result in wastes, some of which would display the hazardous character of acidic or alkaline corrosivity. Maintenance of steam systems and wet-cooling systems would produce blowdown wastes that would likely be managed in lined on-site impoundments. A robust monitoring, inspection, and maintenance program for the HTF and steam treatment systems; inspection and monitoring of impoundment liner integrity; a formally developed and well-appointed spill response capability; and appropriate worker training would be effective in limiting adverse environmental impacts from spills and leaks. HTF system design that includes strategically placed isolation valves could also limit the amount of HTF potentially at risk for a release. Another aspect of HTF use and storage at these facilities is flammability of these substances, some of which have relatively low flash points.

Section 3.5 identifies the types of industrial solid wastes expected to result from the operation of parabolic trough and power tower facilities. Most are commonplace to wastes generated at any thermal electric power–generating facility. Some of these wastes would be generated in high volumes (e.g., lubricating oils, compressor oils, and hydraulic fluids); however, recycling options for these same waste streams are also likely to be available. Other wastes may

[11] Given the volumes of materials produced during facility dismantlement, it is possible that laydown areas used during initial construction would be re-established as temporary storage areas for materials awaiting delivery to recycling areas. Waste materials would ideally be stored in areas used for hazardous materials and waste storage during facility operation before being transported to off-site treatment, storage, or disposal facilities.

need to be managed as hazardous wastes. Properly designed and operated waste storage areas would limit adverse impacts during what is expected to be short-term on-site waste storage. No disposal of industrial solid waste is expected to occur on-site. The use of authorized transportation services should adequately control adverse impacts during transport to off-site treatment, disposal, or recycling facilities, including prompt and qualified response to transportation-related accidents.

Future parabolic trough and power tower facilities that also have TES capabilities would also likely have large quantities of salt present in the TES system. As the pure eutectic, the mixture of sodium and potassium nitrates would not exhibit corrosive properties but would become highly corrosive in the presence of water. Consequently, once released, the salts would be capable of creating chemical burns on contact with living tissue and would behave as strong fertilizers, thus creating adverse impacts on water courses and vegetation. Proper TES system design, together with an appropriate inspection and maintenance program, would preempt accidental releases, while worker training and appropriate containment equipment could limit environmental impacts if releases occur.

5.20.2.2 Dish Engine

Unique conditions would exist at solar dish engine facilities. Stirling-type external heat engines being proposed for commercial application by Stirling Energy Systems (SES) are expected to leak hydrogen from their receivers at a rate of 0.5 ft^3/day (0.014 m^3/day) (Kostok 2008). Replacement of lost hydrogen could be accomplished by providing each dish engine with its own dedicated source of hydrogen. On that design basis, in addition to the approximately 14 ft^3 (0.39 m^3) of hydrogen contained in the receivers of the 30,000 external heat engines that would make up a proposed 750-MW facility, each dish engine would be supported by a compressed gas cylinder (known in the industry as a "K" bottle[12]) of hydrogen containing approximately 196 ft^3 (5.5 m^3) of hydrogen (at standard temperature and pressure) positioned at the base of the dish and connected to the receiver by means of a valve activated by a pressure sensor. This amounts to another 5.9 million ft^3 (0.165 million m^3) of hydrogen deployed throughout the solar field. For logistical reasons, approximately another 100 cylinders would be stored in a central storage facility to address malfunctions or support unscheduled, premature cylinder change-outs (Kostok 2008). Consequently, for a 750-MW facility, the total amount of hydrogen present in the solar field and in a central reserve storage facility would be about 6,320,000 ft^3 (179,000 m^3; a total weight of about 33,000 lb [15,000 kg]) (SES Solar Two, LLC 2008). Operation at full capacity should result in nearly 30,000 change-outs of hydrogen cylinders each year.[13] In such an arrangement, the initial deployment, the central storage facility, as well as the annual change-outs, all represent potential fire risks. Although hydrogen has a very large explosive range of concentrations in air, the explosion potential is low for outside storage and use, because the less-dense hydrogen dissipates quickly when released into the air. A

[12] "K" bottles have a nominal internal gas volume of 1.8 ft^3 (0.05 m^3) at 70°F (21°C) and 1 atm of pressure.

[13] SES representatives indicate that, in the future, their technology development plan would replace individual hydrogen cylinders with centralized bulk hydrogen storage facilities, each capable of simultaneously supporting as many as 300 dish engines.

properly designed central storage facility and proper operating procedures, including worker training, should mitigate the fire risks of both cylinder handling and storage to a sufficient degree.

An alternative design basis for replacing hydrogen lost through leakage would involve development of a centrally located facility for in-situ production of hydrogen through electrolysis of water (SES Solar Two, LLC, 2009). Once produced in the electrolyzer, the hydrogen would be temporarily stored in a high-pressure tank that could store a few days' worth of hydrogen and would supply hydrogen to a distribution network.[14] Such an arrangement would dramatically reduce the amount of hydrogen actually present at the facility at any point in time, with hydrogen production rates at the electrolyzer generally matching the rates of loss of hydrogen from each of the dish engines. Fire risks associated with change-outs of individual cylinders would also be eliminated. Despite these factors, however, fire risks would not be entirely eliminated by this alternative design. In addition to the central hydrogen production facility and high-pressure storage tank, fire risks would exist anywhere within the complex hydrogen distribution network that would deliver hydrogen to each dish engine, and the engines themselves would continue to represent a fire risk.

5.20.2.3 PV Systems

Only a small array of hazardous materials would be used to support the operation of a solar PV facility. Under normal operating circumstances, no unique hazardous materials or waste impacts other than those discussed in Section 5.20.1.2 are anticipated. As discussed more fully in Section 5.21, high-performance solar cell materials contain small amounts of toxic metals such as cadmium, selenium, and arsenic. Under normal conditions, these metals are secured within sealed solar panels and represent no hazard to workers or the public. However, damaged solar cells may create worker exposure and may require special handling during facility decommissioning. Because the metals involved are relatively rare in commerce, efforts have been undertaken to create recycling opportunities for damaged or decommissioned high-performance solar panels; however, given the relative newness of this aspect of the PV solar energy industry, it is not possible to affirm with certainty that such recycling opportunities would materialize or be available at the time current facilities are decommissioned.[15] Absent legitimate recycling opportunities, damaged or decommissioned solar panels containing toxic metals would need to be characterized and might need to be managed as hazardous waste.

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[14] A mitigation measure that would add a return line, allowing hydrogen to return to the storage tank when each dish engine is not in service, would further reduce overall losses of hydrogen to the environment.

[15] Current incentives for PV panel recycling are the result of the relative rarity and expense of the toxic metals currently used in high-performance PV panels. However, should PV technology evolve to the use of other materials in high-performance PV cells, the recycling value of current-day PV panels would be significantly reduced (at least as a source of refabricated PV panels), and such technological evolutions could be a disincentive to the emerging PV recycling market.

5.20.3 Potentially Applicable Mitigation Measures

Means to eliminate or reduce adverse impacts from hazardous materials and wastes include compliance with applicable laws, ordinances, and regulations and conformance with relevant industry standards (including those issued by nonregulatory bodies such as the National Fire Protection Association). For the solar facility projects issued ROWs by the BLM, construction and operation plans must also incorporate elements of relevant construction standards and interconnection requirements of the transmission system operator as well as the reliability requirements of FERC orders.[16]

Solar facility developers should construct several plans addressing various aspects of hazardous materials and waste, including a Hazardous Materials and Waste Management Plan, a Construction and Operation Waste Management Plan, a Fire Management and Protection Plan, a Nuisance Animal and Pest Control Plan, and Vegetation Management Plan (if the facility will use pesticides/herbicides), and a Spill Prevention and Emergency Response Plan. These plans will include the following items:

- A Hazardous Materials and Waste Management Plan should address the selection, transport, storage, and use of all hazardous materials needed for construction, operation, and decommissioning of the facility for local emergency response and public safety authorities and for the regulating agency, and should address the characterization, on-site storage, recycling, and disposal of all resulting wastes.[17] The plan should contain, at a minimum, the following: facility identification; comprehensive hazardous materials inventory; Material Safety Data Sheets (MSDSs) for each type of hazardous material; emergency contacts and mutual aid agreements, if any; site map showing all hazardous materials and waste storage and use locations; copies of spill and emergency response plans (see below), and hazardous materials-related elements of a decommissioning/closure plan.

- A Construction and Operation Waste Management Plan should identify the waste streams that are expected to be generated at the site and address hazardous waste determination procedures, waste storage locations, waste-specific management and disposal requirements (e.g., selecting appropriate waste storage containers, appropriate off-site treatment, storage, and disposal facilities), inspection procedures, and waste minimization procedures. The plan should address all solid and liquid wastes that may be generated at the site in compliance with the CWA requirements to obtain the project's NPDES permit.

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16 See, for example, the construction standards issued by the WAPA (Western 2008) and the generator responsibilities established by the California independent system operator (http://www.caiso.com/thegrid/operations/opsdoc/gcp/index.html).

17 It is not anticipated that any solar energy facility would have hazardous chemicals present on-site in such quantities as to require development of a Risk Management Plan as specified in 40 CFR Part 68.

- A Fire Management and Protection Plan should be developed to implement measures to minimize the potential for fires associated with substances used and stored at the site. The flammability of the specific HTF used at the facility should be considered.

- If pesticides/herbicides are to be used on the site, a Nuisance Animal and Pest Control Plan and an Integrated Vegetation Management Plan should be developed to ensure that applications will be conducted within the framework of managing agencies and will entail the use of only EPA-registered pesticides/herbicides that are nonpersistent and immobile and approved by the managing agency.

- A comprehensive Spill Prevention and Emergency Response Plan should address the possibility of accidental releases for all hazardous materials stored on site. The plan should include the following: be written, periodically updated, and made available to the entire workforce; contain procedures for timely notification of appropriate authorities, including the designated BLM land manager; provide spill/emergency contingency planning for each type of hazardous material present, including the abatement or stabilizing of the release, recovery of the spilled product, and remediation of the affected environmental media; be supported by the strategic deployment of appropriate spill response materials and equipment, including PPE for individuals with spill or emergency response assignments; provide for prompt response to spills and timely delivery of recovered spill materials and contaminated environmental media to appropriately permitted off-site treatment or disposal facilities; formally assign spill and emergency response duties to specified individuals; provide and document appropriate training to individuals with spill or emergency response assignments; provide general awareness training to remaining facility personnel; and provide for written documentation of each event, including root cause analysis, description of corrective actions taken, and characterization of the resulting environmental or health and safety impacts.

Potentially applicable mitigation measures for hazardous materials and wastes at solar facilities include the following:

- All site characterization, construction, operation, and decommissioning activities should be conducted in compliance with applicable federal and state laws and regulations, including the Toxic Substances Control Act of 1976, as amended (15 USC 2601, et seq.). In addition, any release of toxic substances (leaks, spills, and the like) in excess of the reportable quantity established by 40 CFR Part 117 should be reported as required by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, Section 102b. A copy of any report required or requested by any federal agency or state government as a result of a reportable release or spill of any toxic substances should be furnished to the authorized officer concurrent with

the filing of the reports to the involved federal agency or state government. In addition, the United States should be indemnified against any liability arising from the release of any hazardous substance or hazardous waste on the facility or associated with facility activities.

- Project developers should survey project sites for unexploded ordnance, especially if projects are within 20 mi (32 km) of a current U.S. Department of Defense (DoD) installation or formally used defense site.

- Pollution prevention opportunities should be identified and implemented, including material substitution of less hazardous alternatives, recycling, and waste minimization.

- Systems containing hazardous materials should be designed and operated in a manner that limits the potential for their release, constructed of compatible materials in good condition (as verified by periodic inspections), including provision of secondary containment features (to the extent practical); installation of sensors or other devices to monitor system integrity; installation of strategically placed valves to isolate damaged portions and limit the amount of hazardous materials in jeopardy of release; and robust inspection and use of repair procedures.

- Dedicated areas with secondary containment should be established for off-loading hazardous materials transport vehicles.

- To the greatest extent practical and by considering the remoteness of a given facility, “just-in-time” ordering procedures should be employed that are designed to limit the amounts of hazardous materials present on the site to quantities minimally necessary to support continued operations. Excess hazardous materials should receive prompt disposition.

- Written procedures for the storage, use, and transportation of each type of hazardous material present should be provided, including all vehicle and equipment fuels.

- Authorized users for each type of hazardous material should be identified.

- Procedures should be established for fuel storage and dispensing, including shutting off vehicle (equipment) engines; using only authorized hoses, pumps, and other equipment in good working order; maintaining appropriate fire and spill response materials at equipment-fueling stations; providing emergency shutoffs for fuel pumps; ensuring that fueling stations are paved; ensuring that both aboveground fuel tanks and fueling areas have adequate secondary containment; prohibiting smoking, welding, or open flames in fuel storage and dispensing areas; equipping the area with fire suppression devices, as appropriate; conducting routine inspections of fuel storage and dispensing

areas; requiring prompt recovery and remediation of all spills, and providing for the prompt removal of all fuel and fuel tanks used to support construction vehicles and equipment at the completion of facility construction and decommissioning phases.

- Refueling areas should be located away from surface water locations and drainages and on paved surfaces; features should be added to direct spilled materials to sumps or safe storage areas where they can be subsequently recovered.

- All vehicles and equipment should be in proper working condition to ensure that there is no potential for leaks of motor oil, antifreeze, hydraulic fluid, grease, or other hazardous materials.

- Hazardous materials and waste storage areas or facilities should be formally designated and access to them restricted to authorized personnel. Construction debris, especially treated wood, should not be disposed of or stored in areas where it could come in contact with aquatic habitats.

- Design requirements should be established for hazardous materials and waste storage areas that are consistent with accepted industry practices as well as applicable federal, state, and local regulations and that include, at a minimum, containers constructed of compatible materials, properly labeled, and in good condition; secondary containment features for liquid hazardous materials and wastes; physical separation of incompatible chemicals; and fire-fighting capabilities when warranted.

- Written procedures should be established for inspecting hazardous materials and waste storage areas and for plant systems containing hazardous materials; identified deficiencies and their resolution should be documented.

- Schedules should be established for the regular removal of wastes (including sanitary wastewater generated in temporary, portable sanitary facilities) for delivery by licensed haulers to appropriate off-site treatment or disposal facilities.

- During facility decommissioning, the following should occur: emergency response capabilities should be maintained throughout the decommissioning period as long as hazardous materials and wastes remain on-site, and emergency response planning should be extended to any temporary material and equipment storage areas that may have been established; temporary waste storage areas should be properly designated, designed, and equipped; hazardous materials removed from systems should be properly containerized and characterized, and recycling options should be identified and pursued; off-site transportation of recovered hazardous materials and wastes resulting from decommissioning activities should be conducted by authorized carriers; all

hazardous materials and waste should be removed from on-site storage and management areas (including surface impoundments), and the areas should be surveyed for contamination and remediated as necessary.

5.21 HEALTH AND SAFETY

Solar energy development could produce occupational health impacts on workers and environmental health concerns in the area around the facilities. Such impacts and concerns would result from the construction and operation of the primary and supporting solar facilities, including transmission lines. The following subsections discuss the common and technology-specific health and safety concerns that could occur from solar development and potentially applicable mitigation measures.

5.21.1 Common Impacts

5.21.1.1 Occupational Health and Safety

Occupational health and safety considerations related to typical solar energy projects are introduced in Section 3.6. These occupational considerations include physical hazards; risks of injuries and/or fatalities to workers during construction and operation of facilities and associated transmission lines; risks resulting from exposure to weather extremes (e.g., occupational heat stress or stroke, frostbite); risk of harmful interactions with plants and animals; risks associated with working at extreme heights; fire hazards; risks associated with retinal exposures to high levels of glare; a small risk of exposures to hazardous substances used at or emitted from the facilities; risk of electrical shock; and the possibility of increased cancer risk if exposure to magnetic fields of exceptionally high strengths were to occur. Table 5.21-1 enumerates the major occupational health and safety issues related to activities at solar energy facilities and associated transmission systems. Potential control measures for these health and safety issues are also given, including recommendations for the creation of several site plans to address specific issues individually and in detail. For example, a PPE training plan is recommended to ensure that workers know that the PPE is available and how to use it to maximize their safety.

Potential occupational health and safety risks would be very limited during the site characterization phase because of the limited extent of activities. Occupational hazards would be greater during construction, operation, and decommissioning of a solar energy facility; they can be minimized when workers adhere to safety standards and use appropriate protective equipment. However, fatalities and injuries from on-the-job accidents can occur, especially in association with heavy construction activities.

Physical hazards associated with the construction of solar facilities are similar to those from construction in any industry and include possible injuries or deaths due to machinery malfunctions, falls, overexertion, and so on. Statistics for work-related injuries and deaths show a rate of approximately 6.4 injuries per 100 workers and 11.6 deaths per 100,000 workers

TABLE 5.21-1 Occupational Health and Safety Hazards of Solar Energy Facilities and Associated Transmission Lines

Activity	Generic Hazard	Potential Control Measures
Construction[a]		
Clearing ROW and constructing access roads	Physical hazards from the use of heavy equipment, power saws; falling trees and branches; exposure to herbicides; bee stings and animal and insect bites; noise exposure; trips and falls; eye pokes; heat and cold stress; smoke inhalation	Daily safety briefing; PPE training plan; safeguards on equipment; safe practices for downing trees; safe operation of equipment; approved herbicide application procedures; on-site first aid capability
Constructing site facilities and substations, installing building foundations, placing equipment	General construction hazards; working around live electricity and energized equipment; exposure to hazardous materials	Electrical safety plan; hazardous materials safety plan
Installing transmission line support towers	Heavy equipment operation, crane operation; overhead work/falling items; falls from heights	Licensed equipment operators; work area controls; PPE/hard hats; safety equipment
Stringing conductors	Rotating equipment; lines under tension; suspended loads; overhead work/falling items	Work area controls; PPE; safety equipment
Installing underground transmission lines	Heavy equipment operation; buried utilities; falls in trenches	Trenching/confined-space entry plan; ground surveys
General construction activity: power tools	Employee injury from hand and portable power tools	Hand and portable power tool safety plan; PPE training plan
General construction activity: walking/working on surfaces	Employee injury/property damage from inadequate walking and work surfaces	Housekeeping and material-handling and storage plan
General construction activity: noise	Employee exposure to occupational noise	Hearing conservation plan; PPE training plan
General construction activity: injuries	Employee injury to head, eyes/face, hand, body, back, foot, and skin from work around cranes/hoists or other heavy equipment; exposure to hazardous substances; exposure to extreme heat	PPE training plan; injury prevention plan (including heat stress/stroke); hazard communication plan (including provision of material safety data sheets)
General construction activity: fall potential	Fall potential resulting from working in rugged areas	Injury prevention plan; safety harnesses and equipment; rescue response plan

TABLE 5.21-1 (Cont.)

Activity	Generic Hazard	Potential Control Measures
Construction (Cont.)		
General construction activity: welding	Employee exposure to compressed welding gases and to hazards of compressed air-driven tools and equipment	Hazard communication plan; gas-filled equipment safety plan; compressed gas storage, handling, and use training
Installation and testing of gas-filled equipment	Employee injury and property damage due to failure of pressurized system components or unexpected release of pressure	Gas-filled equipment safety plan
General construction activity: working near/in water	Employee exposure to water (water crossings), drowning hazard	Special construction techniques and training; special personal protective devices, monitors
Dangerous animals/ insects/plants	Bites and injuries sustained from contact with dangerous animals, insects, and plants	Injury prevention plan; protective clothing; animal, pest, and vegetation control plan; on-site first-aid capability
Operations		
Daily operations; repairs to facility/ROW	Heavy equipment operation; working around energized transmission lines and shock hazards; exposure to herbicides; exposure to glare from solar collectors	Daily safety briefing; PPE training plan; electrical safety plan; injury prevention plan; licensed operators; safeguards on equipment; safe operation of equipment; approved herbicide application procedures; on-site first-aid capability
Transmission line maintenance	Falls from heights; shock hazards; risks of helicopter/airplane operation	Training; safety equipment; work in good weather
Alternating current (AC) flow at solar field, substations, or along transmission lines	Magnetic field exposures	Minimizing distance from equipment or transmission line to receptors; line routing and ROW spacing
Induced currents along transmission lines	Corrosion of adjacent pipelines and other metallic buried infrastructure	Monitoring; cathodic protection systems; pipe coatings
Induced voltages	Shock hazards	AC mitigation installation; use of ground fault mats; grounding of metallic equipment and objects
Inspections conducted on the ground	Weather extremes; rugged terrain; dangerous animals, insects, and plants	Injury prevention plan; protective clothing; a Nuisance Animal and Pest Control Plan and Vegetation Management Plan; on-site first-aid capability

[a] Health and safety hazards during site decommissioning are similar to those occurring during construction.

annually for construction work (NSC 2006). For operations, the injury and fatality rate for solar facilities can be assumed to be similar to that for the manufacturing industry, which has an injury rate of 6.6 injuries per 100 workers and a fatality rate of approximately 2.5 deaths per 100,000 workers annually (NSC 2006).

The number of injuries and fatalities statistically expected in association with construction and operation of solar facilities was calculated on the basis of National Safety Council (NSC) statistics and the estimated number of full-time equivalent employees (see Section 5.17) and are given in Table 5.21-2. The estimated number of annual injuries during construction would range from less than 1 for a 10-MW dish engine or PV facility up to 90 for a 400-MW parabolic trough facility. The estimated annual construction fatalities are low for all technologies, with a maximum of 0.16 fatalities per year for a 400-MW parabolic trough facility. The estimated incidence of injuries and fatalities is quite low for operations, due to both the low numbers of employees and the relatively low hazard of required activities.

TABLE 5.21-2 Estimates of Annual Fatalities and Injuries for Construction and Operation of Solar Power Facilities[a]

		Annual Injuries		Annual Fatalities	
Technology		Low	High	Low	High
Parabolic trough	Construction	22	90	0.04	0.16
	Operations	2.8	11	0.001	0.004
Power tower	Construction	11	43	0.02	0.08
	Operations	1.3	5.2	0.0005	0.002
Dish engine	Construction	<1	33	0.0008	0.06
	Operations	<1	9.5	0.00005	0.004
PV systems	Construction	<1	15	0.0004	0.03
	Operations	0	1	0	0.0004
Transmission lines (25 mi)[b]	Construction	1.5	3.2	0.003	0.006
	Operations	NA[c]	NA	NA	NA

[a] Estimates are based on the direct employment values given in Section 5.17 and the injury and fatality rates given in NSC (2006). Low values are for minimally sized facilities (i.e., 100 MW for parabolic trough and power tower; 10 MW for dish engine and PV); high values are for large facilities (i.e., 400 MW for parabolic trough and power tower; 750 MW for dish engine and PV).

[b] Low and high estimates are for construction of 25 mi (40 km) of either 230-kV or 500-kV transmission line. Estimates are not available for operation of these lines; injury and fatality rates are expected to be very low, however, because of the low number of workers required.

[c] NA = not available.

Sections 3.5 and 5.20 present the types of potentially hazardous substances that could be present during construction and operation of solar facilities. In general, the volumes of hazardous substances used at solar facilities are small, so that potential occupational exposures would be minimal and not associated with adverse health impacts. A substance used and/or stored at higher volumes at solar facilities is dielectric fluid, which is used as an insulating fluid for electrical devices such as transformers, switches, capacitors, and bushings. Petroleum-based mineral oil is often used as a dielectric fluid; in high-voltage capacitors, however, vegetable-based oils with higher dielectric constants (e.g., castor oil) may be used for better performance. These oils are not volatile and have low oral and dermal toxicity; thus spills could be contained and cleaned up with little potential for exposure or adverse health effects to workers. In some equipment, the dielectric medium is sulfur hexafluoride (SF_6) gas. This heavier-than-air gas is nontoxic but can act as an asphyxiant and irritant and may engage in certain chemical reactions when involved in a fire circumstance that can produce hazardous substances such as hydrogen fluoride (HF). Additionally, SF_6 is ranked as a high global warming potential gas by the EPA (2010), so even small releases could result in adverse global warming impacts. However, SF_6 is often preferred over mineral oil dielectric media because of its superior performance.

Other potentially hazardous substances that could be present in high volumes at solar facilities include HTFs and TES media at parabolic trough and power tower facilities, compressed hydrogen at dish engine facilities, and toxic heavy metals in semiconductors (albeit in sealed solar panels in very small amounts) at PV facilities. These substances are discussed in Section 5.21.2.

There is also a potential for retinal damage if glare from solar receivers is viewed from a close distance and more than momentarily. This hazard requires evaluation for parabolic trough, power tower, and dish engine facilities that concentrate solar energy through the reflection of sunlight from mirrors and heliostats as the mechanism of power production. The hazard potential from these types of facilities was recently evaluated by Ho et al. (2009) and is further discussed below under Technology-Specific Impacts.

5.21.1.2 Public Health and Safety

Health and safety risks to the general public can include physical hazards from unauthorized access to construction or operational areas of solar facilities; increased risk of traffic accidents in the vicinity of solar facilities; risk of eye damage from glare from mirrors, heliostats, and power tower receivers; and aviation safety interference. Because of the remote nature of most solar facilities, these health and safety risks are generally low but should be addressed in facility health and safety plans.

Risks from public exposure to hazardous substances through air emissions from solar facilities are low, because the few substances that are stored and used at the facilities in large quantities have low volatility and inhalation toxicity (see Sections 5.21.2.1 and 5.21.2.2). Small quantities of combustion-related hazardous substances may be emitted from diesel-burning construction equipment. In addition, during operations there may be emissions of similar contaminants from steam boilers using natural gas or coal as an energy source at certain times.

Because these would be supplemental boilers using small amounts of fuel, however, emissions and corresponding health risks are likely to be small. Nevertheless, he health risks of such emissions should be evaluated at the project-specific level.

Electrically energized equipment and conductors associated with solar facilities and the transmission lines that serve them represent electrical hazards. Proper signage and or engineered barriers (e.g., fencing) would be necessary to prevent access to these electrical hazards by unauthorized individuals or wildlife.

Public exposures to magnetic fields associated with solar facilities would be expected to be negligible, because setback zones would require homes and occupied buildings to be located well away from solar facilities and transmission lines.

5.21.2 Technology-Specific Impacts

5.21.2.1 Parabolic Trough and Power Tower

A potential occupational health risk unique to trough and tower facilities would be potential exposure to HTFs and/or TES media. The HTFs most commonly used are therminol and dowtherm (see Table 3.5.2-1). Therminol is an ethylated benzene compound with relatively low volatility at ambient temperatures. It has a low oral and inhalation toxicity (Solutia, Inc. 2006) and is irritating to the skin. Dowtherm is primarily of ethylene glycol, a common antifreeze. It also has a low volatility at ambient temperatures, low inhalation toxicity, and moderate oral toxicity, and brief skin contact is non-irritating (Dow Chemical, Inc. 2004).

HTFs are stored in tanks and/or circulated through the solar field in pipes, so the potential for occupational exposures is low when workers follow applicable handling instructions. Exposures can occur when leaks in the HTF circulation system are repaired or segments of the system are drained to replace damaged components. Toxicity data, handling instructions, appropriate PPE, and training for specific HTFs used would be needed at individual solar facilities.

The use of TES at trough and tower facilities is likely to increase substantially in the coming years. Currently molten salt (a mixture of sodium nitrate and potassium nitrate) is a likely TES medium, although other substances are being investigated. The nitrate salts, which would be used at extremely high temperatures, are highly reactive oxidizers, which accelerate and exacerbate any fires in which they are involved and may react with reducing agents to cause fires. These substances can cause severe irritation through inhalation, ingestion, or dermal contact (Mallinckrodt Baker, Inc. 2007, 2008). Molten salts used at solar facilities would be stored in large tanks isolated from other materials, and the occupational exposure potential would be low. Toxicity data and handling instructions and training for specific TES media used would be needed at individual solar facilities.

Parabolic trough and power tower facilities both rely on mirrored surfaces of excellent reflectivity for their overall performance. In the case of parabolic trough facilities, these mirrors not only reflect but also concentrate sunlight. The presence of these highly reflective surfaces is therefore of concern with respect to potential exposures to reflected sunlight of damaging intensity.

Parabolic-shaped mirrors concentrate reflected sunlight to the mirror's focal point. For most parabolic trough facilities, the focal point is on the order of 3 to 10 ft (1 to 3 m) from the mirrored surface. At or near that focal point, the reflected light is of sufficient intensity to cause damage to unprotected eyes. However, given those physical dimensions, the likelihood of any worker being in a position to actually view the reflected light at its highest intensity is very small, especially assuming adequate training and adherence to established procedures. The mirrors are relatively inaccessible to the general public; however, there is some potential for individuals to view intense reflected light from a project's fence line, depending on the distance. The highest risk of such exposures would occur when mirrors are being rotated from stowed to tracking position (Ho et al. 2009).

For power tower facilities, the heliostats are flat (or nearly flat) surfaces with much longer focal lengths. The heliostats are positioned to direct their reflected light on the receiver at the top of the tower where heat is generated, not through sunlight concentration as in the case of parabolic trough facilities, but by the simple additive effect of many heliostats directing their reflected light to the same spot. The distance from an individual heliostat to the receiver can be hundreds of feet. Similar to the risk from mirrors at parabolic plant facilities, there is some risk of exposure to intense reflected light from heliostats, again particularly when they are being moved from stowed to tracking position or vice versa. An additional consideration is exposure to light reflected from the tower receiver. However, the height of the towers makes the risk of retinal damage at ground level very small. Also, aircraft flying over power tower facilities would be required to be no lower than about 900 ft (274 m) from the top of the tower, so risks of retinal damage to aircraft pilots and passengers flying overhead would be small (BLM and CEC 2009).There is a potential for distraction from viewing bright tower receivers, which could be a hazard for aircraft pilots and for automobile traffic on nearby roadways.

Although coordination with regional airports would direct air traffic away from power tower facilities, there is a possibility that a small plane could fly between a heliostat field and the tower receiver and intercept the reflected light. The closer the plane would be to the receiver, the greater the possibility that it would intercept the reflected light of more than one heliostat. Since individual heliostats have little concentrating effect on incident sunlight, the intensity of the reflected light would be the same or less than the intensity of direct sunlight. The low level of concentration by individual heliostats, the expectation that air traffic controllers would instruct pilots to avoid the immediate vicinity of a tower, and the probability that even if such exposures occurred, they would be of very short duration, collectively suggest that risks of permanent retinal damage to occupants of planes are minimal.

5.21.2.2 Dish Engine

For dish engine facilities, each dish engine would include a cylinder of compressed hydrogen to replace hydrogen working fluid that escapes from the external heat engine through leaks. Hydrogen is a simple asphyxiant (material that causes suffocation at high concentrations), but there is essentially no risk of releases from individual cylinders that would result in hydrogen concentrations of concern with respect to asphyxiation inside solar facility buildings. Hydrogen cylinders are pressurized and must be stored in dry, well-ventilated areas at a temperature of less than 125°F (52°C) to avoid explosion and fire hazard (Aneka Gas, Inc. 2005). Handling instructions and training in cylinder handling would be needed at dish engine facilities.

Ho et al. (2009) summarize the results of several evaluations of the hazard of glare from dish engines, all of which concluded that the potential for retinal damage from exposure to such glare is very small.

5.21.2.3 PV Systems

PV solar facilities do not require the potentially hazardous liquids and gases needed by the other solar energy technologies during operations; however, PV panels do contain potentially hazardous metals in solid form. These metals are encapsulated but could potentially be released to the environment on a small scale if one or several panels were broken or on a larger scale if the solar field caught fire.

Solar panels for utility-scale facilities in the United States would likely utilize nonhazardous silicon-based semiconductor material in the near term. However, semiconductors containing cadmium, copper, gallium, indium, and/or arsenic compounds could be used in the future. Of these, cadmium is the metal with the highest potential for use in utility-scale systems and also has high toxicity. Cadmium-based semiconductor modules contain about 7 g of cadmium per square meter (de Wild-Scholten 2008). Consequently, substantial quantities of cadmium or other semiconductor metals may be present at utility-scale PV facilities.

The release of cadmium and other heavy metals from broken modules and/or during fires constitutes an area of concern (Nieulaar and Alsema 1997; Fthenakis and Zweible 2003). Releases under normal operations could be through leaching from broken or cracked modules. In general, researchers have concluded that such releases would result in a negligible potential for human exposures (EPRI and PIER 2003; Fthenakis and Zweible 2003).

5.21.3 Potential Impacts of Accidents, Sabotage, and Terrorism

Owners and operators of critical infrastructure (which includes solar energy facilities) are responsible for ensuring the operability and reliability of their systems. To do so, they must evaluate the impacts on their system from all credible events, including natural disasters (landslides, earthquakes, storms, and so on) as well as mechanical failure, human error, sabotage, cyber attack, or deliberate destructive acts of both domestic and international origin,

recognizing intrinsic system vulnerabilities, the realistic potential for each event/threat, and the consequences. This section discusses both the regulatory requirements for these assessments and the types of events that could occur at solar facilities and associated transmission lines.

5.21.3.1 Regulatory Background

Regulations promulgated by various federal and state oversight agencies confirm project developers' responsibilities for protecting critical infrastructure through a variety of prescribed actions and system performance requirements designed to protect the public and/or the environment from adverse consequences of disruptions or failures, and to provide for system reliability and resiliency. Regulations and directives promulgated by the FERC are an example of such a regulatory program. Special system designs, construction techniques, advanced communication and system-monitoring capabilities, and other preemptive protective measures have been developed to meet the requirements of those regulations. "Best industry practices" that have also been developed are designed to further ensure system reliability and to minimize interruptions in service (e.g., security measures, fencing, personnel policies). Developers of solar facilities will be expected to conform to all applicable regulations and best industry practices.

Homeland Security Presidential Directive 7 (HSPD-7), signed by President Bush on December 17, 2003, establishes a national policy that affirms the responsibility of federal departments and agencies to identify and prioritize U.S. critical infrastructure and key resources and to protect them from terrorist attacks (DHS 2003). Under that Directive, "federal departments and agencies will identify, prioritize, and coordinate the protection of critical infrastructure and key resources in order to prevent, deter, and mitigate the effects of deliberate efforts to destroy, incapacitate, or exploit them. Federal departments and agencies will work with state and local governments and the private sector to accomplish this objective."

HSPD-7 resulted in the June 2006 publication of the *National Infrastructure Protection Plan* (DHS 2006), the development of which was coordinated by the U.S. Department of Homeland Security (DHS). The current *National Infrastructure Protection Plan* (DHS 2009) comprises 18 sector-specific plans, each addressing a category of critical infrastructure and key resources. Two sector-specific plans are especially relevant to protection of critical infrastructure of solar energy facilities and transmission lines: the plan for energy (DHS and DOE 2007) and the plan for transportation systems (DHS 2007), both of which were published in May 2007. The DOE Office of Energy Efficiency and Electricity Reliability serves as the sector-specific agency for energy and is primarily responsible for the development and implementation of the energy plan. The Transportation Security Administration (TSA) of DHS serves a similar function for the transportation plan.

The energy sector-specific plan addresses the production, refining, storage, and distribution of oil and gas and electricity. The transportation sector-specific plan addresses the movement of people and the transport of goods by all modes of transportation, and especially addresses the transport of hazardous materials (including crude oil, natural gas, and refined petroleum products) by all modes of transport, including pipelines. Pipelines are addressed in the transportation sector-specific plan as a mode of transportation; however, pipelines are also an

integral part of the energy sector. As a result, unique partnerships have been struck between private-sector representatives and representatives of both sector-specific agencies to ensure coordinated implementation of both plans. The energy and transportation plans establish appropriate risk management frameworks to meet their respective goals and objectives. Although the DOE and the TSA are the agencies explicitly directed to develop and implement the plans that most directly address critical infrastructure and key resources for solar facilities, HSPD-7 obligates all federal agencies to cooperate with those efforts. Solar project developers would also be full participants in the implementation of applicable plan objectives and programs.

Although it is important for the public to be informed as to the commitment and basic structural approach of the national integrated effort to address terrorism, the specific strategies and tactics that emerge cannot be shared. Thus, while some protective measures and activities are obvious (e.g., fencing around electric substations and switchyards, routine surveillance and inspections), other measures must remain covert to maintain their effectiveness.

5.21.3.2 Credible Events

5.21.3.2.1 Natural Events. There is a potential for natural events to affect human health and the environment during all phases of development of solar facilities. Such events include tornadoes, earthquakes, severe storms, and fires. Depending on the severity of the event, fixed components of a solar facility could be damaged or destroyed, resulting in economic, safety, and environmental consequences. The probability of a natural event occurring is location-specific and differs among the locations considered in this PEIS. Such differences should be taken into account during project-specific studies and reviews.

The consequences of natural events could include injuries, loss of life, and the release of hazardous materials to the environment. The likelihood of injuries and loss of life may be decreased by emergency planning (e.g., tornado drills) and on-site first-aid capabilities. For hazardous material releases, the potential types and quantities of materials that would be present at a solar energy facility and that potentially could be released to the environment during a natural event are discussed in Section 5.21.2. Substances stored in the highest quantities on-site include HTFs, dielectric fluids, and, in some instances, TES media (most likely sodium nitrate or potassium nitrate salts). These substances have generally low volatility, and thus accidental or intentional releases from tanks would not be likely to pose significant on-site inhalation hazards. However, some HTFs have higher volatility at high temperatures, thereby increasing the inhalation hazard in the case of a fire.

No studies on the impacts of fires at utility-scale PV power plants were found; the interest to date has been on residential and commercial fires where the potentially exposed public has been close to the fire or where a fire in the PV system could quickly spread to the residence or structure on which it is installed. Current thinking is that the risk from fires in roof-mounted PV systems is minimal. Researchers conducted experiments on the release of cadmium from modules when burned at high temperatures and found that less than 0.04% of the cadmium in modules would be released in fires (Fthenakis et al. 2004).

In general, solar facilities would have fairly low numbers of employees on-site during operations. Also, these facilities are being considered for location in remote areas with low numbers of nearby residents. These factors would help limit the potential casualties during adverse natural events. Neighboring residences and businesses should be informed of potential hazards and disaster plans for solar facilities.

5.21.3.2.2 Sabotage or Terrorism. In addition to the natural events described above, there is a potential for intentional destructive acts to affect human health and the environment. In contrast to natural events, for which it is possible to estimate event probabilities based on historical statistical data and information, it is not possible to accurately estimate the probability of sabotage or terrorism. Consequently, discussion of the risks from sabotage or terrorist events generally focuses on the consequences of such events.

The consequences of a sabotage or terrorist attack on a solar facility would be expected to be similar to those discussed above for natural events. Depending on the severity of the event, fixed components of a solar facility could be damaged or destroyed, resulting in economic, safety, and environmental consequences. The potential consequences of such events need to be evaluated on a project- and site-specific basis.

5.21.4 Potentially Applicable Mitigation Measures

5.21.4.1 Occupational Health and Safety

The following mitigation measures to protect solar energy facility and transmission line workers are recommended for implementation during all phases associated with a project.

- All site characterization, construction, operation, and decommissioning activities must be conducted in compliance with applicable federal and state occupational safety and health standards (e.g., the Occupational Health and Safety Administrations [OSHA's] Occupational Health and Safety Standards, 29 CFR Parts 1910 and 1926, respectively).

- A safety assessment should be conducted to describe potential safety issues and the means that would be taken to mitigate them, covering issues such as site access; construction; safe work practices; glare exposure from mirrors, heliostats, and/or power towers; security; heavy equipment transportation; traffic management; emergency procedures; and fire control.

- A health and safety program should be developed to protect workers during site characterization, construction, operation, and decommissioning of a solar energy project. The program should identify all applicable federal and state occupational safety standards and establish safe work practices addressing all hazards, including requirements for developing the following plans: general

injury prevention; PPE requirements and training; respiratory protection; hearing conservation; electrical safety; hazardous materials safety and communication; housekeeping and material handling; confined space entry; hand and portable power tool use; gas-filled equipment use; and rescue response and emergency medical support, including on-site first-aid capability.

- In addition, the health and safety program should address OSHA standard practices for the safe use of explosives and blasting agents (e.g., if used to construct foundations for power tower facilities); measures for reducing occupational EMF exposures; the establishment of fire safety evacuation procedures; and required safety performance standards (e.g., electrical system standards and lighting protection standards). The program should include training requirements for applicable tasks for workers and establish procedures for providing required training to all workers. Documentation of training and a mechanism for reporting serious accidents to appropriate agencies should be established.

- A health risk assessment should evaluate potential cancer and noncancer risks to workers from exposure to facility emission sources during construction and operations. If potential risks are found to exceed applicable threshold levels, measures should be taken to decrease emissions from the source.

- Electrical systems should be designed to meet all applicable safety standards (e.g., National Electrical Code [NEC]) and should comply with the interconnection requirements of the transmission system operator.

- In the event of an accidental release of hazardous substances to the environment, project developers should document the event, including a root cause analysis, a description of appropriate corrective actions taken, and a characterization of the resulting environmental or health and safety impacts. Documentation of the event should be provided to the permitting agencies and other federal and state agencies within 30 days, as required.

- For the mitigation of explosive hazards, workers should be required to comply with the OSHA standard (29 CFR 1910.109) for the safe use of explosives and blasting agents.

- Measures should be considered to reduce occupational EMF exposures, such as backing electrical generators with iron to block the EMF, shutting down generators when work is being done near them, and otherwise limiting exposure time and proximity while generators are running.

5.21.4.2 Public Health and Safety

The following mitigation measures for the protection of public health and safety are recommended for implementation during all phases associated with a solar energy project:

- The project health and safety program should address protection of public health and safety during site characterization, construction, operation, and decommissioning for a solar energy project. The program should establish a safety zone or setback for solar facilities and associated transmission lines from residences and occupied buildings, roads, ROWs, and other public access areas that is sufficient to prevent accidents resulting from various hazards during all phases of development. It should identify requirements for temporary fencing around staging areas, storage yards, and excavations during construction or decommissioning activities. It should also identify measures to be taken during the operations phase to limit public access to facilities (e.g., equipment with access doors should be locked to limit public access, and permanent fencing with slats should be installed around electrical substations).

- A Traffic Management Plan should be prepared for the site access roads to control hazards that could result from increased truck traffic (most likely during construction or decommissioning), to ensure that traffic flow would not be adversely affected and that specific issues of concern (e.g., the locations of school bus routes and stops) are identified and addressed. This plan should incorporate measures such as informational signs, flaggers (when equipment may result in blocked throughways), and traffic cones to identify any necessary changes in temporary lane configurations. The plan should be developed in coordination with local planning authorities.

- Solar facilities should be sited and designed properly to eliminate glint and glare effects on roadway users, nearby residences, commercial areas, or other highly sensitive viewing locations, or reduce it to the lowest achievable levels (see similar mitigation measure under Section 5.14.3). Regardless of the solar technology proposed, a Glint and Glare Assessment, Mitigation, and Monitoring Plan should accurately assess and quantify potential glint and glare effects and determine potential health, safety, and visual impacts associated with glint and glare effects. The assessment should be conducted by qualified individuals using appropriate and commonly accepted software and procedures. The assessment results should be made available to the managing agency in advance of project approval. If the project design is changed during the siting and design process such that substantial changes to glint and glare effects may occur, glint and glare effects shall be recalculated, and the results made available to the managing agency. If any potential for exposure at levels that could cause retinal damage is identified, measures to eliminate the exposure should be implemented (e.g., slatted fencing to shield views from outside the facility). The plan should also set up a system for logging, investigating, and responding to complaints regarding glare.

- A health risk assessment should evaluate potential cancer and noncancer risks to the general public from exposure to facility emission sources during construction and operations. If potential risks are found to exceed applicable threshold levels, measures should be taken to decrease emissions from the source.

- Proper signage and or engineered barriers (e.g., fencing) should be used to limit access to electrically energized equipment and conductors in order to prevent access to electrical hazards by unauthorized individuals or wildlife.

- Because of the high global warming potential of SF_6, the use of alternative dielectric fluids that do not have a high global warming potential should be required.

- If operation of the solar facility and associated transmission lines and substations is expected to cause potential adverse impacts on nearby residences and occupied buildings from noise, sun reflection, or EMF, recommendations for addressing these concerns should be incorporated into the project design (e.g., establishing a sufficient setback from transmission lines).

- The project should be planned to comply with FAA regulations, including lighting requirements, and to avoid potential safety issues associated with proximity to airports, military bases or training areas, or landing strips.

- Operators should develop a Fire Management and Protection Plan to implement measures to minimize the potential for a human-caused fire and to respond to human-caused or natural-caused fires.

- Project developers should work with appropriate agencies (e.g., DOE and TSA) to address critical infrastructure and key resource vulnerabilities at solar facilities, to minimize and plan for potential risks from natural events, sabotage, and terrorism.

5.22 REFERENCES

Note to Reader: This list of references identifies Web pages and associated URLs where reference data were obtained for the analyses presented in this PEIS. 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. The original information has been retained and is available through the Public Information Docket for this PEIS.

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6 ANALYSIS OF BLM'S SOLAR ENERGY DEVELOPMENT ALTERNATIVES

Through this programmatic environmental impact statement (PEIS), the U.S. Department of the Interior (DOI) Bureau of Land Management (BLM) is evaluating three alternatives for managing utility-scale solar energy development on BLM-administered lands in the six-state study area. These alternatives, which are described in Section 2.2, include two action alternatives—a solar energy development program alternative and a solar energy zone (SEZ) program alternative—and a no action alternative.

Under the action alternatives, the BLM would establish a new Solar Energy Program to replace certain elements of its existing Solar Energy Policies (BLM 2007, 2010a,b; see Appendix A, Section A.1).[1] The action alternatives identify lands that would be excluded from utility-scale solar energy development and, on the basis of those exclusions, the lands that would be available for solar right-of-way (ROW) application.[2] Both action alternatives also identify SEZs where the agency would prioritize solar energy and associated transmission infrastructure development. Final SEZs would be identified in the Record of Decision (ROD) for the Solar Programmatic Environmental Impact Statement (PEIS). Under the solar energy development program alternative, the SEZs would constitute a subset of the total lands available (i.e., applications would be accepted within the SEZs and on specific lands outside the SEZs). Under the SEZ program alternative, applications would only be accepted within the SEZs, and no additional lands would be available outside the SEZs.

In addition to establishing lands available for solar ROW authorizations, the action alternatives would establish a suite of program administration and authorization policies and design features that would apply to utility-scale solar energy projects on BLM-administered lands (see Section 2.2.2 and Appendix A, Section A.2).[3] These design features represent the most widely accepted methods to avoid and/or minimize potential impacts from the types of activities associated with solar energy development and to successfully administer solar energy development on public lands and therefore are proposed as standard features of both action alternatives.

Under both action alternatives, the elements of the BLM's new program would be implemented through amendment of almost all of the land use plans within the six-state study

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[1] It is anticipated that elements of the existing policies addressing rental fees, terms of authorizations, due diligence, bonding requirements, and BLM access to records would remain in effect.

[2] The exclusions proposed under the action alternatives would apply only to the siting of utility-scale solar energy generation facilities and not to any required supporting linear infrastructure, such as roads, transmission lines, and natural gas or water pipelines. Management decisions for supporting linear infrastructure, including available lands, are defined in existing applicable land use plans. Siting of supporting infrastructure would be analyzed in project-specific environmental reviews.

[3] As discussed in Section 2.2.2, design features are mitigation measures that have been incorporated into the proposed action or alternatives to avoid or reduce adverse impacts. The proposed programmatic design features of the Solar Energy Program would apply to all utility-scale solar energy ROWs on BLM-administered lands under both action alternatives. Additional design features have been proposed for individual SEZs.

area (see Appendix C). Similar programs have been established and have proven useful for other types of renewable energy development, specifically for wind and geothermal energy development (more information about these and other BLM energy programs is available at http://www.blm.gov/wo/st/en/prog/energy.html).

Under the no action alternative, the BLM would continue to develop solar energy resources under its existing policies (BLM 2007; 2010a,b). The agency would not take further steps to programmatically or comprehensively identify lands excluded and lands available for solar energy development or establish a program of policies or required mitigation measures.

Table 6.1-1 lists the approximate amount of land that would be available for utility-scale solar ROW applications in each state under the three alternatives. Maps showing the distribution of these lands are included at the end of Chapter 2 (see Figures 2.2-1 through 2.2-6).

This chapter presents an analysis of the BLM's three management alternatives in terms of their effectiveness in meeting the objectives outlined as part of BLM's purpose and need for action (see Section 1.3.1). These objectives include the following:

- Facilitating near-term utility-scale solar energy development on public lands;
- Minimizing potential negative environmental, social, and economic impacts;

TABLE 6.1-1 Summary of Potentially Developable BLM-Administered Land under the No Action Alternative, the Solar Energy Development Program Alternative, and the SEZ Program Alternative[a]

State	Total State Acreage[b]	BLM-Administered Lands Constituting No Action Alternative (acres)	BLM-Administered Lands Constituting Solar Energy Development Program Alternative (acres)[c]	BLM-Administered Lands Constituting SEZ Program Alternative (acres)
Arizona	72,700,000	9,218,009	4,485,944	13,735
California	100,200,000	11,067,366	1,766,543	339,090
Colorado	66,500,000	7,282,061	148,072	21,050
Nevada	70,300,000	40,794,055	9,084,050	171,265
New Mexico	77,800,000	12,188,361	4,068,324	113,052
Utah	52,700,000	18,182,368	2,028,222	19,192
Total	440,200,000	98,732,220	21,581,154	677,384

[a] To convert acres to km^2, multiply by 0.004047.

[b] From Table 4.2-1.

[c] The acreage estimates were calculated on the basis of the best available geographic information system (GIS) data. GIS data were not available for the entire set of exclusions, so the exact acreage could not be calculated. Exclusions that could not be mapped would be identified during the ROW application process.

- Providing flexibility to consider a variety of solar energy projects (e.g., location, facility size, and technology);

- Optimizing existing transmission infrastructure and corridors; and

- Standardizing and streamlining the authorization process for solar energy development on BLM-administered lands.

The analysis in this chapter also evaluates the extent to which each management alternative would assist the BLM in meeting the projected demand for utility-scale solar energy development, as estimated by the reasonably foreseeable development scenario (RFDS) developed for this PEIS (see Section 2.4). The extent to which each option would assist the BLM in meeting the mandates of the Energy Policy Act of 2005 (Public Law [P.L.] 109-58) and Order 3285A1, issued by the Secretary of the Interior (2010) (see Section 1.1), including but not limited to the mandate to identify and prioritize specific locations best-suited for utility-scale solar energy development on public lands, is also assessed.

This chapter provides summary-level information on the potential impacts to resources and resource uses from solar energy development in the context of how such impacts would vary as a function of the alternatives. The level of detail presented for individual alternatives is commensurate with the programmatic decisions to be made, which are primarily planning-level decisions (i.e., allocation and exclusion decisions). This chapter provides a summary of the key adverse impacts of solar energy development for each SEZ (based on the detailed analysis of SEZs included in Chapters 8 through 13) that will inform possible decisions regarding the size, configuration, and/or management of the SEZs. This chapter also assesses the cumulative impacts of utility-scale solar development expected in the six-state study area over the next 20 years based on the RFDS.

Table 6.1-2 provides a summary of the environmental impacts of the alternatives. Because of the programmatic focus of the PEIS, the impact summaries are primarily qualitative; however, some impacts have been quantified. Chapter 5 provides a detailed discussion of the impacts summarized here; Appendix J provides a comparison of species affected by alternative. The impacts of solar development itself are largely similar across the alternatives. However, because the alternatives represent planning decisions (i.e., allocations and exclusions for solar ROWs), differences between the alternatives are found in the location, pace, and concentration of this development. Table 6.1-3 includes a summary of the potential resource conflicts identified for individual SEZs and the extent to which these conflicts would potentially limit the amount of land available for development within each SEZ.

Sections 6.1 through 6.3 discuss the potential effectiveness of each of the management alternatives at meeting the described objectives and their potential environmental impacts. Section 6.4 compares the alternatives and identifies the BLM's preferred alternative. Section 6.5 discusses the potential cumulative impacts of developing utility-scale solar energy on BLM-administered lands in the six-state study area over the next 20 years. Section 6.6 discusses the other National Environmental Policy Act of 1969 (NEPA) considerations related to the preferred alternative, including unavoidable adverse impacts, short-term uses of the environment and

TABLE 6.1-2 Summary-Level Assessment of Potential Environmental Impacts by Alternative[a]

Resource	Solar Energy Development Program Alternative (Approximately 22 million acres available for application)	SEZ Program Alternative (Approximately 677,000 acres available for application)	No Action Alternative (Approximately 99 million acres available for application)
Lands and Realty	Utility-scale solar energy development would preclude other land uses within the project footprint and could alter the character of largely rural areas. Development of supporting infrastructure (e.g., new transmission lines, roads) would also locally impact land use. Impacts potentially could be dispersed across the 22 million acres. Design features (e.g., stakeholder coordination/consultation, consolidation of infrastructure) could effectively avoid or minimize many of these impacts.	Same impacts as solar energy development program alternative except impacts would be concentrated into a smaller, known geographic area.	Same impacts as solar energy development program alternative except impacts could be potentially more widespread.
Specially Designated Lands and Lands with Wilderness Characteristics	Specially designated lands and lands with wilderness characteristics could be significantly impacted through direct and indirect impacts (e.g., visual impacts, reduced access, noise impacts, fugitive dust) during both the construction and operations phases. Impacts potentially could be dispersed across the 22 million acres. All NLCS lands (4,714,372 acres) would be excluded, along with SRMAs (3,213,151 acres); ACECs (3,474,696 acres); Desert Wildlife Management Areas (DWMAs); National Recreation Trails and National Back Country Byways; Wild, Scenic, and Recreational Rivers, and segments of rivers determined to be eligible or suitable for Wild and Scenic River status (not quantified).[b] All areas where there is an applicable land use plan decision to protect lands with wilderness characteristics would be excluded (not quantified)	Same impacts as solar energy development program alternative except impacts would be concentrated into a smaller, known geographic area. This could increase the magnitude of potential impacts but affect a smaller number of areas.	Same impacts as solar energy development program alternative except that only NLCS lands currently off-limits to solar energy development would be excluded. Impacts could be potentially more widespread and greater to specially designated lands and lands with wilderness characteristics excluded under the action alternatives.

TABLE 6.1-2 (Cont.)

Resource	Solar Energy Development Program Alternative (Approximately 22 million acres available for application)	SEZ Program Alternative (Approximately 677,000 acres available for application)	No Action Alternative (Approximately 99 million acres available for application)
Rangeland Resources	Some livestock grazing allotments may be affected by solar energy development ROW authorizations through reductions in acreage and/or loss of animal unit months (AUMs). Wild horses and burros also could be affected with animals displaced from the development area; the number of wild horse and burro herd management areas (HMAs) overlapping with or in the vicinity of lands available for ROW application would be less than under the no action alternative. Impacts potentially could be dispersed across the 22 million acres.	Same impacts as solar energy development program alternative except impacts would be concentrated into a smaller geographic area with a known set of grazing allotments.	Same impacts as solar energy development program alternative except impacts could be potentially more widespread and there is less certainty about which grazing allotments and HMAs potentially could be affected.
Recreation	Recreational uses would be precluded within lands used for solar energy development. Recreational experiences could be adversely impacted in areas proximate to solar energy projects and related transmission. Impacts potentially could be dispersed across the 22 million acres. All SRMAs excluded from solar energy development (3,213,151 acres), along with developed recreational facilities, and special-use permit recreation sites (not quantified)	Same impacts as solar energy development program alternative except impacts would be concentrated into a smaller, known geographic area. This could increase the magnitude of potential impacts but affect fewer recreational resources.	Same impacts as solar energy development program alternative except SRMAs, recreational facilities, and special-use permit recreation sites not excluded. Impacts could be potentially more widespread and greater to those recreational areas excluded under the action alternatives.

TABLE 6.1-2 (Cont.)

Resource	Solar Energy Development Program Alternative (Approximately 22 million acres available for application)	SEZ Program Alternative (Approximately 677,000 acres available for application)	No Action Alternative (Approximately 99 million acres available for application)
Military and Civilian Aviation	Military and civilian aviation impacts would be identified and adequately mitigated prior to BLM's issuance of a ROW authorization.	Same impacts as solar energy development program alternative except impacts would be concentrated into a smaller, known geographic area.	Same impacts as solar energy development program alternative except impacts could be potentially more widespread.
Geologic Setting and Soil Resources	Development of large blocks of land for solar energy facilities and related infrastructure would result in impacts to geologic and soil resources in terms of soil compaction and erosion, although these impacts could be effectively mitigated. Impacts to biological soil crusts would be long term and possibly irreversible. Impacts potentially could be dispersed across the 22 million acres.	Same impacts as solar energy development program alternative except impacts would be concentrated into a smaller, known geographic area.	Same impacts as solar energy development program alternative except impacts could be potentially more widespread.
Mineral Resources	Mineral development within the project footprint for utility-scale solar energy development would generally be an incompatible use; however, some resources underlying the project area might be developable (e.g., directional drilling for oil and gas or geothermal resources, underground mining). Impacts potentially could be dispersed across the 22 million acres. Lands within SEZs could be withdrawn from location and entry under the mining laws.	Same impacts as solar energy development program alternative except impacts would be concentrated into a smaller, known geographic area.	Same impacts as solar energy development program alternative except impacts could be potentially more widespread. No SEZs would be identified or withdrawn.

TABLE 6.1-2 (Cont.)

Resource	Solar Energy Development Program Alternative (Approximately 22 million acres available for application)	SEZ Program Alternative (Approximately 677,000 acres available for application)	No Action Alternative (Approximately 99 million acres available for application)
Water Resources	Solar thermal energy technologies with wet-cooling systems require large volumes of water, with potentially significant environmental impacts; however, such projects would be limited primarily to locations with ample groundwater supplies where water rights and the approval of water authorities could be obtained. Solar thermal projects with dry-cooling systems require less than one-tenth of the amount of water required for wet-cooling systems. All solar energy facilities require smaller volumes of water for mirror or panel washing and potable water uses, which would result in relatively minor impacts on water supplies. Other potential impacts, including modification of surface and groundwater flow systems, water contamination resulting from chemical leaks or spills, and water quality degradation by runoff or excessive withdrawals, can be effectively mitigated.	Same impacts solar energy development program alternative except impacts would be concentrated into a smaller, known geographic area. This could increase the magnitude of potential impacts but affect fewer water resources.	Same impacts as solar energy development program alternative except impacts could be potentially more widespread.
Vegetation	Development likely to require total removal of vegetation at most facilities, which could result in significant direct impacts in terms of increased risk of invasive species introduction, changes in species composition and distribution, habitat loss (e.g., dune or riparian areas), and damage to biological soil crusts. Indirect impacts also likely in terms of dust deposition, altered drainage patterns, runoff, and sedimentation. Impacts potentially could be dispersed across the 22 million acres. Design features (e.g., invasive species control programs, fugitive dust control, minimizing size of disturbed areas) could significantly reduce many of these impacts. Multiple exclusions would avoid such impacts, including exclusion of ACECs, Research Natural Areas, and Old Growth Forest (not quantified).	Same impacts as solar energy development program alternative except impacts would be concentrated into a smaller, known geographic area. This could increase the magnitude of potential impacts but affect a smaller number of areas. About 48% of the SEZ lands are located within the Sonoran Basin and Range	Same impacts as solar energy development program alternative except there would be no explicit exclusions to avoid known sensitive vegetation resources. Impacts could be potentially more widespread and greater to those vegetation resources excluded under the action alternatives.

TABLE 6.1-2 (Cont.)

Resource	Solar Energy Development Program Alternative (Approximately 22 million acres available for application)	SEZ Program Alternative (Approximately 677,000 acres available for application)	No Action Alternative (Approximately 99 million acres available for application)
Vegetation *(Cont.)*	About 46% of the lands available for ROW application are located within the Central Basin and Range Ecoregion. About 14% each of the Central Basin and Range and Chihuahuan Deserts Ecoregions, 11% of the Sonoran Basin and Range Ecoregion, and 5% of the Madrean Archipelago Ecoregion are located within the lands that would be available for application. Other ecoregions coincide with these lands at levels below 5%. The land cover types for the following example species overlap with lands that would be available for ROW application by the percentage shown: Joshua tree – 7% Saguaro – 10%	Ecoregion. Of the five ecoregions that coincide with SEZs, 1% or less of each ecoregion would be available for ROW application. Less than 1% of the land cover type for Joshua tree and saguaro species are located within the SEZs.	Lands available for ROW application span 22 ecoregions. About 44% of the available lands are located within the Central Basin and Range Ecoregion. Over 50% of 2 ecoregions (Central Basin and Range, Northern Basin and Range) would be available for application. The land cover types for the following species overlap with the lands that would be available for ROW application by the percentage shown: Joshua tree – 32% Saguaro – 26%

TABLE 6.1-2 (Cont.)

Resource	Solar Energy Development Program Alternative (Approximately 22 million acres available for application)	SEZ Program Alternative (Approximately 677,000 acres available for application)	No Action Alternative (Approximately 99 million acres available for application)
Wildlife and Aquatic Biota	Numerous wildlife species would be adversely impacted by loss of habitat, disturbance, loss of food and prey species, loss of breeding areas, effects on movement and migration, introduction of new species, habitat fragmentation, and changes in water availability. Impacts potentially could be dispersed across the 22 million acres. Design features (e.g., limiting land disturbance, conducting pre-disturbance surveys, controlling surface water runoff) could reduce many of these impacts. Multiple exclusions would avoid such impacts, including exclusion of ACECs, big game migratory corridors and winter ranges, Research Natural Areas, and lands with seasonal restrictions (not quantified). The following example species' habitats overlap with lands that would be available for ROW application by the percentage shown: Western rattlesnake – 6% Golden eagle – 5% Black-tailed jackrabbit – 6% Pronghorn – 5% Mule deer – 6% Mountain lion – 5%	Same impacts as solar energy development program alternative except the potential area of impact would be limited to a smaller, known geographic area. Less than 1% of the habitats for western rattlesnake, golden eagle, black-tailed jackrabbit, pronghorn, mule deer, and mountain lion are located within the SEZs.	Same impacts solar energy development program alternative except there would be no explicit exclusions to avoid known sensitive wildlife resources. Impacts could be potentially more widespread and greater to those wildlife resources excluded under the action alternatives. The following species' habitats overlap with the lands that would be available for ROW application by the percentage shown: Western rattlesnake – 27% Golden eagle – 23% Black-tailed jack rabbit – 24% Pronghorn – 22% Mule deer – 22% Mountain lion – 21%

TABLE 6.1-2 (Cont.)

Resource	Solar Energy Development Program Alternative (Approximately 22 million acres available for application)	SEZ Program Alternative (Approximately 677,000 acres available for application)	No Action Alternative (Approximately 99 million acres available for application)
Special Status Species	Special status species and critical habitats would be protected in accordance with ESA requirements either through avoidance, translocation (plants), or acquisition and protection of compensatory habitat. Impacts potentially could be dispersed across the 22 million acres. Critical habitat designated or proposed by USFWS would be excluded (over 5,954,000 acres). All ACECs designated for habitat would be excluded along with identified Desert Tortoise translocation sites and other areas where BLM has made a commitment to protect sensitive species (not quantified). Lands available for ROW application include areas of potentially suitable habitat for special status species (see Appendix J). For example, the following species' habitats overlap by the percentage shown: Plants: Nevada dune beardtongue – 61% White-margined beardtongue – 8% Munz's cholla – 16% Animals: Desert tortoise – 12% Western burrowing owl – 8% Greater sage-grouse – 8% Gunnison prairie dog – 3% Gunnison sage-grouse – 1% Northern aplomado falcon – 11% Southwestern willow flycatcher -- <1% Townsend's big-eared bat – 7% Utah prairie dog – 12%	Special status species and critical habitats would be protected as under solar energy development program alternative. Same exclusions as under solar energy development program alternative, except, in some states, habitat identified by state fish and game agencies would also be excluded (not quantified). Lands available for ROW application include areas of potentially suitable habitat for special status species (see Appendix J). For example, about 1% or less of the habitat for two plant species (Nevada dune beard tongue, white-margined beard tongue) and nine animal species (desert tortoise, western burrowing owl, greater sage-grouse, Gunnison prairie dog, Gunnison sage-grouse, northern aplomado falcon,	Special status species and critical habitats would be protected as under solar energy development program alternative. Critical habitat, ACECs designated for habitat value, and other areas where BLM has made a commitment to protect sensitive species would not be excluded. Lands available for ROW application include areas of potentially suitable habitat for special status species (see Appendix J). For example, the following species' habitats overlap by the percentage shown: Plants: Nevada dune beardtongue – 66% White-margined beardtongue – 34% Munz's cholla – 45%

TABLE 6.1-2 (Cont.)

Resource	Solar Energy Development Program Alternative (Approximately 22 million acres available for application)	SEZ Program Alternative (Approximately 677,000 acres available for application)	No Action Alternative (Approximately 99 million acres available for application)
Special Status Species *(Cont.)*		southwestern willow flycatcher, Townsend's big-eared bat, and Utah prairie dog) is located within the SEZs; about 4% of the plant Munz's cholla habitats is located with the SEZs.	Animals: Desert tortoise – 29% Western burrowing owl – 27% Greater sage-grouse – 54% Gunnison prairie dog – 15% Gunnison sage-grouse – 24% Northern aplomado falcon – 26% Southwestern willow flycatcher -- 7% Townsend's big-eared bat – 23% Utah prairie dog – 36%
Air Quality and Climate	Air quality would be adversely affected locally and temporarily during construction by fugitive dust and vehicle emissions, although impacts would be relatively minor and could be mitigated (e.g., dust control measures, emissions control devices, vehicle maintenance). Impacts potentially could be dispersed across the 22 million acres. Operations would result in few air quality impacts. Relatively minor CO_2 emissions would be generated by the use of heavy equipment, vehicles, and backup generators. Overall, CO_2 emissions would be reduced if solar energy production offsets fossil fuel energy production.	Same impacts as solar energy development program alternative except impacts would be concentrated into a smaller, known geographic area. This could increase the magnitude of potential impacts, particularly during construction, but affect a smaller number of areas.	Same impacts as solar energy development program alternative except impacts could be potentially more widespread and of smaller magnitude locally. Carbon dioxide emission reductions would occur more slowly if the pace of development is slower.

TABLE 6.1-2 (Cont.)

Resource	Solar Energy Development Program Alternative (Approximately 22 million acres available for application)	SEZ Program Alternative (Approximately 677,000 acres available for application)	No Action Alternative (Approximately 99 million acres available for application)
Visual Resources	Solar energy projects and associated infrastructure introduce strong contrasts in forms, line, colors, and textures of the existing landscape which may be perceived as negative visual impacts. Suitable development sites typically located in basin flats surrounded by elevated lands where sensitive viewing locations exist. Impacts potentially would be dispersed across the 22 million acres. Design features could reduce impacts but some large impacts cannot be avoided. All NLCS lands (4,714,372 acres) would be excluded, ACECs, (3,474,696 acres), SRMAs (3,213,151 acres), along with developed recreational facilities, special-use permit recreation sites, National Recreation Trails, and National Back Country Byways (not quantified). 902 potentially sensitive visual resource areas (not including ACECs) are located in or within 25 mi (40 km) of the lands available for ROW viewsheds.	Same impacts as solar energy development program alternative except the impacts would be concentrated into a smaller, known geographic area. This could increase the magnitude of potential impacts, particularly during construction, but affect a smaller number of areas. SEZs are visible from 149 potentially sensitive visual resource areas (not including ACECs) within 25 mi.	Same impacts as solar energy development program alternative except that only NLCS lands currently off-limits to solar energy development would be excluded. Impacts could be potentially more widespread and greater to those areas excluded under the action alternatives. 1,510 potentially sensitive visual resource areas (not including ACECs) are located in or within 25 mi (40 km) of the lands available for ROW application and could be affected by solar development within their viewsheds.

TABLE 6.1-2 (Cont.)

Resource	Solar Energy Development Program Alternative (Approximately 22 million acres available for application)	SEZ Program Alternative (Approximately 677,000 acres available for application)	No Action Alternative (Approximately 99 million acres available for application)
Acoustic Environment	Construction related noise could adversely affect nearby residents and/or wildlife, and would be greatest for CSP projects requiring power block construction. Operations related noise impacts would generally be less significant than construction related noise impacts but could still be significant for some receptors located near power block or dish engine facilities. Impacts potentially could be dispersed across the 22 million acres. Design features (e.g., siting, engineering controls) would significantly reduce impacts in some circumstances.	Same impacts as solar energy development program alternative except impacts would be concentrated into a smaller, known geographic area. This could increase the magnitude of potential impacts, particularly during construction, but affect a smaller number of areas.	Same impacts as solar energy development program alternative except impacts could be potentially more widespread.
Paleonto-logical Resources	Paleontological resources subject to loss during construction but impacts also possible during operations. Impacts potentially could be dispersed across the 22 million acres. Design features would significantly reduce impacts.	Same impacts as solar energy development program alternative except impacts would be concentrated into a smaller, known geographic area.	Same impacts as solar energy development program alternative except impacts could be potentially more widespread.
Cultural Resources and Native American Concerns	Cultural resources subject to loss during construction but impacts also possible during operations. Impacts potentially could be dispersed across the 22 million acres. Design features (e.g., minimizing land disturbance, consultation and records searches, training and education programs) would significantly reduce some impacts.	Same impacts as development program except impacts would be concentrated into a smaller, known geographic area.	Same impacts as solar energy development program alternative except there would be no explicit exclusions to avoid known sensitive cultural resources.

TABLE 6.1-2 (Cont.)

Resource	Solar Energy Development Program Alternative (Approximately 22 million acres available for application)	SEZ Program Alternative (Approximately 677,000 acres available for application)	No Action Alternative (Approximately 99 million acres available for application)
Cultural Resources and Native American Concerns *(Cont.)*	ACECs designated for cultural or historic resource values, National Historic and Scenic Trails, National Historic and Natural Landmarks, properties designated or eligible for the National Register of Historic Places, and areas with important cultural and archaeological resources excluded.		Impacts could be potentially more widespread and greater to those cultural resources excluded under the action alternatives.
Transportation	Local road systems and traffic flow could be adversely impacted during construction. Impacts during operations would be minor. Impacts potentially could be dispersed across the 22 million acres. Design features (e.g., road improvements, ride-sharing programs, staggered work schedules, traffic control measures) would significantly reduce impacts.	Same impacts as solar energy development program alternative except impacts would be concentrated into a smaller, known geographic area. This could increase the magnitude of potential impacts, particularly during construction, but affect a smaller number of areas.	Same impacts as solar energy development program alternative except impacts could be potentially more widespread.

[a] To convert acres to km^2, multiply by 0.004047.

[b] The acreage estimates were calculated on the basis of the best available GIS data. GIS data were not available for the entire set of exclusions and, therefore, the acreages cannot be quantified at this time.

TABLE 6.1-3 Potential Effects of Environmental Impact Considerations on Acres Available for Solar Energy Development in the Proposed SEZs[a,b]

State/SEZ	Total SEZ Acres	Environmental Impact Consideration[c]	Amount of SEZ with Possible Development Restrictions[d]
Arizona			
Brenda	3,878	Possible restrictions to development on east side of SEZ to reduce impacts to Plomosa SRMA. Military aviation concerns related to structures >250 ft. Because of water availability limits, wet-cooling options would not be feasible. Need to avoid Bouse Wash, Tyson Wash, other dry washes, dry wash woodland, chenopod scrub habitat, sand dunes, sand transport systems, sand flats, agricultural and riparian habitats, and saguaro cactus communities. Nesting habitat for bird species listed under the MBTA, and habitat for discovered populations and occupied habitats of special status species should be avoided. Potential for prehistoric sites, especially in eastern portion of SEZ, that if present should be avoided.	Restricted areas to be identified; extent unknown.
Bullard Wash	7,239	Military aviation concerns related to structures >250 ft. Restricting development of solar facilities within 5 mi (8 km) of the Tres Alamos WA, as well as restricting solar development to lower-profile facilities, should be considered. Because of water availability limits, wet-cooling options would not be feasible.	Restricted areas to be identified; extent unknown.

TABLE 6.1-3 (Cont.)

State/SEZ	Total SEZ Acres	Environmental Impact Consideration[c]	Amount of SEZ with Possible Development Restrictions[d]
Arizona (Cont.)			
		Facilities should avoid the wetland, dry washes, dry wash woodland, mesquite bosque, and riparian habitat; and Joshua tree and saguaro cactus communities Nesting habitat for bird species listed under the MBTA, and habitat for discovered populations and occupied habitats of special status species should be avoided. No cultural or historic resource surveys have been conducted.	
Gillespie	2,618	Power tower development should be prohibited to avoid visual impacts. Military aviation concerns related to structures >250 ft. Wet-cooling options would not be feasible if groundwater was the chosen water source for a solar project. Need to avoid wetland, dry wash, dry wash woodland, mesquite bosque, riparian habitat, and saguaro cactus communities and to minimize impacts on tributaries of Centennial Wash. Nesting habitat for bird species listed under the MBTA, and habitat for discovered populations and occupied habitats of special status species should be avoided. Avoidance or minimization of groundwater withdrawals to serve solar energy development on the SEZ could reduce or eliminate impacts on nine special status species.	Restricted areas to be identified; extent unknown.

TABLE 6.1-3 (Cont.)

State/SEZ	Total SEZ Acres	Environmental Impact Consideration[c]	Amount of SEZ with Possible Development Restrictions[d]
California			
Imperial East	5,722	Development on portions of the SEZ may be incompatible with existing military or civilian aviation use. Because of water availability limits, wet-cooling options would not be feasible. Need to avoid wetland and riparian habitats (within the western and southern portions of the SEZ), sand dune habitat, and sand transport areas within the SEZ. Nesting habitat for bird species listed under the MBTA, and habitat for discovered populations and occupied habitats of special status species should be avoided. Additional cultural and historic resource surveys are needed. Development could affect Native American burials and prehistoric and historic resources.	Restricted areas to be identified; extent unknown.
Iron Mountain	106,522	*Minerals*: The presence of the KSLA must be addressed to evaluate the compatibility of solar development in the KSLA with continuation of sodium mineral leasing (the KSLA is assumed to be restricted from development). Development in 2,101 acres in the northwest portion of the SEZ should be consistent with VRM Class II to mitigate impacts on the Old Woman Mountains WA; an additional 9,311 acres should be consistent with VRM Class III. Development in 5,725 acres south of State Route 62 should be consistent with VRM Class III to mitigate impacts within the Palen-McCoy WA. Development in 21,219 acres of the eastern portion of the SEZ should be consistent with VRM Class II objectives to mitigate impacts on the Turtle Mountains WA; an additional 13,301 acres should be consistent with VRM Class III. There is some overlap of areas affected by visual restrictions. Development on portions of the SEZ may be incompatible with existing military use.	69% (total of 73,984 acres; 50,984 acres [accounting for overlapping restricted areas] could be restricted due to visual impacts; an additional 23,000 acres of the Danby Lake KSLA should not be developed due to multiple resource conflicts). Note that a small portion of the excluded area may be overestimated because the area of visual restrictions for Old Woman Mountain WA on the northwest side of the SEZ overlaps with part of the KSLA. Additional restricted areas to be identified; extent unknown.

TABLE 6.1-3 (Cont.)

State/SEZ	Total SEZ Acres	Environmental Impact Consideration[c]	Amount of SEZ with Possible Development Restrictions[d]
California (Cont.)			
		About 23,000 acres of the Danby Lake KSLA is within the northwest corner of the SEZ and is not likely developable. Because of water availability limits, wet-cooling options would not be feasible. Development in Danby Lake, Homer Wash, riparian, playa, chenopod scrub, sand dune, and dry wash habitats, and rocky cliff and outcrop habitats, should be avoided. Nesting habitat for bird species listed under the MBTA, and habitat for discovered populations and occupied habitats of special status species should be avoided. Avoidance of significant sites (historic properties) within the proposed Iron Mountain SEZ, specifically in the vicinity of Danby Lake and near the Iron Mountain Divisional Camp, is recommended.	
Pisgah	23,950	Development in 2,237 acres in the western portion of the SEZ should be consistent with VRM Class II to mitigate impacts on the Cady Mountains WSA, an additional 7,961 acres should be consistent with VRM Class III objectives. Development in 454 acres of the SEZ located south of I-40 should be consistent with VRM Class III objectives to mitigate impacts on the Rodman Mountains WA and travelers on I-40 and Historic Route 66. Development on portions of the SEZ may be incompatible with existing military use. Mining claims present in the portion of the SEZ south of I-40 represent a prior existing right that could preclude development as long as they are in place. Because of water availability limits, wet-cooling options would not be feasible.	44% (10,652 acres) could be restricted because of visual impacts. Additional restricted areas to be identified; extent unknown.

TABLE 6.1-3 (Cont.)

State/SEZ	Total SEZ Acres	Environmental Impact Consideration[c]	Amount of SEZ with Possible Development Restrictions[d]
California (Cont.)			
		Need to avoid impacts on playa, chenopod scrub, and desert dry wash habitat; sand dune and sand transport areas; and rocky cliff and outcrop habitats; particularly near Troy Dry Lake in the eastern portion of the SEZ, ephemeral drainages, and potential nesting habitat for ten desert bird focal species. Nesting habitat for bird species listed under the MBTA, and habitat for discovered populations and occupied habitats of special status species should be avoided. Avoidance or minimization of groundwater withdrawals to serve solar energy development on the SEZ could reduce or eliminate impacts on three special status species. Areas of significant prehistoric remains within the SEZ that are identified through the Calico Solar Power Project (to date, an area that includes a 400-ft [122-m] buffer, and in some instances, fencing) should be avoided.	
Riverside East	202,896	Development in 67,704 acres in the northwest portion of the SEZ should be consistent with VRM Class II to mitigate impacts on Joshua Tree NP and Palen-McCoy WA. Development in 11,926 acres in the northeast portion of the SEZ should be consistent with VRM Class II objectives; an additional 19,676 acres should be consistent with VRM Class III objectives. Development on portions of the SEZ may be incompatible with existing military use. Existing mining claims should be avoided. Because of water availability limits, wet-cooling options would not be feasible.	51% (total of 103,113 acres; 99,306 acres could be restricted due to visual impacts; an additional 3,807 acres of wetlands should be avoided). Additional restricted areas to be identified; extent unknown.

TABLE 6.1-3 (Cont.)

State/SEZ	Total SEZ Acres	Environmental Impact Consideration[c]	Amount of SEZ with Possible Development Restrictions[d]
California (Cont.)			
		Land disturbance activities should avoid impacts to the extent possible near the regions surrounding Palen Lake, Ford Dry Lake, McCoy Wash, and the Colorado River Aqueduct. Avoid 3,807 acres of wetland habitat within the SEZ. Avoid wetland, riparian, playa, dry wash woodland, sand dune and sand transport areas, and chenopod scrub habitats within the SEZ. Avoid ephemeral drainages, Ford Dry Lake, Palen Lake, McCoy Wash, and the Colorado River Aqueduct. Nesting habitat for bird species listed under the MBTA, and habitat for discovered populations and occupied habitats of special status species should be avoided. Additional cultural and historic resource surveys are needed. Development in the vicinity of Palen and Ford Dry Lakes and important WWII Desert Training Center areas, and along intact trail networks, should be avoided.	
Colorado			
Antonito Southeast	9,729	Development in 1,100 acres should be consistent with VRM Class II to mitigate impacts on the West Fork of the North Branch of the Old Spanish Trail, the Cumbres and Toltec Scenic Railroad, and the San Antonio WSA; an additional 3,250 acres should be consistent with VRM Class III objectives. Power tower development should be prohibited to avoid visual impacts. Development on portions of the SEZ may be incompatible with existing military airspace use.	47% (total of 4,600 acres; 4,350 acres could be restricted due to visual impacts; an additional 250 acres of pronghorn summer concentration area should be avoided). Additional restricted areas to be identified; extent unknown.

TABLE 6.1-3 (Cont.)

State/SEZ	Total SEZ Acres	Environmental Impact Consideration[c]	Amount of SEZ with Possible Development Restrictions[d]
Colorado (Cont.)			
		Because of water availability limits, wet-cooling options would not be feasible. Land disturbance activities should avoid impacts to the extent possible in the vicinity of Alta Lake and two additional wetland areas, along with ephemeral washes present on the site. Avoid 253 acres of pronghorn summer concentration area and the Alta Lake area. Should avoid grassland, wetland, riparian, sagebrush, and woodland habitat. Prairie dog colonies should be avoided. Nesting habitat for bird species listed under the MBTA, and habitat for discovered populations and occupied habitats of special status species should be avoided.	
De Tilla Gulch	1,522	Power tower development should be prohibited to avoid visual impacts. Wet-cooling technologies should incorporate water conservation measures to reduce water needs. Ephemeral drainages within the SEZ, and riparian, wetland, and grassland habitats should be avoided to the extent practicable. Should avoid elk severe winter range and pronghorn winter concentration area. Should avoid prairie dog colonies and grassland habitat. Nesting habitat for bird species listed under the MBTA, and habitat for discovered populations and occupied habitats of special status species should be avoided.	Restricted areas to be identified; extent unknown.

TABLE 6.1-3 (Cont.)

State/SEZ	Total SEZ Acres	Environmental Impact Consideration[c]	Amount of SEZ with Possible Development Restrictions[d]
Colorado (Cont.)			
Fourmile East	3,882	Power tower development should be prohibited to avoid visual impacts. Development in 1,578 acres should be consistent with VRM Class II, to mitigate impacts to the Los Caminos Antiguos Scenic Byway, Old Spanish National Historic Trail, and the Sangre de Cristo WA; development in an additional 1,647 acres should be consistent with VRM Class III. Because of water availability limits, wet-cooling options would not be feasible. Wetland, sand dune, playa, and riparian habitats within the SEZ should be avoided. Prairie dog colonies, approximately 213 acres of elk summer range, nesting habitat for bird species listed under the MBTA, and habitat for discovered populations and occupied habitats of special status species should be avoided.	83% (3,225 acres) could be restricted due to visual impacts. Additional restricted areas to be identified; extent unknown.
Los Mogotes East	5,918	Power tower development should be prohibited to avoid visual impacts. Because of water availability limits, wet-cooling options would not be feasible. Land disturbance activities should avoid impacts to the extent possible near ephemeral washes on site and surrounding wetlands. Facilities should avoid drywash and wetland habitats, prairie dog colonies, approximately 135 acres of mule deer winter range, and pronghorn winter concentration area. Should avoid wetland, riparian, grassland, marsh, meadow, and woodland habitat, nesting habitat for bird species listed under the MBTA, and habitat for discovered populations and occupied habitats of special status species.	Restricted areas to be identified; extent unknown.

TABLE 6.1-3 (Cont.)

State/SEZ	Total SEZ Acres	Environmental Impact Consideration[c]	Amount of SEZ with Possible Development Restrictions[d]
Nevada			
Amargosa Valley	31,625	Development within 15,359 acres in the southwestern portion of the SEZ should be consistent with VRM Class II objectives to mitigate impacts to Death Valley NP. DoD-authorized airspace from ground level to 9,400 ft above mean sea level; facilities over 50 ft may cause unacceptable electromagnetic interference. Because of water availability limits, wet-cooling options would not be feasible. Avoidance of groundwater withdrawals would reduce or prevent impacts on 25 groundwater-dependent special status species. Facilities should avoid the 100-year floodplain of the Amargosa River (3,915 acres), as well as dry wash, playa, riparian, and chenopod scrub habitat, nesting habitat for bird species listed under the MBTA, habitat for discovered populations and occupied habitats of special status species. Evaluation of impacts of solar development close to the Big Dune to the east of the SEZ is needed.	61% (total of 19,274 acres; 15,359 acres could be restricted due to visual impacts.; an additional 3,915 acres of Amargosa River floodplain should be avoided). Additional restricted areas to be identified; extent unknown.
Delamar Valley	16,552	Development within 2,080 acres in the SEZ should be consistent with VRM Class II objectives to mitigate impacts on the Delamar Mountains WA, an additional 5,485 acres should be consistent with VRM Class III objectives. Development within 4,921 acres of the SEZ should be consistent with VRM Class III objectives to mitigate impacts on the South Pahroc Range WA. There is some overlap of areas affected by visual restrictions. DoD-authorized airspace from 100 ft above ground level (AGL) to unlimited altitude; facilities over 50 ft may cause unacceptable electromagnetic interference.	65% (total of 10,821 acres [accounting for overlapping restricted areas] could be restricted due to visual impacts. Additional restricted areas to be identified; extent unknown.

TABLE 6.1-3 (Cont.)

State/SEZ	Total SEZ Acres	Environmental Impact Consideration[c]	Amount of SEZ with Possible Development Restrictions[d]
Nevada (Cont.)			
		Because of water availability limits, wet-cooling options would not be feasible. Facilities should avoid intermittent streams, ephemeral washes, Delamar Dry Lake, habitat in playas, riparian, marsh, and greasewood flats within the SEZ. Joshua tree communities, nesting habitat for bird species listed under the MBTA, and habitat for discovered populations and occupied habitats of special status species should be avoided. Significant cultural sites within the proposed SEZ should be avoided, especially in the vicinity of the dry lake.	
Dry Lake	15,649	Military aviation concerns related to structures >250 ft. Wet-cooling and dry-cooling options would not be feasible unless further hydrologic study of the basin reveals that more water is available. Facilities should avoid the 100-year floodplain (1,569 acres), as well as the dry lake, dry washes, dry wash woodland, chenopod scrub, ephemeral washes, desert pavement, and playa habitats within the SEZ. Nesting habitat for bird species listed under the MBTA and habitat for discovered populations and occupied habitats of special status species should be avoided. The Old Spanish Trail NRHP-listed site within the southeastern portion of the proposed SEZ should be avoided.	10% (1,569 acres) of floodplain should be avoided. Additional restricted areas to be identified; extent unknown.

TABLE 6.1-3 (Cont.)

State/SEZ	Total SEZ Acres	Environmental Impact Consideration[c]	Amount of SEZ with Possible Development Restrictions[d]
Nevada (Cont.)			
Dry Lake Valley North	76,874	DoD authorized airspace from 100 to 60,000 ft AGL; facilities over 50 ft may cause unacceptable electromagnetic interference. Because of water availability limits, wet-cooling options would not be feasible. Facilities should avoid intermittent streams, ephemeral washes, dry wash, playa, marsh, scrub-shrub wetland, riparian, and greasewood flat habitats within the SEZ. Nesting habitat for bird species listed under the MBTA, and habitat for discovered populations and occupied habitats of special status species should be avoided.	Restricted areas to be identified; extent unknown.
East Mormon Mountain	8,968	Power tower development should be prohibited to avoid visual impacts. Military concerns related to location in Low Altitude Training Navigation Area. Because of water availability limits, wet-cooling options would not be feasible. Facilities should avoid all dry washes; ephemeral stream channels (including Toquop Wash and South Fork Toquop Wash); playa, riparian, rocky cliff and rock outcrop habitats; and Joshua tree communities. Nesting habitat for bird species listed under the MBTA, and habitat for discovered populations and occupied habitats of special status species should be avoided. Avoidance of Toquop and South Fork Washes would also address cultural resource concerns.	Restricted areas to be identified; extent unknown.

TABLE 6.1-3 (Cont.)

State/SEZ	Total SEZ Acres	Environmental Impact Consideration[c]	Amount of SEZ with Possible Development Restrictions[d]
Nevada (Cont.)			
Gold Point	4,810	DoD-authorized airspace from ground level to 9,400 ft above mean sea level; facilities over 50 ft may cause unacceptable electromagnetic interference. Because of water availability limits, wet-cooling options would not be feasible. Facilities should avoid the unnamed intermittent stream; the playa area in the northeast corner of the SEZ; ephemeral washes; riparian, dry wash, cliff, outcrop, canyon, playa, wetland, sagebrush, and greasewood flat habitats. Nesting habitat for bird species listed under the MBTA and habitat for discovered populations and occupied habitats of special status species should be avoided.	Restricted areas to be identified; extent unknown.
Millers	16,787	Facilities over 50 ft may cause unacceptable electromagnetic interference. Because of water availability limits, wet-cooling options would not be feasible. Facilities should avoid the ephemeral stream channels of Ione Wash and Peavine Creek; alluvial fan features along the western edge of the SEZ; playa wetlands, dry washes, and greasewood flat habitats within the SEZ. Nesting habitat for bird species listed under the MBTA and habitat for discovered populations and occupied habitats of special status species should be avoided. Avoidance of areas with a high potential for a high density of sites, such as in the vicinity of both the former Lake Tonopah and Millers town site, is recommended.	Restricted areas to be identified; extent unknown.

TABLE 6.1-3 (Cont.)

State/SEZ	Total SEZ Acres	Environmental Impact Consideration[c]	Amount of SEZ with Possible Development Restrictions[d]
New Mexico			
Afton	77,623	Development in 12,528 acres in the eastern portion of the SEZ should be consistent with VRM Class II to mitigate impacts on communities within the Mesilla Valley. Development in 2,900 acres in the southwestern portion of the SEZ should be consistent with VRM Class II to mitigate impacts on the Aden Lava Flow WSA; an additional 9,600 acres should be consistent with VRM Class III. The height of power towers should be restricted such that the receiver and any navigation hazard lighting will not be directly visible from western portions of Mesilla Valley. Because of water availability limits, wet- and dry-cooling options would not be feasible. Siting of solar facilities and construction activities should avoid the areas identified as being within a 100-year floodplain that total 1,654 acres within the proposed SEZ. All ephermeral streams; and wetland, dry wash, playa, riparian, succulent, and dune communities; desert grasslands, sand dune and sand transport systems; rocky slopes, cliffs, and outcrops within the SEZ should be avoided to the extent practicable. Nesting habitat for bird species listed under the MBTA and habitat for discovered populations and occupied habitats of special status species should be avoided. To avoid paleontological impacts, avoidance of the eastern edge of the SEZ may be warranted if a paleontological survey results in findings similar to those known south of the SEZ.	34% (26,682 acres; 25,028 could be restricted due to visual impacts; an additional 1,654 acres of floodplain should be avoided). Additional restricted areas to be identified; extent unknown.

TABLE 6.1-3 (Cont.)

State/SEZ	Total SEZ Acres	Environmental Impact Consideration[c]	Amount of SEZ with Possible Development Restrictions[d]
New Mexico (Cont.)			
Mason Draw	12,909	Consideration should be given to restricting the height of solar facilities in portions of the SEZ to minimize impacts on the Prehistoric Trackways National Monument and the Robledo Mountains WSA and ACEC. Because of water availability limits, wet-cooling options would not be feasible. Facilities should avoid the 100-year floodplain of Kimble Draw (325 acres), as well as all wetland, riparian, dry wash, playa, succulent and desert grassland habitats, as well as sand dune and sand transport systems within the SEZ. Nesting habitat for bird species listed under the MBTA and habitat for discovered populations and occupied habitats of special status species should be avoided.	2.5% (325 acres) of floodplain should be avoided. Additional restricted areas to be identified; extent unknown.
Red Sands	22,520	Disturbance of gypsite crusts should be avoided to minimize the risk of soil loss by wind erosion. Because of water availability limits, wet-cooling options would not be feasible. Facilities should avoid the 100-year floodplain (54 acres), as well as all wetland, dry wash, playa, riparian, succulent, and desert grassland habitats as well as sand dune habitat and sand transport systems within the SEZ. Nesting habitat for bird species listed under the MBTA and habitat for discovered populations and occupied habitats of special status species should be avoided. Power tower development should be prohibited to avoid visual impacts.	0.2% (54 acres) of floodplain should be avoided. Additional restricted areas to be identified; extent unknown.

TABLE 6.1-3 (Cont.)

State/SEZ	Total SEZ Acres	Environmental Impact Consideration[c]	Amount of SEZ with Possible Development Restrictions[d]
Utah			
Escalante Valley	6,614	Because of water availability limits, wet-cooling options would not be feasible. Facilities should avoid ephemeral washes, dry wash, dry lake, and playa habitats; sand dune and sand transport areas (particularly within the southwest portion of the SEZ); and pinyon-juniper and oak/mahogany woodlands. Nesting habitat for bird species listed under the MBTA and habitat for discovered populations and occupied habitats of special status species should be avoided.	Restricted areas to be identified; extent unknown.
Milford Flats	6,480	Because of water availability limits, wet-cooling options would not be feasible. Facilities should avoid ephemeral washes; dry wash, riparian, playa, greasewood flats, rocky cliff and outcrop, and woodland habitats; and Minersville Canal. Nesting habitat for bird species listed under the MBTA, and habitat for discovered populations and occupied habitats of special status species should be avoided.	Restricted areas to be identified; extent unknown.
Wah Wah Valley	6,097	Because of water availability limits, wet-cooling options would not be feasible. Facilities should avoid Wah Wah wash, other dry wash, playa, greasewood flat, wetland, rocky cliff and outcrop, woodland, and riparian habitats; and the inter-mountain big sagebrush shrubland cover type in the southwestern portion of the SEZ. Nesting habitat for bird species listed under the MBTA, and habitat for discovered populations and occupied habitats of special status species should be avoided.	Restricted areas to be identified; extent unknown.

TABLE 6.1-3 (Cont.)

State/SEZ	Total SEZ Acres	Environmental Impact Consideration[c]	Amount of SEZ with Possible Development Restrictions[d]
Utah (Cont.)			
	677,384 acres for all SEZs		Total Restrictions: 254,299 acres; 38% of total SEZ acreage, additional restricted areas to be identified.

Abbreviations: ACEC = Area of Critical Environmental Concern; BLM = Bureau of Land Management; DoD = U.S. Department of Defense; KOP = key observation point; KSLA = known sodium leasing area; MBTA = Migratory Bird Treat Act; MTR = military training route; NRHP = National Register of Historic Places; NP = National Park; SEZ = solar energy zone; VRM = visual resource management; WA = Wilderness Area; WWII = World War II.

[a] SEZs addressed in this Draft PEIS are proposed. Decisions on final SEZs, their size, and their boundaries will be made in the ROD for the PEIS.

[b] To convert acres to km^2, multiply by 0.004047. To convert ft to m, multiply by 0.3048. To convert mi to km, multiply by 1.609.

[c] All solar development in 100-yr floodplains and potential jurisdictional water bodies subject to Clean Water Act Section 404 permitting should be avoided, However, these areas have only been mapped in a few of the SEZs; where specific floodplain areas are known they have been stated in SEZ summaries.

[d] For purposes of analysis in this PEIS, the developable area was assumed to be up to 80% of the total area for all SEZs assuming that siting constraints likely would be identified during project-specific analyses. SEZ-specific analyses presented in Chapters 8 through 13 and summarized in this table have identified a number of potential conflicts that could restrict the amount of land available for development within the SEZs to 80% or less. These findings support the assumption that only 80% of any given SEZ would be developable. However, these restrictions need to be verified by additional project-specific evaluations. Restrictions related to potential visual impacts also need to be evaluated in light of ongoing BLM policy-making regarding mitigation of visual impacts.

long-term productivity, irreversible and irretrievable commitment of resources, and mitigation of adverse impacts.

6.1 IMPACTS OF THE SOLAR ENERGY DEVELOPMENT PROGRAM ALTERNATIVE

As discussed throughout the PEIS, all BLM-administered lands are not appropriate for solar energy development. Under the solar energy development program alternative, certain categories of land that are known or believed to be unsuitable for utility-scale solar development would be excluded from development to guide solar energy developers to areas where there are fewer resource conflicts and potential controversy. This process, described as "screening for success," would allow time and effort to be directed to those projects that have a greater chance of success. Under this alternative, the lands that would be excluded from utility-scale solar energy development include BLM-administered lands currently off-limits to development, including lands prohibited by law, regulation, Presidential proclamation or Executive Order (e.g., lands in the National Landscape Conservation System [NLCS]),[4] along with lands that (1) have slopes greater than or equal to 5%, (2) have solar insolation levels below 6.5 kWh/m^2/day, and (3) have known resources, resource uses, or special designations identified in local land use plans that are incompatible with solar energy development. A detailed discussion of these exclusions is provided in Section 2.2.2.2 and Table 2.2-2. On the basis of these exclusions, approximately 22 million acres (87,336 km^2) of BLM-administered lands would be available for ROW application under this alternative. A subset of these lands, approximately 677,400 acres (2,741 km^2), would be identified as SEZs where the agency would prioritize solar energy and associated transmission infrastructure development.[5]

This alternative would also establish comprehensive program administration and authorization policies and design features to be applied to utility-scale solar energy projects that are issued ROWs on BLM-administered lands in the six-state study area. These policies and design features were developed in part on the basis of impact analyses presented in Chapter 5. As part of this alternative, the BLM has identified additional SEZ-specific design features to address SEZ-specific resource conflicts. These SEZ-specific design features were identified on the basis of the analyses presented in Chapters 8 through 13 of this PEIS. The proposed policies and design features are presented in Section A.2 of Appendix A. The elements of the BLM's new

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4 The boundaries of National Landscape Conservation System (NLCS) units may be expanded by legislation, or Congress may establish entirely new NLCS units. See, for example, P.L. 111-11. Such lands would be removed automatically from the area of BLM-administered public lands available for solar energy development. Wilderness areas within the NLCS do not include the Tabeguache Area in Colorado because it is not officially designated as wilderness; however, by act of Congress, this area is to be managed as wilderness and, as a result, solar energy development is prohibited in the Tabeguache Area.

5 As discussed in Section 2.2.2.2, in the future, based on lessons learned from individual projects and/or new information (e.g., ecoregional assessments), the BLM could decide to expand SEZs, add SEZs, or remove or reduce SEZs. Changes to SEZs would have to go through a land use planning process, which would be subject to the appropriate environmental analysis.

program under this alternative would be implemented through amendment of the land use plans within the six-state study area.[6]

Under the solar energy development program alternative, individual ROW applications would continue to be evaluated on a project-by-project basis; however, the BLM proposes that these evaluations would tier to the programmatic analyses presented in this PEIS and the decisions implemented in the resultant ROD and land use plan amendments to the extent appropriate. Site- and project-specific data would be assessed in the individual project reviews and impacts not adequately mitigated by the program's administration and authorization policies and design features would be addressed through the implementation of additional mitigation requirements incorporated into the project plan of development (POD) and ROW authorization stipulations. Analysis of an application may result in a decision to deny the application.

As described in Section 2.2.2.1, as an element of the proposed program, the BLM would implement an adaptive management plan for solar energy development developed in coordination with potentially affected natural resource management agencies, to ensure that new data and lessons learned about the impacts of solar energy projects would be reviewed and, as appropriate, incorporated into the program through revised policies and design features. Changes to the BLM's Solar Energy Program will be subject to appropriate environmental analysis and land use planning.

The following subsections discuss the effectiveness of the solar energy development program alternative in meeting the BLM's established program objectives and describe the potential environmental impacts of the alternative.

6.1.1 Facilitate Near-Term Solar Energy Development (Pace of Development)

Under this alternative, the BLM would establish a set of programmatic administration and authorization policies and design features that would facilitate development by establishing a clear, consistent, and unambiguous process and set of conditions for utility-scale solar energy development on BLM-administered lands. A number of program elements would contribute to these efficiencies, as follows:

- By excluding lands with known sensitive resources, resource uses, and special designations, the agency would accept ROW applications for utility-scale

[6] Under this alternative, most of the land use plans in the six-state study area would be amended. Section 2815(d) of the National Defense Authorization Act for Fiscal Year 2000 (P.L. 106-65) placed a moratorium on planning efforts on BLM-administered lands "adjacent to, or near the Utah Test and Training Range (UTTR) and Dugway Proving Grounds or beneath Military Operating Areas, Restricted Areas, and airspace that make up the UTTR" (NDAA § 2815(a), 113 Stat. 512, 852 [1999]). This area encompasses a portion of the lands within the boundaries of the Box Elder, Pony Express, House Range, Warm Springs, and Pinyon land use plans. Within these areas, decisions related to whether lands would be available for ROW application, and adoption of the policies and design features of the PEIS, cannot be implemented via land use plan amendments at this time. Solar energy development ROW applications would be deferred until such time plan amendments or new land use plan(s) address solar energy development. No SEZs are located within the UTTR affected areas.

solar energy development only where such development may be expected to encounter fewer potential resource conflicts. Time and effort would be directed to those projects that have a greater chance of success. Review of projects proposed within any of the 24 proposed SEZs would be further streamlined, because these areas have undergone intensive site-specific analyses as part of this PEIS and mitigation has been proposed for identified resource conflicts (see Chapters 8 through 13).

- The identification of lands which would be excluded from utility-scale solar energy development, and lands which would be available, would help focus the efforts of BLM field staff and developers. However, the 22 million acres (87,336 km^2) that would be available for application are likely to include many areas not suitable for solar energy development because of as yet unidentified conflicts with other resources. As described in the authorization policies in Appendix A, BLM staff will be required to coordinate with federal, state, and local stakeholders and evaluate site-specific resource conflicts as part of the application analysis process.

- To the extent that decisions about future solar energy projects could be tiered to the analyses in this PEIS or decisions in the resultant ROD, project review and approval time lines would be shortened. The proposed program administration and authorization policies and design features are comprehensive and address the majority of operational and design requirements for most projects. The universe of issues that would be evaluated in detail at the project level would be reduced to site-specific and species-specific issues and concerns. For several of the SEZs, it is expected that, with the implementation of required design features, impacts on many resources would be minimal, and thus development could proceed with very limited additional environmental analysis.[7]

- Amending the land use plans within the six-state study area to implement the new program would facilitate individual project approvals and would ensure that multiple individual plan amendments would not be required.

It is anticipated that these program elements would collectively reduce the amount of time and resources required to obtain ROW authorizations and would speed up the pace of utility-scale solar energy development in the six-state study area without compromising the level of protection for natural and cultural resources. Shortened development time lines, particularly for projects proposed within SEZs, would reduce the cost to the government, developers, and stakeholders. These outcomes would likely increase the agency's ability to meet the mandates of the Energy Policy Act of 2005 and Secretarial Order 3285A1 (Secretary of the Interior 2010).

[7] Note that for all proposed SEZs, government-to-government consultation and inter-agency consultation are still ongoing and could result in the identification of additional concerns.

6.1.2 Minimize Environmental Impacts

Utility-scale solar energy facilities are industrial facilities that require large tracts of land and can generate substantial impacts on a variety of natural and cultural resources. Proper consultation, siting and design, and application of mitigation measures can avoid, minimize, or mitigate many of these impacts. The proposed program administration and authorization policies and design features under this alternative would ensure that potential environmental impacts are addressed thoroughly and consistently for all utility-scale solar energy projects on BLM-administered lands. Specific program elements have been developed to address the many aspects of managing environmental impacts, as follows:

- The proposed program administration and authorization policies establish requirements for coordination and/or consultation with other federal and state agencies and for government-to-government consultation, and establish requirements for public involvement. Collectively, these policies ensure that all projects are thoroughly reviewed, input is collected from all potentially affected land manager and interested stakeholders, and any project proposals that are anticipated to result in unacceptable adverse impacts are eliminated early in the application process.

- The proposed ROW exclusions would avoid impacts of utility-scale solar energy development on known sensitive resources, resource uses, and specially designated areas. Proposed projects on the lands that would be available for ROW application would be thoroughly reviewed to ensure that impacts to other sensitive resources and resource uses not currently identified would also be avoided or mitigated. As described in the program administration and authorization policies in Appendix A, BLM staff will be required to coordinate with federal, state, and local stakeholders and evaluate site-specific resource conflicts as part of the application analysis process. Analysis of an application may result in a decision to deny the application.

- By restricting utility-scale development to lands with slopes less than 5%, the BLM would effectively limit development to those BLM-administered lands assumed to be best suited with respect to technology limitations. By restricting development to lands with solar insolation levels greater than or equal to 6.5 $kWh/m^2/day$, the BLM would be making available those lands where utility-scale development is assumed to be most economically viable. These proposed restrictions will facilitate the efficient use of BLM-administered lands and meet the multiple-use intent of the Federal Land Policy and Management Act of 1976 (FLPMA) by reserving for other uses lands that are not well suited for solar energy development.

- The proposed design features, developed on the basis of extensive impact analyses conducted in this PEIS, address the full array of potential impacts associated with each phase of development (i.e., site evaluation, construction, operation, and decommissioning). For many project locations, the majority

of potential impacts would be addressed by these requirements. Individual project environmental reviews would be required to address any additional site-specific and species-specific issues and concerns.

- By making 22 million acres (87,336 km^2) of land available for ROW application, the BLM would provide opportunities to site solar energy projects on lands that have been previously disturbed or developed.

- The larger land area available for solar energy development under this alternative would provide the flexibility to site projects in a manner that could reduce the negative impacts of issues such as fragmentation of habitat, and proliferation of projects that might interfere with other resource values and uses. However, this same flexibility also would increase the uncertainty regarding the siting of such projects, and limit the assurance that a reduction in negative impacts would, in fact, occur. That is, this flexibility might actually increase the possibility for fragmentation of habitat, or result in greater impacts to other resource values and uses.

- The prioritization of development in SEZs could limit some environmental impacts. These areas were selected as lands best suited for utility-scale solar development (i.e., lands with fewer potential resource conflicts). Although some potentially significant resource and resource use conflicts have been discovered for some SEZs, SEZ-specific design features have been identified to address those potential impacts. The concentration of development in the SEZs could also allow for the consolidation of related infrastructure (e.g., roads, transmission lines) and less total land disturbance.[8]

- Proposed adaptive management strategies would ensure that new data and lessons learned about the impacts of solar energy development are incorporated into future programmatic and project-specific requirements. At the project level, developers would be required to develop monitoring programs in coordination with the BLM to evaluate the environmental conditions at the site through all phases of development, to establish metrics against which monitoring observations could be measured, to identify potential mitigation measures, and to establish protocols for incorporating monitoring observations and new mitigation measures into standard operating procedures.

- Implementing a comprehensive program would allow the BLM to better assess potential cumulative impacts of solar energy development across the six-state study area over time.

- A program that would facilitate solar energy development on BLM-administered lands would ensure that the development would be subjected

[8] Based on the potential conflicts identified, some of the proposed SEZ areas may be reduced in size or eliminated entirely when the final SEZs are identified in the ROD for this PEIS.

to rigorous environmental review, including a thorough public involvement process.

Table 6.1-2 includes a summary the environmental impacts associated with solar energy development under this alternative and the ways in which the impacts would be mitigated by the programmatic exclusions, policies and design features. As reflected in that table, for several resource and impact areas, implementation of the proposed design features is expected to ensure that impacts would be negligible or minor. For certain resource areas (e.g., hazardous materials and waste, health and safety), there are few, if any, unique site- or project-specific issues that would not be fully addressed by the programmatic requirements. For other resource areas (e.g., lands and realty, rangeland resources, military and civilian aviation, geologic setting and soils, mineral resources, air quality, acoustic environment, paleontological resources, transportation), the programmatic requirements are comprehensive and broad enough to address most issues even though there could be some site- and project-specific variables. For example, although paleontological resources vary in occurrence and density by site, impacts on these resources can be mitigated and the design feature requiring a paleontological resources management plan would ensure potential impacts are identified and addressed. Similarly, although traffic patterns and local road use vary by location, the design features requiring development of a transportation plan and traffic management plan would ensure local issues are identified and addressed.

For other resource and impact areas, the full effectiveness of the proposed design features intended to reduce potential impacts can be assessed only through the additional project-specific analyses that would be required under the proposed program. These areas include specially designated areas and lands with wilderness characteristics, recreation, water resources, vegetation, wildlife and aquatic biota, special status species, visual resources, cultural resources, Native American concerns, and environmental justice. For example, the magnitude of potential impacts of a given project on water resources would depend on project-specific parameters and site-specific conditions. The water requirements would depend on the size of the project and the technology used (e.g., concentrating solar power [CSP] versus photovoltaic [PV], wet cooling versus dry cooling systems). The nature of the impacts would depend on the amount of locally and regionally available water resources; the source of water supply; and other water uses, including requirements to support sensitive species and/or their critical habitats. These types of impacts cannot be assessed fully until project and site specific information is known.

BLM's intent in identifying SEZs was to find areas well suited to utility-scale solar energy production, with few impediments to solar facility construction and operation, where BLM would prioritize solar energy and associated transmission infrastructure development. In identifying the 24 SEZs evaluated in this PEIS, the BLM targeted areas with low slope, near existing transmission or designated corridors and near existing roads, and with a minimum area of 2,500 acres (10 km^2). The BLM also excluded from the SEZs NLCS lands and other sensitive classes of lands (e.g., critical and sensitive habitat, ACECs, no surface occupancy areas,

wilderness characteristic areas, SRMAs, ROW exclusion and avoidance areas, National Historic and Scenic Trails, areas of Tribal concern, and the like; see Table 2.2-2).[9]

Through the in-depth SEZ analyses presented in Chapters 8 through 13, the BLM discovered some potentially significant impacts on various resources and resource uses that could result from solar energy development in the proposed SEZs. The implementation of programmatic policies and design features required as part of this alternative could help to minimize environmental impacts in the SEZs. In addition, the BLM has proposed SEZ-specific design features that would further avoid and/or minimize potential impacts in these areas. These additional requirements would reduce the amount of developable land within some SEZs. The extent to which these impacts potentially would limit the amount of land available for development within each SEZ is provided in Table 6.1-3.

As discussed in Section 5.11.4, utility-scale solar energy development could result in reduced emissions of greenhouse gases (GHGs) and combustion-related pollutants, if the development offsets electricity generation by fossil fuel power plants. As discussed in Section 6.1.2, the pace of solar energy development is expected to be faster under this alternative, compared to the current pace, and therefore the potential beneficial impacts of reduced GHG emissions may be realized at a faster rate.

As a result of these considerations, the BLM anticipates that by implementing the proposed program administration and authorization policies and design features identified in the PEIS, the agency would maximize its ability to effectively identify and avoid, mitigate, or minimize potential adverse environmental impacts.

6.1.3 Minimize Social and Economic Impacts

Utility-scale solar energy development under this alternative is expected to result primarily in economic benefits in terms of both jobs and income created (see Section 5.17.2). These benefits would occur as both direct impacts, resulting from the wages and salaries, procurement of goods and services, and collection of state sales and income taxes, and indirect impacts, resulting from new jobs, income, expenditures, and tax revenues subsequently created as the direct impacts circulate through the economy. These benefits occur during both the construction and operations phases, with the construction phase benefits being temporary and the operations phase benefits being more long term. The specific benefits vary by technology, because some technologies generate more jobs than other technologies. For example, a 100-MW parabolic trough facility would create 350 new direct construction jobs and 43 new direct operations jobs, whereas a PV facility of comparable generation capacity would create 30 new direct construction jobs and very few direct operations jobs (see Tables 5.17.2-1 through 5.17.2-4 for detailed information about the economic impacts of construction and

[9] Although these classes of lands should have been excluded from the proposed SEZs, some may not have been because of incomplete information on the locations of these areas and incomplete GIS data.

operation of solar energy facilities by technology type).[10] The benefits in terms of indirect jobs and total income also vary by state, because the extent of in-state spending and economic multiplier effects vary by state.

Because utility-scale solar energy development would be accompanied by transmission system development and new access road construction in many locations, potential economic benefits also result from the direct and indirect jobs associated with this infrastructure construction. These impacts are discussed in Section 5.17.1.2.

The BLM would incur agency-related costs associated with developing, implementing, and managing solar energy development on BLM-administered lands. However, under the BLM's ROW program, which is a cost recovery program, a substantial portion of the costs for processing ROW applications, including environmental review requirements, would be paid for by developers. In addition, as discussed in Section 5.17.2, the Federal Government will collect income from ROW rental payments, which include an acreage component and capacity fee component (see Tables 5.17.2-1 through 5.17.2-4). As discussed in Section 2.2.2.2, the BLM anticipates that it may offer lands within the proposed SEZs through a competitive process. In areas where this is implemented, the revenue to the Federal Government likely would be higher than in other areas. A competitive process, however, could increase costs for developers of solar facilities.

As discussed in Section 5.17.1.1, there may be some adverse economic impacts to displaced public land users associated with solar development (e.g., loss of grazing allotments). There may also be adverse social impacts resulting from changes in recreation, property values, and environmental amenities (e.g., environmental quality, rural community values, or cultural values). There could also be beneficial social impacts associated with solar development resulting from economic growth and a positive reception to the presence of a renewable energy industry. At the programmatic level, it is difficult to quantify these impacts.

6.1.4 Provide Flexibility to Solar Industry

By making a relatively large amount of land available for utility-scale solar ROW applications, particularly when compared to the amount of land that would be needed to support the projected RFDS, this alternative provides a great degree of flexibility in identifying appropriate locations for utility-scale development (i.e., economically attractive locations with minimal environmental or cultural resource conflicts).

However, concerns exist that by excluding lands with slopes greater than or equal to 5% and with solar insolation levels below 6.5 $kWh/m^2/day$, the BLM could be removing lands that some developers may find both technically and economically feasible to pursue in the future.

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[10] The estimate provided in the text here for number of PV construction jobs is based on an extrapolation of data in Table 5.17.2-4.

6.1.5 Optimize Existing Transmission Infrastructure and Corridors

By making a relatively large amount of land available for utility-scale solar ROW applications, developers could identify and propose projects that optimize existing transmission infrastructure and designated transmission corridors. As discussed in Appendix G, an analysis of the extent to which the lack of transmission access could constrain solar energy development on lands that would be made available for ROW application under this application indicated that the majority of these lands are within 25 mi (40 km) of existing transmission lines or designated corridors.

Although it is likely that most new utility-scale solar energy development will require new transmission capacity, projects that can be located near existing transmission lines would incur fewer environmental impacts associated with connecting to and upgrading the existing lines. Similarly, solar projects that utilize existing corridors would incur reduced environmental impacts, assuming the designation process factored potential environmental and other siting concerns into the corridor alignment. The use of existing transmission infrastructure and corridors could also reduce cost, time, and controversy.

6.1.6 Standardize and Streamline the Authorization Process

The new program would standardize requirements and reduce uncertainty for project applications. It would streamline project review and approval processes, and ensure consistency in the way utility-scale ROW applications are managed. Individual ROW applications would continue to be evaluated on a project-by-project basis; however, the BLM proposes that these evaluations would tier to the programmatic analyses presented in the PEIS and the decisions implemented in the resultant ROD and land use plan amendments to the extent appropriate.

6.1.7 Meet Projected Demand for Solar Energy Development

On the basis of the RFDS for solar energy development (which is assumed to be largely the same for each alternative), the estimated amount of solar energy generation on BLM-administered lands in the study area over the 20-year study period (through approximately 2030) is about 24,000 MW, with a corresponding dedicated use of about 214,000 acres (866 km^2) of BLM-administered lands. As shown in Table 6.1-4, the BLM-administered lands that would be available for ROW application under the solar energy development program alternative, approximately 22 million acres (87,336 km^2), far exceed the amount of land that would be developed under the RFDS in each of the six states. The BLM recognizes that it is likely that the 22 million acres (87,336 km^2) includes some lands where development would conflict with existing resources or resource uses, so that the actual amount of lands available for utility-scale solar energy under this alternative would be something less than 22 million acres (87,336 km^2). The extent to which this is the case cannot be assessed at this time; however, it is likely that the actual amount of developable lands would easily accommodate the level of development projected by the RFDS.

TABLE 6.1-4 Percentage of Available Lands Developed by BLM Action Alternatives Based on Estimated Acres Developed under RFDS

State	Estimated Acres[a] Developed under RFDS[b]	Solar Energy Development Program Alternative: Total Proposed Acres[a] Available[c]	Solar Energy Development Program Alternative: Percentage Developed under RFDS	SEZ Program Alternative: Total Proposed Acres[a] Available[d]	SEZ Program Alternative: Percentage Developed under RFDS
Arizona	21,816	4,485,944	0.5	13,735	100[e]
California	138,789	1,766,543	7.9	339,090	40.9
Colorado	19,746	148,072	13.3	21,050	93.8
Nevada	15,309	9,084,050	0.2	171,265	8.9
New Mexico	7,497	4,068,324	0.2	113,052	6.6
Utah	10,971	2,028,222	0.6	19,192	57.2
Total	214,119	21,581,154	1.0	677,384	31.6

[a] To convert acres to km^2, multiply by 0.004047.

[b] See Table 2.4-1 for basis for these estimates.

[c] See Section 2.2.2.2 for basis for these estimates.

[d] See Section 2.2.2.3 for basis for these estimates. For the purpose of the RFDS estimates of development, the entire acreage is used in the calculation of percentage developed; however, some portion will not be developable because of various restrictions.

[e] The estimated number of acres developed based on the RFDS projection exceeds the acreage proposed to be available in Arizona under the SEZ program alternative, so it is assumed that 100% of the SEZs would be developed over the 20-year time line assessed in this PEIS.

6.2 IMPACTS OF THE SEZ PROGRAM ALTERNATIVE

Under the SEZ program alternative, the BLM would adopt the same set of standard program administration and authorization policies and design features for utility-scale solar energy development as proposed under the solar energy development program alternative, but would authorize such solar energy development only in SEZs. Unlike the solar energy development program alternative, lands outside of SEZs would be excluded from utility-scale solar energy ROW applications. Under this alternative, about 677,400 acres (2,741 km^2) of BLM-administered lands would be available for ROW applications. As discussed in Section 2.2.2.2, in the future, based on lessons learned from individual projects and/or new information (e.g., ecoregional assessments), the BLM could decide to expand, add, remove, or reduce SEZs. Changes to SEZs would have to go through a land use planning process, which would be subject to the appropriate environmental analysis.

Under the SEZ program alternative, the management of solar energy development on BLM-administered lands would be the same as described for the solar energy development program alternative. The BLM would establish comprehensive program administration and authorization policies and design features as part of this alternative. The elements of the BLM's

new program under this alternative would be implemented through amendment of the land use plans within the six-state study area.[11]

The following subsections discuss the effectiveness of the SEZ program alternative in meeting the BLM's established program objectives and describe the potential environmental impacts of the alternative.

6.2.1 Facilitate Near-Term Solar Energy Development (Pace of Development)

The impacts on the pace of development under this alternative would be much the same as those described for the solar energy development program alternative in Section 6.1.1; although it is possible, this alternative could speed up the pace of development even further. Elements of the new program would reduce the amount of time and resources required to obtain ROW authorizations, and this would translate into reduced costs to government, developers, and stakeholders. As with the solar energy development program alternative, these outcomes would likely increase the agency's ability to meet the mandates of the Energy Policy Act of 2005 and Secretarial Order 3285A1 (Secretary of the Interior 2010).

6.2.2 Minimize Environmental Impacts

Similar to the solar energy development program alternative, environmental impacts under the SEZ program alternative would be minimized in the following ways:

- Government-to-government consultation and public input would ensure thorough review of the proposed locations of development within SEZs.

- Because the developable land area for utility-scale solar energy development would be restricted to SEZs, known sensitive resources would be avoided for the most part, SEZ-specific design features would protect any sensitive resources identified in SEZs, and uncertainty of the distribution of impacts, including possible fragmentation of habitat, would be reduced.

- The proposed design features listed in Appendix A, Section A.2, would address the full array of potential impacts associated with each phase of development.

- The concentration of development in the SEZs could allow for the consolidation of related infrastructure (e.g., roads, transmission lines) and less total land disturbance.

[11] See footnote 6.

- The requirement to implement adaptive management strategies would ensure that mitigation measures would be implemented if unforeseen impacts were identified during project planning, construction, or operations.

- Because of the proximity of solar development projects that could occur under the SEZ program alternative, cumulative impacts for some resources (e.g., water, visual, socioeconomics) in localized areas around the SEZs could be high; however the certainty of this location may allow these impacts to be more easily addressed. An analysis of the potential cumulative impacts for each SEZ is included in Chapters 8 through 13.

By making 677,400 acres (2,741 km^2) of land available for ROW application, the BLM would limit opportunities to site solar energy projects on lands that have been previously disturbed or developed.

Table 6.1-2 summarizes the environmental impacts that might be associated with solar energy development under this alternative and the extent to which the impacts would be mitigated by the programmatic exclusions, policies, and design features. As reflected in that table, it is not possible to fully assess the impacts on some resources (e.g., specially designated areas and lands with wilderness characteristics, recreation, military aviation, water resources, vegetation, wildlife and aquatic biota, special status species, visual resources, cultural resources, Native American concerns, and environmental justice), because they are dependent on specific project details not defined at the programmatic level. However, this type of analysis would be done thoroughly through additional project-specific analyses that would be required under the proposed program.

Table 6.1-3 summarizes the potentially significant impacts on some resources and resource uses from solar energy development in the SEZs; these are discussed in detail in Chapters 8 through 13. The implementation of program administration and authorization policies and design features as part of this alternative would minimize environmental impacts of development in the SEZs, although the SEZ-specific design features would also reduce the amount of land within some SEZs that could be developed.[12]

The BLM anticipates that by implementing the proposed policies and design features identified in the PEIS, the agency would maximize its ability to effectively identify and avoid, mitigate, or minimize potential adverse environmental impacts.

6.2.3 Minimize Social and Economic Impacts

The potential socioeconomic impacts of this alternative would be similar to those described in Section 6.1.3 for the solar energy development program alternative; however, both

[12] Based on the potential conflicts identified, some of the proposed SEZ areas may be reduced in size or eliminated entirely when the final SEZs are identified in the ROD for this PEIS.

the economic benefits and the potential adverse economic and social impacts would be concentrated solely in the vicinity of the SEZs.

The BLM's efforts to oversee utility-scale solar energy development in the six-state study area would be streamlined under the SEZ program alternative by virtue of the smaller geographic area and the opportunities for tiering to the SEZ-specific analyses provided in this PEIS. In addition to receiving ROW rental payments, the BLM would have the opportunity to offer lands within the SEZs through competitive processes and maximize the revenue to the Federal Government.

6.2.4 Provide Flexibility to Solar Industry

By making fewer BLM-administered lands available for utility-scale solar energy development, however, the SEZ program alternative might reduce the flexibility of both the agency and developers in terms of identifying appropriate locations for utility-scale development. There are likely to be economically attractive sites for solar energy development outside of the SEZs that can meet the environmental protection measures outlined in the PEIS. It is important to note however, that the BLM may identify additional SEZs in the future on the basis of lessons learned from individual projects and/or new information and, in doing so, the agency could increase the amount of land available for ROW application if needed to support solar energy development in specific areas of interest to industry. The BLM could also decide to amend individual land use plans to accommodate individual solar energy development projects if warranted.

6.2.5 Optimize Existing Transmission Infrastructure and Corridors

All of the SEZs are located near existing transmission lines and/or corridors, and development in the SEZs would optimize their use. However, as discussed in Section 6.1.5, there are many potentially suitable development areas for utility-scale solar outside the SEZs that are proximate to existing transmission infrastructure, and these lands would not be available for development under this alternative.

As discussed in Section 6.1.5, while most new utility-scale solar energy development will require new transmission capacity, projects that can be located near existing transmission lines would incur fewer environmental impacts associated with connecting to and upgrading the existing lines. Similarly, solar projects that utilize existing corridors would incur reduced environmental impacts, assuming the designation process factored potential environmental and other siting concerns into the corridor alignment. The use of existing transmission infrastructure and corridors could also reduce cost, time, and controversy.

6.2.6 Standardize and Streamline the Authorization Process

The new program would standardize requirements and reduce uncertainty for project applicants. It would streamline project review and approval processes and ensure consistency in the way utility-scale ROW applications are managed. Because this alternative would limit utility-scale development to those areas most intensively studied in this PEIS, it is likely that BLM staff efforts to review and approve ROW applications would be most efficient under this alternative.

6.2.7 Meet Projected Demand for Solar Energy Development

Assuming that all the lands within the SEZs could be developed, the amount of lands available for development (677,400 acres [2,741 km^2]) would be about 3% of the amount of lands that would be available under the solar energy development program alternative (22 million acres [87,336 km^2]). Across all six states, the lands available within the SEZs would be three times the amount of land required to support the RFDS projected development of 24,000 MW (214,000 acres [866 km^2]). However, as shown in Table 6.1-4, in at least two states (Arizona and Colorado), the amount of land that would be available for ROW application may not be enough to support the total state-specific development projected in the RFDS. Specifically, in Arizona, the RFDS development would require 21,816 acres (88.3 km^2), which exceeds the 13,735 acres (55.6 km^2) that would be available under the SEZ program alternative. In Colorado, 19,746 acres (80 km^2) would be developed under the RFDS which constitutes almost 94% of the 21,050 (85.2 km^2) acres that would be available.

Additionally, constraints on development within some SEZ areas are known to exist; these constraints are summarized in Table 6.1-3 and discussed in greater detail in each of the SEZ-specific analyses presented in Chapters 8 through 13. The SEZ-specific analyses identified distinct areas within many of the SEZs that either should not be developed or should have development restrictions (e.g., areas with ephemeral stream channels or floodplains, areas with military flight restrictions for facilities with tall structures, areas with potential visual resource conflicts, areas close to residences for noisy technologies). And it is recognized that some SEZ areas will likely require additional exclusions or restrictions, the extent of which may not be known until site- and project-specific environmental analyses can be completed. Given these factors, it is possible that the amount of lands that would be available under the SEZ program alternative might not be enough to support full development of the RFDS in states other than Arizona and Colorado. In particular, this is may be true for California, where the RFDS would require 41% of the available lands if all the lands in the SEZs were developable, and SEZ-specific analyses have shown that substantial portions of the SEZs would likely have development restrictions (see Chapter 9). The full development scenario under the RFDS for the state of Utah would require 57% of the total land available in Utah SEZs, so if additional restrictions on development within the Utah SEZs are identified, it is also possible that the SEZs would not adequately support solar energy development in that state over the 20-year study period.

Because this alternative may not make an adequate amount of lands available to support the RFDS projections, at least in some states, it is possible that the total amount of utility-scale solar

energy developed on BLM-administered lands over the 20-year study period could be constrained unless the BLM identified additional SEZs.

6.3 IMPACTS OF THE NO ACTION ALTERNATIVE

Under the no action alternative, solar energy development would continue on BLM-administered lands in accordance with the terms and conditions of the existing Solar Energy Policies (BLM 2007; 2010a,b). The BLM would not implement a comprehensive program to provide guidance to BLM field staff, developers, and other stakeholders in the six-state study area. Specifically, the required program administration and authorization policies and design features, and land use plan amendments proposed in this PEIS would not be implemented. Future solar energy projects and land use plan amendments would continue to be evaluated solely on an individual, case-by-case basis.

The following subsections discuss the effectiveness of the no action alternative in meeting the BLM's established program objectives.

6.3.1 Facilitate Near-Term Solar Energy Development (Pace of Development)

The pace of solar energy development on BLM-administered lands would not be enhanced by the no action alternative:

- Developers and stakeholders would not have clear direction from the BLM as to which lands (other than NLCS lands) would be excluded from or, conversely, available for utility-scale solar development and thus could spend time and resources investigating inappropriate locations.

- There would be no programmatic evaluation of solar energy development to which individual project analyses could tier, thereby requiring each project review to evaluate the entire suite of environmental, cultural, and socioeconomic impact issues, including those that have no site- or project-specific aspects, at an individual, detailed level.

- There would be no comprehensive design features to implement. BLM field staff, developers, and stakeholders would be required to identify and evaluate the effectiveness and appropriateness of potential mitigation measures on a case-by-case basis.

- The BLM would not identify SEZs to facilitate and prioritize utility-scale solar energy development in those areas well-suited for such development and where potential resource conflicts have been identified.

- As necessary, individual land use plans would have to be amended for individual projects as a part of the project evaluation and approval, which could delay the process.

The extended development time lines likely to result under the no action alternative could jeopardize developers' business agreements, potentially putting any given project at risk of abandonment. In addition, extended time lines could increase the costs for all concerned parties, including the government, developers, and stakeholders. Furthermore, developers could elect to avoid delay and uncertainty by shifting their projects to state, Tribal, and private land with potentially less federal environmental oversight (Section 6.3.2). If this shift were to occur, resulting in less development of solar energy on BLM-administered lands, this outcome would be in conflict with the mandates of the Energy Policy Act of 2005 and Secretarial Order 3285A1 (Secretary of the Interior 2010).

6.3.2 Minimize Environmental Impacts

In general, direct and indirect environmental impacts associated with individual utility-scale solar energy projects under the no action alternative could be similar to those under the proposed action alternatives (see Sections 6.1.2 and 6.2.2), because the BLM is required to identify and address environmental impacts of all ROW authorizations and conform to existing land use plan decisions. However, under the no action alternative, the benefits of reducing the potential for environmental impacts by excluding utility-scale development from lands with slopes less than 5%, lands with solar insolation levels greater than or equal to 6.5 $kWh/m^2/day$, and lands where sensitive resources are present might not be fully realized. In addition, without comprehensive guidance on impact mitigation, the potential for field staff to require different mitigation measures from project to project would be high. Lack of consistency could translate into inadequate mitigation of impacts for some projects and overly onerous mitigation requirements for other projects. Furthermore, adaptive management strategies regarding solar energy development, associated impacts, and effective mitigation measures that would be integrated over time as suggested under the action alternatives would not be necessarily be part of the no action alternative.

Table 6.1-2 summarizes the environmental impacts that might be associated with solar energy development under this alternative. As reflected in that table, the no action alternative would do little to avoid impacts on sensitive resources, resource uses, and special designations by way of programmatic exclusions. Instead, BLM field staff would be required to review applications to ensure that these areas are properly addressed.

If the absence of a comprehensive program were to result in delays in processing ROW applications on BLM-administered lands or in increases in the cost of developing solar power on BLM-administered lands, developers could respond by focusing their development efforts on state-owned, Tribal, and private lands. While solar energy development on nonfederal lands is subject to a wide array of environmental reviews and approvals by virtue of state and local permitting processes, it may not be subject to NEPA requirements if federal funding or permitting is not required for the project.

In terms of the potential beneficial impacts of utility-scale solar energy development in offsetting the emissions of greenhouse gases and combustion-related pollutants from fossil fuel

energy sources, if the pace of solar energy development is slower under the no action alternative, these benefits would be realized at a slower rate.

Maintaining access to the 99 million acres (400,000 km^2) of land currently available for ROW application would maximize opportunities to site solar energy projects on lands that have been previously disturbed or developed.

6.3.3 Minimize Social and Economic Impacts

If the pace of utility-scale solar energy development under the no action alternative were slower than under the action alternatives, there could be a delay in the economic benefits from the development in the six-state study area, in terms of direct and indirect jobs created and income in the communities.

Under the no action alternative, the BLM will not be able to conduct competitive leasing as easily as it might under the proposed action alternatives. As a result, potential revenues to the government related to utility-scale solar energy development on BLM-administered lands may be lower under this alternative.

In addition, it is anticipated that the no action alternative would cause BLM staff to spend additional time and resources on the reviews and approvals of utility-scale ROW applications, and this will incur greater costs to the agency and the applicants. Developers might propose projects in inappropriate locations, opportunities to tier analyses from this programmatic evaluation would not exist, and ROW authorizations would require individual land use plan amendments.

6.3.4 Provide Flexibility to Solar Industry

The relatively large amount of land available for utility-scale ROW applications under the no action alternative, particularly when compared to the amount of land that would be needed to support the projected RFDS, provides a great degree of flexibility in identifying appropriate locations for utility-scale development (i.e., economically attractive locations with minimal environmental or cultural resource conflicts). However, under the no action alternative, programmatic guidance would not be provided to developers with respect to lands and projects that ultimately may not be approvable by the BLM.

6.3.5 Optimize Existing Transmission Infrastructure and Corridors

The relatively large amount of land available for utility-scale ROW applications under the no action alternative provides a great degree of flexibility in identifying locations for utility-scale development that optimize existing transmission infrastructure and designated transmission corridors. However, under the no action alternative, little guidance would be provided to developers with respect to lands and projects that ultimately may not be approvable by the BLM.

6.3.6 Standardize and Streamline the Authorization Process

Under the no action alternative, the BLM would not implement a comprehensive program to standardize and streamline the agency's review and approval of utility-scale solar energy ROW authorizations that would include program administration and authorization policies and design features and land use plan amendments. The BLM would continue to address issues as they arise through individual policy statements and guidance.

6.3.7 Meet Projected Demand for Solar Energy Development

Lands currently off-limits to development (i.e., the NLCS lands identified in Section 6.1) would continue to remain off-limits and would not be available for ROW application. Applications for utility-scale solar development would be accepted in all other areas and reviewed in the context of existing land use plan decisions. Under the no action alternative, approximately 99 million acres (400,000 km^2) of BLM-administered lands could be considered for ROW application. This amount of land is several orders of magnitude greater than the amount of land likely to be developed on the basis of the RFDS projections (214,000 acres [866 km^2]), although ROW applications likely would not be approved on a large percentage of these lands because of conflicts with known resources, resource uses, and existing special designations.

6.4 COMPARISON OF ALTERNATIVES AND SELECTION OF PREFERRED ALTERNATIVE

This section provides a comparison of the alternatives evaluated in this PEIS on the basis of the evaluations presented in Sections 6.1 through 6.3. The comparison is included to support the BLM's decision regarding which alternative presents the best management approach to utility-scale solar energy development on BLM-administered lands based on the stated objectives. Table 6.4-1 provides a summary-level comparison of the management alternatives with respect to the objectives established for the action and the extent to which each alternative would assist the BLM in meeting the projected demands for solar energy development as estimated by the RFDS.

The BLM has selected the solar energy development program alternative as the preferred alternative for the purposes of the draft PEIS. On the basis of the comparisons presented in Table 6.4-1, it appears that the solar energy development program alternative would best meet the BLM's objectives for managing utility-scale solar energy development on BLM-administered lands. It would likely result in the highest pace of development at the lowest cost to the government, developers, and stakeholders. Simultaneously, it would provide a comprehensive approach for ensuring that potential adverse impacts would be minimized to the greatest extent possible. If the pace of development is greatest under this alternative, it would accelerate the rate at which the economic benefits would be realized at the local, state, and regional levels. This alternative would make an adequate amount of lands available to support the level of development projected in the RFDS and would provide a great deal of flexibility in siting both

TABLE 6.4-1 Comparison of BLM's Alternatives with Respect to Objectives for the Agency's Action

Objective	Solar Energy Development Program Alternative	SEZ Program Alternative	No Action Alternative
Facilitate near-term utility-scale development on public land	Increased pace of development Development in the prioritized SEZs likely to occur at an even faster pace Reduced costs to the government, developers, and stakeholders Effective in assisting BLM in meeting its mandates[a]	Increased pace of development likely due to detailed analyses of SEZs Reduced costs to the government, developers, and stakeholders Effective in assisting BLM in meeting its mandates[a]	No discernible effect on pace of development Development could shift toward nonfederal lands, making it more difficult for BLM to achieve its mandates[a]
Minimize potential environmental impacts	Comprehensive program to identify and avoid, mitigate, or minimize potential adverse impacts Protection of resources, resource uses, and special designations through combination of exclusions and mitigation Prioritization of development in SEZs, which were identified as lands well-suited for solar energy development where potential resource conflicts have been identified and appropriate mitigation has been suggested Potentially would allow a greater degree of development on previously disturbed lands	Comprehensive program to identify and avoid, mitigate, or minimize potential adverse impacts Development limited to the SEZs, protecting more resources, resource uses, and special designations through avoidance Additional mitigation required in SEZs Limits possibilities for focusing development to previously disturbed lands outside SEZs	Environmental impacts evaluated project-by-project with potential for inconsistencies in the type and degree of required mitigation If development shifts to nonfederal lands, it would be subject to less federal environmental oversight and public involvement Potentially would allow a greater degree of development on previously disturbed lands

TABLE 6.4-1 (Cont.)

Objective	Solar Energy Development Program Alternative	SEZ Program Alternative	No Action Alternative
Minimize potential social and economic impacts	Economic benefits in terms of (1) direct and indirect jobs and income created and (2) ROW rental payments to the Federal Government Prioritization of development in the SEZs, could concentrate benefits in a smaller number of local economies Potential adverse and beneficial social impacts	Economic benefits in terms of (1) direct and indirect jobs and income created and (2) ROW rental payments to the Federal Government With development limited to the SEZs, benefits would be concentrated in a smaller number of local economies Potential adverse and beneficial social impacts	Potential economic benefits essentially the same as under the action alternatives, although realized at a slower rate if pace of development is slower Less potential for these benefits to be concentrated in specific areas
Provide flexibility to solar industry	A great degree of flexibility in identifying appropriate locations for utility-scale development	Limited flexibility in identifying appropriate locations for utility-scale development	Maximum degree of flexibility in identifying appropriate locations for utility-scale development Limited guidance to developers on which lands and projects would ultimately be approvable
Optimize existing transmission infrastructure and corridors	Opportunities for developers to identify and propose projects that optimize existing transmission infrastructure and/or designated corridors	Opportunities for developers to identify and propose projects that optimize existing transmission infrastructure and/or designated corridors limited to SEZs Opportunities to consolidate infrastructure required for new solar facilities	Maximum opportunities for developers to identify and propose projects that optimize existing transmission infrastructure and/or designated corridors

TABLE 6.4-1 (Cont.)

Objective	Solar Energy Development Program Alternative	SEZ Program Alternative	No Action Alternative
Standardize and streamline authorization process	Streamlining of project review and approval processes; more consistent management of ROW applications With prioritization of development in the SEZs, additional streamlining of opportunities over development on other available lands	Streamlining of project review and approval processes; more consistent management of ROW applications	No discernible effect in terms of standardizing and streamlining the authorization process
Meet projected demand for solar energy development as estimated by the RFDS	About 22 million acres[b] available for ROW application, which is more than adequate to support the RFDS projected level of development	Less than 677,400 acres available for ROW application, which may not be enough land to support the RFDS projected level of development in some states BLM identification of additional SEZs in the future would make additional land available but would require additional environmental review and land use plan amendments	About 99 million acres available for ROW application, which is more than adequate to support the RFDS projected level of development

[a] These mandates are established by the Energy Policy Act of 2005 (P.L. 109-58) and Secretarial Order 3285A1 (Secretary of the Interior 2010) (see Section 1.1).

[b] To convert acres to km^2, multiply by 0.004047.

solar energy facilities and associated transmission infrastructure. In addition, the solar energy development program alternative would be very effective at facilitating development on BLM-administered lands in accordance with the mandates of the Energy Policy Act of 2005 and Secretarial Order 3285A1 (Secretary of the Interior 2010).

6.5 CUMULATIVE IMPACTS

This cumulative impact assessment describes how the environmental, social, and economic conditions within the six-state study area may be incrementally impacted over the next 20 years by utility-scale solar energy development that is likely to take place on BLM-administered lands consistent with the proposed action. The Council on Environmental Quality (CEQ), in its regulations implementing the procedural provisions of NEPA (40 CFR 1500-1508), defines cumulative effects as follows:

> ...the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions (40 CFR 1508.7).

The discussion of cumulative impacts in this chapter describes the impacts of solar energy development in the context of other activities that also could impact environmental resources over the next 20 years. Cumulative impact analyses have also been developed for individual SEZs as part of Chapters 8 through 13. The SEZ-specific cumulative impact analyses evaluate the impacts of a maximum development scenario for each SEZ, regardless of the state-specific RFDS projections, at a level of detail suitable for supporting analyses of specific projects proposed within and near the SEZs.

The cumulative analysis in this chapter encompasses the same resources analyzed in Chapter 5 and considers the impacts that could occur as a result of solar energy development over the next 20 years assuming that the proposed policies and design features common to both action alternatives are adopted. Individual projects will include a comprehensive, on-going environmental monitoring component to evaluate environmental conditions and adjust impact mitigation requirements as necessary. As a result, the BLM's Solar Energy Program would be expected to continue to provide needed impact mitigation over time, consistent with an adaptive approach.

The scope of the cumulative impact analysis in this chapter assumes solar energy development at the level projected in the RFDS. Potential differences in cumulative impacts between alternatives are highlighted as appropriate. In applying the RFDS to all alternatives, the following caveats must be considered.

As discussed in Section 6.2, there is the possibility that the total level of development could be curtailed under the SEZ program alternative, at least in some states, because this alternative may not make enough lands available for ROW application. The extent to which this might occur cannot be quantified at least in part because the BLM might identify additional

SEZs in the future to make more land available. Furthermore, because the RFDS is based on the state-specific renewable portfolio standards (RPSs), which are mandatory in each of the six states except Utah, it was assumed that development that does not occur on BLM-administered lands for various reasons would be made up for by development on non-BLM-administered lands within each state.

As discussed in Section 6.3, the no action alternative would make ample lands available for ROW application to support the projected RFDS development levels. Although this alternative would not likely enhance the pace of utility-scale development over the next 20 years (see Section 6.3.1), the extent to which development would occur cannot be quantified. As with the SEZ program alternative, under the no action alternative solar development that did not occur on BLM-administered lands was assumed to be made up for by development on non-BLM-administered lands.

By restricting and/or prioritizing development in the SEZs under the two action alternatives, cumulative impacts may be more concentrated and/or severe within individual SEZs than described in this section. On the other hand, the concentration of development in the SEZs may also allow for the consolidation of related infrastructure (e.g., roads, transmission lines) and less total land disturbance. Cumulative impacts analyses for individual SEZs are presented in Chapters 8 through 13.

An overview of ongoing and reasonably foreseeable future activities in the six-state study area is presented in Section 6.5.1, including energy production and distribution (Section 6.5.1.1), and other activities such as recreation, mineral production, military operations, grazing and rangeland management, fire management, forestry, transportation, and industrial development (Section 6.5.1.2.1). General trends in population growth, energy demand, water availability, and climate change are discussed in Section 6.5.1.2.2. Cumulative impacts for the resource areas are discussed in Section 6.5.2.

6.5.1 Overview of Activities in the Six-State Study Area

Activities in the six-state study area considered in the cumulative impact analysis include projects, actions, and trends that could affect human and environmental receptors within the defined regions of influence and the defined 20-year time frame. Tables 6.5-1 and 6.5-2 present the types of future actions and trends that have been identified in the study area as part of the cumulative impact analysis. Programmatic-level actions on federal lands are presented in Table 6.5-3; these include actions that have been approved and are under way, and those that are still in the planning stages.

TABLE 6.5-1 Types of Actions in the Six-State Study Area

Type of Actions	Associated Activities and Facilities
Oil and gas production	*Exploration and development* Geophysical seismic surveys Access roads and well pads Well drilling and construction Pipeline and utility corridors Gas compressor stations and oil production batteries Site reclamation and rehabilitation Spills/releases *Production* Production and processing plants Refineries Carrier pipelines Spills/releases Power plants Access roads *Oil shale mining and processing* Surface mines Underground mines In situ retorting Processing plants (rock crushing and retorting) Refineries Solid waste (overburden, waste rock, spent shale, and tailings) Site reclamation and rehabilitation *Tar sands mining and processing* Surface mines Underground mines In situ recovery (e.g., steam injection) Extraction plants Solid waste (overburden, waste sand, spent sand, tailings) Refineries Site reclamation and rehabilitation
Coal production	*Exploration and development* Exploratory drilling and trenching Access roads and helipads *Production* Surface mines Underground mines Access roads Processing (beneficiation) plants Transportation (e.g., railroads) Solid waste (overburden, waste rock, and tailings) Site reclamation and rehabilitation

TABLE 6.5-1 (Cont.)

Type of Actions	Associated Activities and Facilities
Coal production *(Cont.)*	*Electricity generation* Construction Operations Decommissioning
Nuclear electricity generation	*Uranium exploration and production* Exploration Mining and milling Access roads Transportation (e.g., railroads) Solid waste (overburden, waste rock, and tailings) Leachate mining wastes Site reclamation and rehabilitation *Electricity generation and transmission* Construction Operations Decommissioning
Renewable energy development	*Wind energy* Installation of meteorological towers Access roads Installation and operation of turbine towers Electrical collector lines, transformers, and substations Transmission interties Ancillary facilities (e.g., control building and sanitary facilities) Site reclamation and rehabilitation *Geothermal energy* Geophysical gravity, seismic, and temperature well surveys Access roads Well drilling and construction Power plants Pipeline and transmission interties Solid waste Hydrogen sulfide recovery and recycling Site reclamation and rehabilitation *Hydropower* Generating stations Dam or diversion structures Access roads Electrical substations and transformer pads Transmission interties Ancillary facilities (e.g., control building and sanitary facilities)

TABLE 6.5-1 (Cont.)

Type of Actions	Associated Activities and Facilities
Renewable energy development *(Cont.)*	*Solar energy* Vegetation clearing and excavation Construction of solar collectors Generation facilities Access roads Electrical substations and transformer pads Transmission interties Ancillary facilities (e.g., control building and sanitary facilities) Site reclamation and rehabilitation
	Biomass resources Feedstock cultivation and harvesting Power plants Ethanol and biodiesel facilities Biogas facilities Access roads Electrical substations and transformer pads Transmission interties Ancillary facilities (e.g., control building and sanitary facilities) Site reclamation and rehabilitation
	Mandatory renewable portfolio standards
Transmission and distribution systems	*Utility corridors* Carrier pipelines Oil and gas pipelines Fuel transfer stations Spills/releases Transmission lines Substations Access roads
Recreation	Visiting scenic and historic places Cross-country and downhill skiing Hunting and fishing ATV use Horseback riding Camping, hiking, and picnicking Viewing wildlife Rock climbing River rafting Driving for pleasure

TABLE 6.5-1 (Cont.)

Type of Actions	Associated Activities and Facilities
Minerals production	*Exploration and development* Exploratory drilling and trenching Access roads and helipads *Production* Surface mines Underground mines Access roads Transportation (e.g., railroads) Solid waste (overburden, waste rock, and tailings) Leachate mining wastes
Military operations	Air space operations Spills/releases Training and equipment testing Housing Expansion Realignment and closure
Grazing and rangeland management	Livestock grazing Rangeland improvements (e.g., water pipelines, reservoirs, and fences) Rangeland restoration, rehabilitation, or other conservation measures
Fire management	Fire suppression Fuels management Wildland fire reclamation
Forestry	Timber and vegetation harvesting Access roads Interim and final reclamation
Transportation	Highways, roads, and parkways Railroads (coal transport) Hazardous material releases Airport construction/expansion
Remediation	Abandoned mine lands Hazardous material sites

TABLE 6.5-2 General Trends in the Six-State Study Area

General Trend	Associated Activities
Population growth	Agricultural, residential, commercial, and industrial property development adjacent to federal land Urbanization Roads and traffic Land use modification Employment Resource use (e.g., water) Tax revenue
Energy demand	Resource use Energy development Energy transmission and distribution
Water demand	Resource use
Climate change	Water cycle changes Wildland fires Habitat changes

6.5.1.1 Energy Production and Distribution

6.5.1.1.1 Oil and Gas Production

Oil and gas provide 62% of the energy supply in the United States and almost all of its transportation fuels (EIA 2010a). In 2009 about 16% of domestic oil and in 2008 about 17% of domestic natural gas were produced in the six-state study area (EIA 2010b,c).

Table 6.5-4 compares oil production between 2000 and 2009 and gas production between 2000 and 2008 in the study area. During this period, overall production of oil in the study area decreased by about 14% (although it increased significantly in Colorado and Utah); overall gas production increased by about 9%. The Energy Information Administration (EIA) projects that the reliance on fossil fuels will decline in the coming decades and that fossil fuels (oil, gas, and coal) will provide a 78% share of the total U.S. primary energy supply in 2035 (compared to 84% in 2008) (EIA 2010a). Future actions will focus on the development of new recovery techniques to enhance oil and gas recovery in the field.

Onshore oil and gas production on federal lands make up about 5% and 11%, respectively, of domestic production. In fiscal year (FY) 2009, sales of oil and gas from BLM-administered lands in the six-state study area accounted for about half of the total oil and gas sales volume from federal lands. In that year, 53,114 oil and gas wells operated on more than 10,000 leases (Table 6.5-5). Across the United States, federal leases with at least one producing well increased from 19,036 in FY 1992 to 22,599 in FY 2009, while the number of producing wells increased from 52,926 to 85,330 (BLM 2010c).

TABLE 6.5-3 Programmatic-Level Actions on Federal Land

Description	Responsible Agency	Status	Primary Impact Location
Oil shale and tar sands development	BLM	Notice of Availability of final PEIS published September 5, 2008, and Record of Decision published Nov. 19, 2008	Colorado, Utah, and Wyoming
Wind energy development	BLM	Notice of Availability of Record of Decision published Jan. 11, 2006	Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming
West-wide energy corridors	DOE, BLM, FS	Notice of Availability of final PEIS published Nov. 28, 2008, and Record of Decision published Jan. 14, 2009	Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming
Vegetation management	BLM	Notice of Availability of Record of Decision published Oct. 5, 2007	Alaska, Arizona, California, Colorado, Idaho, Montana, Nebraska, New Mexico, Nevada, North Dakota, South Dakota, Oklahoma, Oregon, Texas, Utah, Washington, and Wyoming
Geothermal energy development	BLM, FS	Notice of Availability of final PEIS published Oct. 24, 2008, and Record of Decision published Dec. 17, 2008	Alaska, Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, Washington, and Wyoming

A recent interagency study of the oil and gas resources on federal lands focused on 11 geologic provinces across the United States, 7 of which are located in the western United States: the Montana Thrust Belt, Powder River Basin, Wyoming Thrust Belt, Greater Green River Basin, Denver Basin, Uinta-Piceance Basin, and Paradox/San Juan Basin (DOI 2006). The study found that approximately 22,814,000 acres (92,324 km^2) of the federal land in these basins is available for oil and gas leasing with standard stipulations. Based on resource estimates, these lands contain 737 million barrels (117 billion L) of oil and 24.733 trillion ft^3 (0.7015 trillion m^3) of natural gas. Approximately 17,283,000 acres (66,941 km^2) of the federal land is available for leasing with restrictions beyond standard stipulations. Based on resource estimates, these lands contain 2,760 million barrels (438.8 billion L) of oil and 76.983 trillion ft^3 (2.180 trillion m^3) of natural gas. The potential for the future expansion in oil and gas exploration, development, and production on federal lands is high.

TABLE 6.5-4 Trends in Oil and Gas Production in the Six-State Study Area

State	Oil Production (tbbl)[a] 2000	Oil Production (tbbl)[a] 2009	Oil Production (tbbl)[a] Percentage Change	Gas Production (mcf)[b] 2000	Gas Production (mcf)[b] 2008	Gas Production (mcf)[b] Percentage Change
Arizona	59	46	–22.0	368	523	42.1
California	271,132	207,094	–23.6	418,865	296,469	–29.2
Colorado	18,481	28,324	53.3	760,213	1,389,399	82.8
Nevada	621	455	–26.7	7	4	–42.9
New Mexico	67,198	61,146	–9.0	1,820,516	1,446,204	–20.6
Utah	15,636	22,927	46.6	281,117	433,566	54.2
Total	373,127	319,992	−14.2	3,281,086	3,566,165	8.7

[a] tbbl = thousand barrels. To convert bbl to L, multiply by 159.

[b] mcf = million cubic feet. To convert cf to m^3, multiply by 0.02832.

Sources: EIA (2001, 2010b,c).

TABLE 6.5-5 Oil and Gas Activities on Public Lands of the United States in FY 2009

State	Producible and Service Holes	Producible Leases	Acres[a] in Producing Status	Oil Sales Volume (bbl)[b]	Gas Sales Volume (mcf)[c]
Arizona	2	0	0	–[d]	–
California	7,281	317	78,826	19,606,220	4,623,593
Colorado	5,543	2,266	1,522,230	4,087,627	269,878,099
Nevada	121	29	14,998	430,586	15,509
New Mexico	33,523	6,554	4,347,437	26,939,311	780,102,883
Utah	6,644	1,427	1,092,640	11,240,070	285,857,559
Total	53,114	10,593	7,056,041	62,303,814	1,340,477,643

[a] To convert acres to km^2, multiply by 0.004047.

[b] bbl = barrels. To convert bbl to L, multiply by 159.

[c] mcf = million cubic feet. To convert cf to m^3, multiply by 0.02832.

[d] A dash indicates no activity.

Source: BLM (2010c).

Oil shale is a sedimentary rock that releases petroleum-like liquid when heated. The mining and processing of oil shale is more complex and expensive than conventional oil recovery; however, increasing oil prices and advances in technology are making it a more feasible energy option. It is estimated that about 72% of the U.S. acreage containing oil shale deposits occurs under federal land in the Green River Formation, a geologic unit that underlies portions of Colorado, Utah, and Wyoming. The oil shale in the Green River Formation has the potential to yield as much as 800 billion barrels (127 trillion L) of oil (BLM 2008a). While there are currently no federal oil shale leases for commercial development, the likelihood of future leases is high. The BLM has prepared a PEIS for oil shale leasing in these three states (BLM 2008b).

Tar sand deposits are another oil-yielding resource under western federal land, primarily in eastern Utah. These deposits are a combination of clay, sand, water, and bitumen that can be mined and processed to produce oil. It is estimated that these deposits could yield as much as 76 billion barrels (12 trillion L) of oil (BLM 2005). While there are currently no federal tar sand leases, the likelihood of future leases is high. The BLM has prepared a PEIS for tar sands leasing (together with oil shale leasing) in Colorado, Utah, and Wyoming (BLM 2008b).

6.5.1.1.2 Coal Production

The electric power sector is the largest consumer of coal, and coal accounts for about half of the electricity generation in the United States (EIA 2010d). Coal production in the West reached a record level in 2008, with a total of 678.5 million short tons (615.5 million MT) being produced in the western states, about half of the total U.S. coal production (1,170.4 million short tons [1,061.8 million MT]) in 2008 (EIA 2010d). Table 6.5-6 compares coal production between 2002 and 2008 in the four producing states within the six-state study area. During this period, overall production decreased in these states by almost 12% (after peaking in 2005). Although coal production is declining in the study area states, the EIA (2010d) projects continued growth

TABLE 6.5-6 Coal Production in the Producing States within the Six-State Study Area in 2002 and 2008[a]

State	2002 (thousand short tons)	2008 (thousand short tons)	Percentage Change from 2002 to 2008
Arizona	12,804	8,025	−37.3
Colorado	35,103	32,028	−8.8
New Mexico	28,916	25,645	−11.3
Utah	25,304	24,365	−3.7
Total	102,127	90,063	−11.8

[a] To convert short tons to metric tons (MT), multiply by 0.9072.

Sources: EIA (2003, 2010d).

in the West through 2030, although most of the growth is attributed to increased output of surface mines in the Powder River Basin in Wyoming outside the six-state study area. Demand for low-sulfur western coal isexpected to increase because of its environmental benefits relative to other coal sources (National Energy Development Policy Group 2001).

6.5.1.1.3 Nuclear Electricity Generation

Nuclear reactors generating electricity are operating in only two of the six states in the study area (see http://www.nrc.gov/reactors/operating.html): Arizona and California. In Arizona, the Palo Verde Nuclear Generating Station, which is located approximately 36 mi (58 km) west of Phoenix, has three operating reactors, generating approximately 3,870 megawatts of electricity (MWe). In California there are two operating nuclear reactors at the Diablo Canyon Power Plant, about 12 mi (19 km) west-southwest of San Luis Obispo and two reactors at the San Onofre Nuclear Generating Station 4 mi (6.4 km) southeast of San Clemente. The total generating capacity of the Diablo Canyon reactors is 2,240 MWe; the combined rated capacity of the San Onofre reactors is 2,150 MWe (NRC 1996).

6.5.1.1.4 Renewable Energy Development

Solar Energy. In 2008, solar energy accounted for about 1% of renewable electricity generation and about 0.097% of the total U.S. electricity supply (EIA 2010e). As discussed in Section 1.3.3, as of February 2010, there were 127 active applications pending for utility-scale solar power–generating facilities on BLM-administered public lands, with a total estimated capacity of approximately 74,000 MW (see Appendix B). However, it is not expected that all active applications will result in ROW authorizations; applications are often terminated either because the developer decides to drop the project or because the BLM determines that the application is not viable. The RFDS assumed for this PEIS estimates that solar development on BLM-administered lands over the 20-year study period will be about one-third of that represented by the active BLM applications, or 24,000 MW. An additional 8,000 MW is projected to be developed on non-BLM lands in the study area.

Manufacturing of components for utility-scale solar facilities occurs in all states in the study area; these facilities are generally located in larger urban areas (Momentum Technologies 2010).

Wind Energy. In 2008, wind energy accounted for about 5% of the renewable electricity generation and 0.34% of the total U.S. electrical supply (EIA 2010e). In 2009, the total wind generation capacity in the United States was 35,086 MW and provided 1.9% of the national energy demand; this represented a 39% increase in installed wind capacity (IEA 2010). The BLM manages 20.6 million acres (83,368 km^2) of public lands with wind potential and has authorized a total of 192 ROWs for the use of public lands for wind energy. Of these, 27 authorizations have a total installed capacity of 437 MW on land in western states.

Geothermal Energy. Geothermal energy resources are the steam and hot water generated by heat from within the earth. In 2008, they accounted for about 5% of the renewable electricity generation and 0.36% of the total U.S. electricity supply (EIA 2010e). Approximately 530 million acres (2.4 million km^2) in 12 western states have geothermal resources with potential for generation of electricity or for heating applications; about 47% of this is on federal lands (BLM and USFS 2008). Nevada is currently the highest-producing state (Table 6.5-7). The number of geothermal energy leases in the study area issued by BLM doubled between FY 2002 and FY 2009, with the greatest increase occurring in Nevada. The total number of acres used for geothermal development tripled during this period.

Hydroelectric Power. In 2008, hydroelectric power generation accounted for about 2.5% of the total U.S. electricity supply (EIA 2010e). California depends heavily on this resource. Since the areas best suited for this technology have already been developed, it is likely that future development of this technology will be relatively low.

The U.S. Army Corps of Engineers (USACE) maintains a database of dams in the United States, called the National Inventory of Dams (NID). The NID is a searchable database of about 79,000 U.S. dams. The Website also provides links to state Web sites containing information on dams and hydroelectric projects. It can be accessed at http://crunch.tec.army.mil/.

TABLE 6.5-7 Competitive and Noncompetitive Geothermal Leases on BLM Public Lands in FY 2002 and FY 2009

			FY 2009			
	FY 2002		Competitive[d]		Noncompetitive	
State	Acres[a,b]	Leases[c]	Acres	Leases	Acres	Leases
Arizona	0	0	0	0	2,084	1
California	100,766	72	78,693	58	11,399	13
Nevada	236,601	171	530,425	206	342,917	231
New Mexico	4,581[c]	4[e]	2,941	3	0	0
Utah	6,906	8	96,360	38	1,761	1
Total	348,854	255	708,419	305	358,161	246

[a] Number represents acreage for both competitive and noncompetitive leases.

[b] To convert acres to km^2, multiply by 0.004047.

[c] Number represents total for both competitive and noncompetitive leases.

[d] Includes both Energy Policy Act of 2005 leases and pre-act leases.

[e] There were only competitive geothermal leases in New Mexico.

Sources: BLM (2003, 2010d).

Biomass Resources. In 2008, biomass resources accounted for about 52% of renewable electricity generation and about 3.9% of the total U.S. electricity supply (EIA 2010e). It is estimated that restoration activities on as many as 12 million acres (48,562 km^2) of federal land administered by the BLM would remove biomass that could be used as an energy source.

Mandatory State Renewable Portfolio Standards. Five of the six states in the study area have set mandatory standards, known as Renewable Portfolio Standards (RPSs), that require electric utilities to generate a specified amount of electricity from renewable sources (e.g., solar, wind, geothermal, or biomass) by a given date; Utah has set a voluntary RPS. States cite various reasons for mandating the increased use of renewable energy. These generally include greenhouse gas (GHG) reduction, as well as the benefits of job creation, energy security, and cleaner air (Pew Center on Global Climate Change 2010).

Some states allow utilities to comply with the RPS through tradable renewable energy credits. The standards differ in the portions of renewable energy required (from 15% by 2025 in Arizona to 33% by 2020 in California) (North Carolina Solar Center and Interstate Renewable Energy Council 2010). In Nevada and New Mexico the RPSs include a solar set-aside, requiring that 5% and 20%, respectively, of the utilities' portfolios be provided from solar energy. The state RPS requirements are discussed in greater detail in Appendix D.

6.5.1.1.5 Transmission and Distribution Systems

About 90% of the oil and gas pipeline and electricity transmission ROWs in the western United States cross public lands (National Energy Policy Development Group 2001). In FY 2009, the BLM had a total of 62,905 existing ROWs for oil and gas pipelines and electricity transmission lines in the six-state study area (BLM 2010d). This represents a 19.3% increase over the number of ROWs (52,724) in existence in FY 2002.The largest increase in ROWs issued between FY 2002 and FY 2009 occurred in California (up 26.9%), Utah (up 23.9%), and New Mexico (up 21.6%) (Table 6.5-8). BLM processed 2,135 ROW applications and issued or amended 1,834 ROWs in FY 2009 (BLM 2010d).

The National Energy Policy Development Group (2001) projects that the demand for additional energy and electricity will increase the number of ROWs across public lands in the years to come. Other federal agencies authorized to issue ROWs for electric, oil, and gas transmission include the U.S. Forest Service (USFS), the National Park Service (NPS) (electric only), the U.S. Fish and Wildlife Service (USFWS), the U.S. Bureau of Reclamation (BOR), and the Bureau of Indian Affairs (BIA).

Transmission Line Projects

Numerous energy projects in the western states are proposing to build inter- and intrastate transmission lines. Some projects emphasize the need to transmit energy from renewable

TABLE 6.5-8 Number of Existing Oil and Gas Pipeline and Transmission Line ROWs on BLM Public Lands in FY 2002 and FY 2009

State	Total ROWs in FY 2002	Total ROWs in FY 2009			Percentage Increase from FY 2002 to FY 2009
		MLA[a]	FLPMA[b]	Total	
Arizona	4,503	285	4,429	4,714	4.7
California	5,700	268	6,966	7,234	22.2
Colorado	5,836	1,361	5,308	6,669	14.3
Nevada	7,062	167	7,995	8,162	15.6
New Mexico	24,809	20,604	9,556	30,160	21.6
Utah	4,814	1,193	4,773	5,966	23.9
Total	52,724	23,878	39,027	62,905	18.8

[a] MLA = Mineral Leasing Act of 1920.

[b] FLPMA = Federal Land Policy and Management Act of 1976.

Sources: BLM (2003, 2010d).

sources; others are intended to improve system reliability and meet the growing demand for electricity in a given region. The following sections describe planned transmission line projects and related studies in the Southwest (including states in the study area).

TEPPC's Synchronized Study Plan. The Transmission Expansion Planning Policy Committee (TEPPC) of the Western Electricity Coordinating Council developed its Synchronized Study Plan (TEPPC 2008) to evaluate transmission expansion needs within the Western Interconnection and addresses potential reliability and congestion issues associated with energy transmission. The TEPPC provides support for the long-term regional planning of the transmission system in the West. The planning process includes a sequence of steps that take a transmission project from inception to operation: investigation of expansion needs; project formation to respond to needs; technical ratings studies for specific proposals; and licensing and construction. Transmission projects, including the expansion projects listed in the TEPPC study, are listed in Table 6.5-9. These cases will be evaluated by TEPPC to determine their effectiveness in reducing congestion costs to system users.

Western Renewable Energy Zones. The Western Governors' Association (WGA) and the DOE have launched the Western Renewable Energy Zone (WREZ) initiative. The initiative is intended to facilitate the construction of utility-scale renewable energy facilities and expansion of the electricity transmission system needed to develop and deliver energy from renewable resources areas within the Western Interconnection to load centers. Participants include several western states as well as two Canadian provinces and areas in Mexico that are part of the Western Interconnection. The work is being conducted in four phases, the first of which was documented in the June 2009 Phase 1 Report (WGA and DOE 2009). The WREZ initiative is described in detail in Appendix D, Section D.1.1.

TABLE 6.5-9 Planned Transmission Projects, Including Expansions, in the Six-State Study Area

Project Name	Description	Applicant/Sponsor	Planned In-service Date	Comments
Northern Lights Montana–Las Vegas HVDC Line	500-kV HVDC from Montana to Las Vegas, Nevada, following the SWIP corridor from Borah, Idaho	TransCanada		2008 TEPPC study requested
Northern Lights Wyoming–Las Vegas HVDC Line	500-kV HVDC from Wyoming to Las Vegas, Nevada, following the Southwest Intertie Project (SWIP) corridor from Borah, Idaho	TransCanada		2008 TEPPC study requested
TransWest Express Project	±600-kV HVDC from Powder River Basin, Wyoming, through Utah to Las Vegas, Nevada	National Grid, Arizona Public Service (APS), PacifiCorp, Western Area Power Administration (Western), and Wyoming Infrastructure Authority (WIA)	2015	Initial feasibility studies completed. 2008 TEPPC study requested.
Zephyr Project (formerly Northern Lights Inland Project)	New 500-kV DC line from Medicine Bow area in Wyoming, through Midpoint, Idaho, southward down the eastern side of Nevada to the Las Vegas area	TransCanada	2015	Preliminary application filed with BLM
Southwest Intertie Project (SWIP)	New 500-kV line from Twin Falls, Idaho, to Las Vegas, Nevada	LS Power, NV Energy		ROW approved in 1998. EA August 2007
Gateway South Segment #1	500-kV AC from Mona, Utah, to Crystal, Nevada	PacificCorp, National Grid, APS, and WIA	2014	Initial feasibility studies completed. 2008 TEPPC study requested.

TABLE 6.5-9 (Cont.)

Project Name	Description	Applicant/Sponsor	Planned In-service Date	Comments
Gateway South Segment #2	500-kV AC double circuit from Aeolus, Wyoming, to Mona, Utah	PacifiCorp, National Grid, APS, and WIA	2014	Initial feasibility studies completed. TEPCC study requested.
Wyoming - Colorado Intertie Project	345-kV line connecting northeastern Wyoming to the Denver, Colorado, area	Trans-Elect, Inc., Western, WIA	2014	Phase II status (WECC path rating process), TOT 3 (Western Electricity Coordinating Council Path 36) rating increase to 900 kV in 2007.
Populus –Terminal Project	345-kV double circuit from new substation in Idaho looping in various lines with connections at terminal substations in Utah	PacifiCorp	2010	2008 TEPPC study requested.
Midpoint – White Pine Project (SWIP North)	500-kV line from Midpoint, Idaho, to White Pine, Nevada	LS Power and Great Basin Transmission LLC	2011	2008 TEPPC study requested.
Wyoming–Colorado Intertie Project	345-kV line from northeastern Wyoming to Denver, Colorado, area (Pawnee)	TransElect, WIA, and Western	2012	
Power River – Denver Project		North American Power Group	2003	

TABLE 6.5-9 (Cont.)

Project Name	Description	Applicant/Sponsor	Planned In-service Date	Comments
High Plains Express	High-voltage backbone transmission path from Wyoming, across eastern Colorado and New Mexico to connect with facilities in Arizona	Colorado Springs Utilities, Platte River Power Authority, Public Service Company of New Mexico, Salt River Project (SRP), TransElect, Tri-State Generation & Transmission Association (TSG&T), Western, Xcel Energy, WIA, New Mexico Renewable Transmission Authority, Colorado Clean Energy Authority	2018	Feasibility study completed; ROW and permitting scheduled for 2009.
Eastern Plains Project	500-kV line running south to north in the eastern plains region of Colorado	TSG&T and Xcel	2012–2013	
Devers–Palo Verde Project No. 2	Single-circuit, 500-kV line following the route of Devers-Palo Verde #1, from Devers, Calif., west to Colorado River Substation (midpoint) west of the City of Blythe, Calif. and from Devers to Valley substations in Calif., along the existing Devers-Valley #1 right of way	Southern California Edison (SCE)	2013	Pending ROD. The Arizona portion of the project was canceled.
SunZia Project	Addition to Path 47 to provide 1,200 MW+ non-simultaneous capacity from southern New Mexico to southern Arizona	Southwestern Power Group II, LLC	2011	Scoping to begin in early 2009

TABLE 6.5-9 (Cont.)

Project Name	Description	Applicant/Sponsor	Planned In-service Date	Comments
Sonora–Arizona Interconnection Project	500-kV line from Palo Verde, Arizona, to Santa Ana, Mexico; other sources report two 345-kV circuits, approximately 300 mi[a] long	Public Service Company of New Mexico (PNM)	2004	
Palo Verde – Yuma West Project	500-kV line	NRG	2002	
Canada–Northern California Transmission Project, Phase 1	500-kV line from British Columbia to Round Butte/Grizzly, Oregon, and ±500-kV HVDC from Round Butte/Grizzly, Oregon, to Tesla/Tracy, California	Pacific Gas & Electric (PG&E)	2015	
Interconnection to California–Northern California Transmission Project	500/230-kV transformer at Devils Gap Substation in Spokane, Washington ,area and possible phase shifters	Avista Corp.	2015	
Central California Clean Energy Transmission Project	500-kV double circuit from Midway to Fresno, California	PG&E		
Lake Elsinore Advance Pumped Storage Project and Interconnection	500-kV line Talega Escondido /Valley Serrano, California	Nevada Hydro Company, Inc., and the Lake Elsinore Valley Municipal Water District	2012	
San Francisco Bay Area Bulk Transmission Reinforcement Project	500/230-kV substation and 500-kV and 230-kV lines with configuration changes	PG&E		

TABLE 6.5-9 (Cont.)

Project Name	Description	Applicant/Sponsor	Planned In-service Date	Comments
Southern Navajo Path 51	Increase rating to 3,200 MW (upgrade of four existing series capacitors)	APS	2010	
TOT 3 (Western Electricity Coordinating Council Path 36) Upgrade Project (Miracle Mile)	230-kV line	Western	2019	WECC Phase II status
Navajo Transmission Project–Segment 1	500-kV line from Four Corners, New Mexico, to a point south of Navajo, Arizona, on Navajo–Moenkopi line and 500-kV line from Moenkopi to Mead/Marketplace area, Nevada	Dine Power Authority	2010	Pending ROD; access across Indian reservation is on hold.
Sigurd to Red Butte to Crystal (Segment G) Project (part of the Gateway South Project, running from Wyoming to the desert Southwest)	345-kV line from Sigurd to Red Butte in southwest Utah and from Red Butte to the existing substation at Crystal	Rocky Mountain Power		Scoping meetings were held in October 2009. Draft EIS pending.
Ely Energy Center Project (SWIP South)	500-kV Robinson Summit–Harry Allen Project in Las Vegas area	Sierra Pacific Resources	2011	

TABLE 6.5-9 (Cont.)

Project Name	Description	Applicant/Sponsor	Planned In-service Date	Comments
Sunrise Powerlink Project	New line about 123 miles from the Imperial Valley Substation in Imperial County to the western part of San Diego County (in Imperial County the line is a 500-kV line extending to a new Suncrest Substation south of I-8; from there, the line proceeds as a 230-kV line to the Sycamore Canyon Substation on Marine Corps Air Station Miramar.	San Diego Gas & Electric (SDG&E)	2012	
Path 27 Upgrade	Intermountain DC line (Utah)	Los Angeles Department of Water & Power	2009	
Indian Hills–Upland Project	500-kV line	Los Angeles Department of Water & Power; Imperial Irrigation District	2010	

[a] To convert mi to km, multiply by 1.609.

Sources: APS et al. (2007); TEPPC (2008).

The WREZ Phase 1 Report identified and mapped the preliminary WREZs and described the criteria and methodology used to define these areas. The multistep process presented in the Phase 1 report included identifying Qualified Resource Areas (QRAs), which are defined as areas with sufficient potential generation capacity to justify the construction of new regional transmission, while excluding lands on the basis of statutory or regulatory limitations and existing conflicts. (The QRAs identified in the Phase 1 Report will be further analyzed in the next phase of work and, ultimately, may be designated as WREZs.) The locations of WREZs with respect to BLM-administered lands being analyzed in this PEIS are shown in Figures D-2 through D-7.

Next steps for undertaking the WREZ initiative include further study of the QRAs, such as the addition of wildlife considerations, in order to define the WREZs. Additionally, work will be done to identify local transmission corridors, coordinate energy purchasing from the WREZs,

and foster interstate cooperation for renewable energy generation and transmission (see Appendix D).

Natural Gas Pipeline Projects

Currently 10 interstate and 9 intrastate natural gas pipeline companies provide transportation services within the Western Region (Arizona, California, Idaho, Nevada, Oregon, and Washington), the fewest number serving any region. A little more than half of the capacity entering the region is on pipeline systems carrying natural gas from the Rocky Mountain area and the Permian and San Juan Basins. These systems enter the region at the New Mexico–Arizona and Nevada–Utah state lines; the remaining capacity arrives on natural gas pipelines that access Canadian natural gas at the Idaho and Washington state borders with British Columbia, Canada (EIA 2010f). The following sections describe several planned expansion projections on the interstate natural gas pipeline system in the Western Region.

- *Rockies Express-West Pipeline.* In April 2007, the Federal Energy Regulatory Commission (FERC) approved approved the Rockies Express-West interstate pipeline project to transport more than 1.5 billion ft^3 (42.5 million m^3) per day of Rocky Mountain natural gas to supply states east of the Rockies. Two related components, proposed by TransColorado Gas Transmission Co. and Questar Overthrust Pipeline Co., were also approved. Together, these projects will consist of approximately 800 mi (1,287 km) of new pipeline and more than 237,000 horsepower (hp) of compression, meter stations, and other related facilities. The pipeline system will span portions of Colorado, Wyoming, Nebraska, Kansas, Missouri, and New Mexico (FERC 2008).

- *Bronco Pipeline Project.* The Bronco Pipeline Project is a natural gas pipeline system being proposed by Spectra Energy to connect natural gas supplies in the Rocky Mountains to underserved markets in the Western Region. The pipeline system will be more than 650 mi (1,046 km) long and will have an initial capacity of more than 1 billion ft^3 (28,326,847 m^3) per day. The system will include three compressor stations (for 64,000 hp in total). The pipeline will access supply basins in Wyoming, Utah, and Colorado and will stretch westward toward its terminus in Malin, Oregon, interconnecting with several pipelines on the way. The project is planned to be in service as early as 2011 (Spectra Energy 2008).

- *2010 Gas Expansion Project.* The Kern River Gas Transmission Company is constructing the 2010 Expansion Project to increase the amount of natural gas transported on its system by approximately 145 million ft^3 (4,105,943 m^3) per day. The Kern River system stretches from Wyoming, through Utah, Nevada, and California, providing take-away capacity for the developing natural gas supplies in the producing areas of the Rocky Mountains. The Kern River system has a design capacity of 1.9 billion ft^3 (53,802,000 m^3) per day. The

project was placed in service in April 2010 (Kern River Gas Transmission Company 2010).

- *White River Lateral Expansion.* The White River Lateral Expansion, constructed by the Questar Overthrust Pipeline Company, would consist of a 140-mi (225-km) natural gas pipeline with a capacity of 810 million ft^3 (22,936,646 m^3) per day. The pipeline would extent from the White River Hub in the Piceance Basin to Wamsutter, Wyoming. The in-service date is January 1, 2011, with an in-service date for partial volumes on January 1, 2010 (Questar Overthrust Pipeline Company 2008).

- *Magnum Gas Storage Project.* Magnum Gas Storage, LLC proposes to construct the Magnum Gas Storage Project, a project including four new natural gas storage salt caverns, a 62-mi (100-km) header pipeline, a 9-mi (14.5-km) local pipeline, and associated facilities in Millard, Juab, and Utah Counties, Utah. The pipeline will be capable of transporting as much as 1.2 billion ft^3 (34 million m^3) of natural gas per day. The first cavern is expected to be available for natural gas storage beginning in early 2012 (Magnum Gas Storage, LLC 2010).

- *Sunstone Pipeline Project.* Williams and TransCanada Corporation are proposing to build the Sunstone Pipeline between the Opal Hub in Wyoming and Stanfield, Oregon. The 602-mi (969 km), 42-in. (107-cm) diameter pipeline would have a capacity of up to 1.2 billion ft^3 (33,980,216 m^3) per day. The pipeline would deliver gas to markets in the northwest. The project is temporarily on hold (Williams Northwest Pipeline 2010).

6.5.1.2 Other Activities and Trends

6.5.1.2.1 Other Activities

Recreation

Table 6.5-10 lists the number of recreation visits for the BLM, USFS, and NPS in the six-state study area in FY 2000 and FY 2005. By far, the USFS experienced the greatest number of visits (more than 90 million). Visits to BLM lands in the study area increased by 3.9 million (about 12%), with the greatest increases occurring in Colorado and Nevada. Visits to USFS sites decreased by about 4.4 million (about 6%) in the three states for which data were available (Arizona, California, and Colorado). Visits to NPS sites decreased by 3.9 million (about 6%) between FY 2000 and FY 2005. The greatest declines occurred in Nevada and Utah.

The fastest growing outdoor recreation activities through 2050 (as measured by the number of participants) are projected to be cross-country skiing (95% growth); downhill skiing

TABLE 6.5-10 Recreation Visits for the BLM, USFS, and NPS in FY 2000 and FY 2005

	Visits to BLM Lands			Visits to FS Lands			Visits to NPS Lands[a]		
State	FY 2000	FY 2005	Percentage Change	FY 2000	FY 2005	Percentage Change	FY 2000	FY 2005	Percentage Change
Arizona	4,997,000	5,557,000	11.2	13,859,000	14,309,000	3.2	11,525,818	10,799,429	–6.3
California	8,400,000	9,604,000	14.3	32,403,000	29,786,000	–8.1	34,410,505	33,400,604	–2.9
Colorado	4,756,000	5,746,000	20.8	27,948,000	25,728,000	–7.9	5,807,033	5,352,839	–7.8
Nevada	5,045,000	6,183,000	22.6	–[b]	7,188,000	–[b]	6,647,299	5,847,070	–12.0
New Mexico	2,380,000	2,384,000	<1.0	–[b]	2,912,000	–[b]	1,766,079	1,650,441	–6.6
Utah	6,169,000	6,208,000	<1.0	–[b]	10,620,000	–[b]	8,843,646	8,046,646	–9.0
Totals:	31,747,000	35,682,000	12.4	–[b]	90,543,000	–[b]	69,000,380	65,097,029	–5.7

[a] NPS data are reported for calendar year (January through December).

[b] Data for 2000 not available.

Sources: BLM (2001, 2006); Parker (2007); NPS (2001, 2006).

(93% growth); visiting historic places (76% growth); sightseeing (71% growth); and biking (70% growth). By activity days, increases through 2050 are projected to be in visiting historic places (116% growth); downhill skiing (110% growth); snowmobiling (99% growth); sightseeing (98% growth); and non-consumptive wildlife activity (97% growth) (Bowker et al. 1999). Public lands offer opportunities for these activities; for example, most downhill skiing capacity is located in the western states, especially on national forest lands (Cordell et al. 1990). Therefore, the potential for increased tourism and recreational use of public lands over the next 20 years is considered high.

Minerals Production

Economic production of mineral resources on BLM-administered land includes locatable, leasable, and salable solid minerals. Locatable minerals, defined under the General Mining Law of 1972, can be obtained by locating a mining claim; they include both metallic and nonmetallic materials. Locatable minerals mined on BLM land include, but are not limited to, gold, silver, and lead. By the end of FY 2009, there were 282,118 active mining claims in the six-state study area on file with the BLM, with the highest number (176,958) in Nevada (BLM 2010d). This represents a 52% increase from FY 2002, in which 145,676 mining claims (88,124 in Nevada) were on file (BLM 2003).

Leasable minerals are subject to the Mining Leasing Act of 1920 and include energy and nonenergy resources; leases to these resources are obtained through a competitive bidding process. Leasable minerals mined on BLM land include, but are not limited to, sodium, potassium, phosphate, and gilsonite. The number of leases and associated acres for sodium, potassium, phosphate, and gilsonite on BLM-administered land in FY 2002 and FY 2009 are shown in Table 6.5-11. The number of leases and associated acres for sodium mining has decreased since FY 2002; potassium, phosphate, and gilsonite leases have remained relatively steady (gilsonite is a natural, resinous hydrocarbon that is similar to a hard petroleum asphalt).

Salable minerals include basic natural resources such as sand and gravel that the BLM sells to the public at fair market value. Other salable materials include soil, stone, clay, and pumice. In FY 2009 in the six-state study area, about 8.4 million yd^3 (6.4 million m^3) of mineral materials was disposed of through exclusive and nonexclusive sales and free use permits, representing a decrease of about 3 million yd^3 (2.3 million m^3) (27%) from FY 2002 (BLM 2003, 2010d).

Military Operations

The U.S. Department of Defense (DoD) currently owns and manages 229 installations occupying over 19.1 million acres (77,500 km^2) in the six-state study area, with the greatest acreages in New Mexico, California, and Nevada (DoD 2008). Table 6.5-12 shows a breakdown in the number and acreages of installations by military service. Implementation of the 2005 Base Realignment and Closure Program will result in the closure of 9 sites and realignment at an additional 44 sites.

TABLE 6.5-11 Solid Mineral Leases on BLM Public Lands in FY 2002 and FY 2009

Leasable Mineral Resource	Number of Leases		Acres[a]	
	FY 2002	FY 2009	FY 2002	FY 2009
Sodium				
Arizona	1	1	4	4
California	31	13	25,567	21,266
Colorado	8	8	16,674	16,675
New Mexico	4	3	2,000	1,560
Total	44	25	44,245	39,505
Potassium				
California	8	6	10,286	10,286
Nevada	0	1	0	2,320
New Mexico	111	117	134,396	143,833
Utah	18	18	34,612	34,612
Total	137	142	179,294	191,051
Phosphate				
Utah	7	7	13,028	13,029
Gilsonite				
Utah	13	14	3,640	3,680

[a] To convert acres to km^2, multiply by 0.004047.

Sources: BLM (2003, 2010d).

Grazing and Rangeland Management

In FY 2002, grazing land accounted for about 63% of the land area in the six-state study area. Grazing takes place on lands the Economic Research Service (ERS) categorizes as cropland pasture, grassland pasture and range, and forest land-grazed (Table 6.5-13). Cropland pasture is the smallest, but generally the most productive component of grazing acreage, accounting for only about 1% of the land area in the study area. Grassland pasture and range occupies almost half (48%) of the land area. Grazing is also high on forest land in the study area, accounting for about 14% of land area. New Mexico, Nevada, and Arizona have the greatest percentage of grazing land. Almost all BLM lands, as well as the majority of the acreage of the USFS, are available for grazing by private livestock ranchers.

The total grazing land in the United States has declined by about 25% since 1945, mainly because of changes in land use to recreational, wildlife, and environmental uses (with some acres converted to urban uses). Other reasons cited by Lubowski et al. (2006) include fewer farms and less land in farms, increases in forest stand density (making grazing more difficult), and changes in livestock feeding practices.

TABLE 6.5-12 Number and Acreage of DoD Facilities by Military Service in the Six-State Study Area in FY 2007

	Military Service									
	Army		Navy		Air Force		Marine Corps		Total	
State	No.[a]	Acres[b]	No.	Acres	No.	Acres	No.	Acres	No.	Acres
Arizona	6	1,151,498	0	0	9	2,693,262	3	700,419	18	4,552,149
California	28	909,176	76	1,341,389	30	501,768	12	1,282,991	146	4,035,324
Colorado	8	408,265	1	17	10	75,157	0	0	19	483,439
New Mexico	4	4,653,285	1	85	8	198,344	0	0	13	4,851,714
Nevada	2	147,662	7	119,416	8	3,137,291	0	0	17	3,404,369
Utah	10	865,391	1	525	5	947,469	0	0	16	1,813,385
Total	58	8,135,277	86	1,461,432	70	4,867,909	15	1,983,410	229	19,140,380

[a] Numbers represent small, medium, and large installations with plant replacement values greater than zero.

[b] To convert acres to km^2, multiply by 0.004047.

Source: DoD (2008).

TABLE 6.5-13 Grazing Land in the Six-State Study Area, 2002[a]

State	Cropland Pasture (1,000 acres[b])	Grassland Pasture and Range (1,000 acres)	Forest Land Grazed (1,000 acres)	Total Grazing Land (1,000 acres)	Percentage of State Land Area
Arizona	214	40,533	11,709	52,456	72.2
California	1,345	21,729	12,070	35,144	35.1
Colorado	1,835	28,158	10,516	40,509	60.9
Nevada	314	46,448	6,887	53,649	76.4
New Mexico	837	51,676	9,482	61,995	79.7
Utah	602	24,339	9,596	34,537	65.5
Total	5,147	212,883	60,260	278,290	63.2

[a] Includes both federal and nonfederal land.

[b] To convert acres to km^2, multiply by 0.004047.

Source: ERS (2007).

At the beginning of FY 2009, there were 7,235 permits and leases for livestock grazing, with a total of about 6.8 million active animal unit months (AUMs) on BLM-administered land in the six-state study area. Of those, about 4.3 million AUMs (63%) were authorized and in use (BLM 2010d). About 90% of the authorizations were for the grazing of cattle, 9.5% for sheep and goats, and less than 1% for horses and burros. The nonuse AUMs are generally attributed to drought and financial conditions (BLM 2004). Table 6.5-14 shows the number of grazing permits and leases and AUMs by state for BLM-administered rangeland in FY 2002 and FY 2009. The number of permits and leases in FY 2009 was down about 3.4% compared to FY 2002; authorized AUMS were also down relative to FY 2002, by about 6%. An additional 8 million AUMs is authorized by the USFS annually (Schuster and Krebs 2003).

Since 1996, there has been a general downward trend in the number of permits and leases and active use of federal lands for grazing. This trend continues a decades-long trend for public land livestock operators and for the livestock industry as a whole as it consolidates into fewer but larger operations. Studies have shown, however, that federal rangelands administered by the BLM and the USFS will continue to be an important part of the livestock-raising subsector of the agriculture industry (BLM 2004).

Fire Management

Wildland fires on federal lands are managed by the BLM and other federal agencies. BLM's fire management and aviation program has three levels of organization: the national office (leadership and oversight as well as policy, procedures, and budgets); state offices (coordination of policies and interagency activities at the state level); and field offices (on-the-ground fire management and aviation activities). Together these agencies and offices employ a

TABLE 6.5-14 Grazing Permits and Leases and AUMs on BLM Public Lands in FY 2002 and FY 2009

	FY 2002			FY 2009		
State	Permits or Leases	Active AUMs[a]	Authorized AUMs[b]	Permits or Leases	Active AUMs[a]	Authorized AUMs[b]
Arizona	767	676,970	469,833	764	644,585	455,213
California	593	316,971	199,383	529	326,664	201,240
Colorado	1,609	644,603	389,314	1,549	616,359	374,879
Nevada	661	2,221,140	1,295,744	659	2,137,105	1,085,641
New Mexico	2,312	1,872,958	1,463,818	2,279	1,853,015	1,443,567
Utah	1,550	1,236,840	758,984	1,455	1,208,575	736,308
Total:	7,492	6,969,482	4,577,076	7,235	6,786,303	4,296,848

[a] An AUM (animal unit month) is the amount of forage needed by an "animal unit" (i.e., a mature 1,000-lb cow and her calf) for 1 month. The active AUMs reported are the total number that could be authorized on BLM public lands.

[b] For FY 2002, the authorized AUM count is for the period March 2001 through February 2002; for FY 2009, it is for March 2008 through February 2009.

Source: BLM (2003, 2010d).

broad range of activities, including fire suppression, preparedness, predictive measures, fuels management, fire planning, community assistance and protection, prevention and education, and safety. Suppression operations and safety are the core activities for the fire management program.

In FY 2009, 2,090 fires affected 430,299 acres (1,741 km^2) of forest and nonforest federal lands (of which 127,497 acres [516 km^2] were BLM-administered). Of these fires, 67% were attributed to lightning strikes; the remainder were attributed to human factors (BLM 2010d).

Forestry

About 33% of the land in the United States is forest land (749 million acres [3,031,107 km^2]); of this, about one-third (246 million acres [995,531 km^2]) is owned by the Federal Government. The remainder is classified as nonfederal forest land (406 million acres [1,643,030 km^2]) and forest land in parks and other special use areas (98 million acres [396,593 km^2]) (Lubowski et al. 2006). The USFS defines forest land as "land at least 10% stocked by forest trees of any size, including land that formerly had such tree cover and that will be naturally or artificially reforested." Timberland is a class of forest land that is capable of commercial timber production and not removed from timber use by statute or administrative regulation (Alig et al. 2003).

As of 2002, about 17% of U.S. forest land (124 million acres [501,812 km^2]) was located in the six-state study area (Table 6.5-15). Of the six states, California has the greatest forest land acreage (40.2 million acres [162,684 km^2]), followed by Colorado (21.6 million acres [87,412 km^2]) and Arizona (19.4 million acres [78,506 km^2]). About 34% (42.3 million acres [171,183 km^2]) of forest land in the study area is classified as timberland, of which about 27.3 million acres (110,480 km^2) is federally owned. Timberland makes up the highest percentage of forest land in Colorado (54%) and California (44%).

The USDA reports that in recent decades, U.S. timberland acreage has had an upward trend, gaining 19 million acres (76,891 km^2) between 1987 and 1997 and stabilizing at 504 million acres (2,039,634 km^2) between 1997 and 2002. These increases were due in part to reclassification in response to rising prices for forest products (Lubowski et al. 2006). Forecasts of forest land acreage in the West over the next 40 years show a slight decline (about 3% relative to 2002), although total public forest land acreage is not expected to change. The total area of timberland in the West (including public, forest industry, and nonindustrial private land) is also projected to decline by about 3% by 2050 (Alig et al. 2003).

Major timber products include roundwood, lumber (softwood and hardwood), plywood, turpentine, rosin, pulpwood, and paperboard. Production levels for these products rose steadily between 1965 and 1988, then experienced declines until the mid-1990s. Since the mid-1990s, roundwood production has fallen slightly. Lumber production has been increasing but, as of FY 2002, remains below the record levels of the late 1980s. The USDA reported a record in per-capita consumption of lumber in the United States in 2002, which was below the high set in 1999

TABLE 6.5-15 Forest Land in the Six-State Study Area by Major Class, FY 2002

	Total Forest Land (1,000 acres[a])			Timberland (1,000 acres)			Reserved Timberland and Other Forest Land[c] (1,000 acres)
State	Federal	Nonfederal	Total[b]	Federal	Nonfederal	Total[b]	
Arizona	10,192	9,235	19,427	2,438	1,089	3,527	15,901
California	22,371	17,862	40,233	10,130	7,651	17,781	22,451
Colorado	15,075	6,562	21,637	8,020	3,587	11,607	10,030
Nevada	9,608	596	10,204	265	99	363	9,841
New Mexico	9,522	7,159	16,682	2,829	1,530	4,359	12,323
Utah	11,913	3,764	15,676	3,586	1,097	4,683	10,994
Total	78,681	45,178	123,859	27,268	15,053	42,320	81,540

[a] To convert to km^2, multiply by 0.004047.

[b] Distributions may not add to totals due to rounding.

[c] Includes forest land in parks, wildlife areas, and other special use areas.

Source: ERS (2007).

but greater than per-capita consumption levels in the 1960s, 1970s, and early 1980s. About 40% of the lumber consumed was used for housing. Other uses include manufacturing, 13%; nonresidential construction (e.g., railroads), 8%; and shipping (pallets, containers, and dunnage), 11% (Howard 2003).

The potential for continued growth in the wood products markets will follow the trends in new housing construction and residential improvements. Demand by the furniture and fixtures industry, another major market for hardwood lumber, plywood, veneer, and particleboard, is on the decline, falling 11% in 2002, because of continued growth in furniture imports from China (Howard 2003).

Transportation

The Federal Lands Highway Program is administered by the Federal Lands Highway Division of the Federal Highway Administration (FHWA) within the U.S. Department of Transportation. The program provides funding and engineering services for the planning, design, construction, and rehabilitation of forest highway system roads, bridges and tunnels, park roads and parkways, Indian reservation roads, defense access roads, other federal lands roads, and public authority–owned roads serving federal lands (FHWA 2010). A recent Transportation Research Board task force report cites the important relationship between transportation and visitation levels on federal lands. As tourism-related visits (and traffic) rise, access and user demands are exceeding the system's carrying capacity. Current interagency initiatives are focusing on meeting these demands (Eck and Wilson 2000).

Coal is an important commodity transported by rail. Over the past decade, coal's share of rail traffic has increased mainly because of the increased production in the western states of low-sulfur coal, which is transported long distances over rail. The Bureau of Transportation Statistics (BTS 2008a,b) reported a total of 78.9 million tons (71.6 MT) of coal transported (exported) by domestic railroads from Colorado, New Mexico, and Utah in 2005, up from 76.3 million tons (69.2 MT) in 2002. The demand for clean coal (i.e., low-sulfur coal) is expected to increase in the coming decades. This increase in demand could result in capacity shortfalls and delays in transportation, since the current rail system has little excess capacity (National Energy Policy Development Group 2001). Currently, two rail expansion projects have been proposed for the Powder River Basin of Wyoming to meet this increased demand: the Dakota, Minnesota, & Eastern Railroad Powder River Basin Expansion Project and the Burlington Northern and Santa Fe Railway Company's expansion projects (to four tracks).

Remediation

The U.S. Environmental Protection Agency (EPA) uses the National Priorities List (NPL) as an informational tool to identify sites that may present a significant risk to public health and/or the environment. Sites included on the NPL undergo an initial assessment to determine whether further investigation to characterize the nature and extent of the public health and environmental risks associated with the site is necessary, and to determine what response action, if any, may be

warranted. Inclusion of a site on the NPL does not necessarily mean that the EPA will require a response action. The number of sites on the NPL in each of the six western states, as of September 2010, is as follows (numbers in parentheses indicate additional sites that have been deleted from the NPL): Arizona, 9 (3); California, 94 with an additional 2 proposed (12); Colorado, 18 with an additional 2 proposed (3); Nevada, 1 (0); New Mexico, 13 with an additional 1 proposed (4); and Utah, 16 with an additional 3 proposed (4). Additional information on these sites, including site name, description, threats/contaminants, and cleanup status, can be found at http://www.epa.gov/superfund/sites/npl/ (EPA 2010).

As of the end of FY 2009, the BLM reported a total of 3,113 sites on its public lands in the six-state study area that have had releases of hazardous substances and other pollutants, with the greatest number (1,234 sites, or 40%) having occurred in California. Two other states had release sites numbering more than 15% of the total: Arizona (647) and Nevada (602). Of the total sites, 2,398 have been closed and administratively archived with no further action planned. During FY 2009, 450 removal actions and 19 remedial actions were conducted on BLM lands in the study area (BLM 2010d).

6.5.1.2.2 General Trends

Population Trends

The West is the fastest growing region in the United States. Between 1990 and 2000, it grew at a faster rate (19.7%) than the nation as a whole (13.2%). Four states within the six-state study area had population increases greater than 25% in the 10-year period, with Nevada growing by more than 66% (Table 6.5-16). The West is also the most urbanized of the four U.S. regions, with more than 88% of the population living in urban areas in 2000 (Table 6.5-17). In 2000, the percentages of populations living in urban areas in five of the six states in the study area were above the national average of 79%, with the highest being California (at 94.4%) (BLM 2004).

The BLM (2004) also reported an important trend in the relationship between the amount of public land and the population growth in western state counties. In 1994, the ERS classified counties into three groups: metropolitan (22% of counties); nonmetropolitan nonpublic lands (31% of counties); and nonmetropolitan public lands (47% of counties). *Nonmetropolitan public lands* were defined as counties with federal lands occupying more than 30% of the total area. Between 1990 and 2000, counties designated by the ERS as *nonmetropolitan public land* experienced an increase in population of 25%, about 10% higher than the increase for counties designated *nonmetropolitan nonpublic land* and 5% higher than the increase for counties designated *metropolitan* over the same period. This disproportionate rate of population increase is changing the environmental context of public lands throughout the West.

TABLE 6.5-16 Population Change in the Six-State Study Area and the United States from 2000 to 2009

	Population		Percentage Increase
	2000	2009	2000 to 2009
State			
Arizona	5,130,632	6,595,778	28.6
California	33,871,648	36,961,664	9.1
Colorado	4,301,261	5,024,748	16.8
Nevada	1,998,257	2,643,085	32.3
New Mexico	1,819,046	2,009,671	10.5
Utah	2,233,169	2,784,572	24.7
Region			
West	63,197,932	71,568,081	13.2
Northeast	53,594,378	55,283,679	3.2
Midwest	64,392,776	66,636,911	3.5
South	100,236,820	113,317,879	13.1
Total for United States	281,421,906	307,006,330	9.1

Source: U.S. Bureau of the Census (2010).

TABLE 6.5-17 Rural and Urban Populations in the Six-State Study Area and the United States from 1990 to 2000

	1990 (%)		2000 (%)		Urban Increase (%)
	Urban	Rural	Urban	Rural	1990 to 2000
State					
Arizona	87.5	12.5	88.2	11.8	0.7
California	92.6	7.4	94.4	5.6	1.8
Colorado	82.4	17.6	84.5	15.5	2.0
Nevada	88.3	11.7	91.5	8.5	3.2
New Mexico	73.0	27.0	75.0	25.0	2.0
Utah	87.0	13.0	88.2	11.8	1.2
Region					
West	86.3	13.7	88.6	11.4	2.4
Northeast	78.9	21.1	84.4	15.6	5.5
Midwest	71.7	28.3	74.7	25.3	3.0
South	68.6	31.4	72.8	27.2	4.2
Total for United States	75.2	24.8	79.0	21.0	3.8

Source: BLM (2004).

Energy Demand

Energy consumption in the United States is on the rise and projected to increase by 14.4% between 2006 and 2035 (Table 6.5-18). Fossil fuels, including liquid fuels, natural gas, and coal, would account for about 80% of energy consumption in 2035, down from 85% in 2006. The decline in fossil fuel use is attributed to the greater use of renewable energy resources, which is projected to increase to 8.4% in 2030, from 5.7% in 2006 (EIA 2008, 2010a).

In the West, energy consumption is projected to grow at a faster rate (1.1% annually) than in the nation as a whole (0.7% annually). During the period between 2006 and 2030, the energy consumption in these states is projected to increase by 29% (Table 6.5-19). The highest growth areas for energy consumption in the West would be in nonhydroelectric renewables, coal, liquid fuels, and natural gas. Little or no growth is expected in the nuclear and hydroelectric categories. Note that coal consumption in the western states is projected to grow at an annual rate (2.7%) that is more than two times that for the United States (at 1.2%), primarily because of the regional abundance of coal (Section 4.4.1.2) (EIA 2008).

Currently, coal and nonhydroelectric renewables account for more than half of the resources used for electric power generation in the West (Table 6.5-19). The coal share is projected to increase to 44% by 2030. Electricity generation from other fossil fuels and natural gas is expected to decrease over the same period, with natural gas falling off sharply after 2016. The share of nonhydroelectric renewable resources would increase to 34% in 2030 (with an even higher share, 57%, projected for the Pacific Region) (EIA 2008).

Water Availability

In 2005 (the latest year for which annual statistics are available at publication), freshwater and saline water withdrawals in the United States were estimated to be 410,000 million gal/day (460,000 thousand ac-ft/yr), with 80% of the total withdrawals coming from surface water. In the six-state study area, freshwater and saline water withdrawals were estimated to be 76,370 million gal/day (84,740 thousand ac-ft/year), with the highest usage occurring in California and Colorado. Surface water accounted for 73.6% of total water withdrawals in the study area; although about half of the water withdrawals in Arizona and New Mexico were from groundwater sources (Table 6.5-20).

The U.S. Geological Survey (USGS) defines eight categories of water use in the United States: public supply, domestic, irrigation, livestock, aquaculture, industrial, mining, and thermoelectric power. Water withdrawals for these categories for 2000 and 2005 are shown in Table 6.5-21. The greatest water consumption in the states with highest usage (California and Colorado) is in the category of freshwater for irrigation. Consumption of freshwater via the public supply is generally proportional to the state population. The highest per-capita usage in 2005 occurred in Nevada (350 gal [1,325 L] per day) and Utah (238 gal [901 L] per day).

TABLE 6.5-18 Total Energy Consumption, Population, and Carbon Dioxide Emissions for the United States and the Western Region, 2008 to 2030

Energy-Related Parameter	Year 2008	2015	2025	2035	Percentage Change from 2008 to 2035 (annual rate)
United States					
Energy consumption (quadrillion Btu)[a]					
Liquid fuels	38.35	38.81	40.14	42.02	9.6 (0.3)
Natural gas	23.91	22.35	24.24	25.56	6.9 (0.2)
Coal	22.41	22.35	23.63	25.11	12 (0.4)
Nuclear electricity	8.46	8.75	9.29	9.41	11 (0.4)
Renewables [b]	5.70	8.37	9.27	9.63	69 (2.5)
Biofuels heat and coproducts	1.03	0.77	1.49	2.56	148 (5.3)
Net electricity imports	0.11	0.07	0.08	0.09	-18 (-0.5)
Total[c]	100.09	101.61	108.26	114.51	14.4 (0.5)
Population (millions)	305.37	326.70	358.62	390.70	28 (0.9)
CO_2 emissions (million metric tons)	5,814.4	5,730.7	6,015.8	6,320.4	8.7 (0.3)
	2006	2010	2020	2030	Percentage Change from 2006 to 2030 (annual rate)
Western Region[d]					
Energy Consumption (quadrillion Btu)[a]					
Liquid fuels	8.11	8.40	9.23	10.06	24 (0.9)
Natural gas	5.02	5.23	5.58	5.45	9 (0.3)
Coal	2.51	2.73	3.35	4.74	89 (2.7)
Nuclear electricity	0.77	0.77	0.78	0.78	1 (0.1)
Hydroelectricity	2.01	1.93	2.01	2.01	0 (0)
Nonhydro renewables	0.64	1.05	1.36	1.61	150 (3.9)
Net electricity imports	–0.02	–0.02	–0.02	–0.03	26 (1.0)
Total[c]	19.05	20.12	22.30	24.64	29 (1.1)
Population (millions)	69.09	72.62	82.11	92.65	34 (1.2)
CO_2 emissions (million metric tons)	1,060.59	1,100.55	1,220.42	1,406.06	33 (1.2)

[a] One million billion, i.e., 10^{15}.

[b] Includes conventional hydroelectric.

[c] Totals may not equal sum of components due to independent rounding.

[d] Population and electricity divisions used in projected energy analysis by the EIA cover an area in the western United States that contains but is not exactly matched with the study area.

Source: EIA (2008, 2010a).

TABLE 6.5-19 Total Electric Power Generation for the United States and the Western Region, 2006 to 2030

Electric Power Generation	Electric Power Generation (quadrillion Btu)[a] 2006	2010	2020	2030	Percentage Change from 2006 to 2030 (annual rate)
United States					
Liquid fuels and other petroleum	0.64	0.56	0.59	0.63	–2 (–0.1)
Natural gas	6.42	6.89	6.09	5.13	–20 (–0.9)
Steam coal	20.48	21.01	23.67	27.55	35 (1.2)
Nuclear power	8.21	8.31	9.05	9.57	17 (0.6)
Renewable energy[b]	3.74	4.53	5.64	6.13	64 (2.1)
Others[c]	0.19	0.18	0.17	0.20	8 (0.3)
Total	39.68	41.46	45.21	49.21	24 (0.9)
Western Region[d]					
Liquid fuels and other petroleum	0.12	0.11	0.12	0.15	19 (0.7)
Natural gas	1.56	1.64	1.59	1.13	–28 (–1.4)
Steam coal	2.34	2.56	3.00	4.19	79 (2.5)
Nuclear power	0.77	0.77	0.78	0.78	1 (0.1)
Renewable energy[b]	2.36	2.68	3.01	3.25	38 (1.3)
Others[c]	–0.01	–0.01	–0.01	–0.02	52 (1.8)
Total	7.15	7.75	8.49	9.48	33 (1.2)

[a] One million billion, i.e., 10^{15}.

[b] Includes conventional hydroelectric, geothermal, wood and wood waste, biogenic municipal solid waste, other biomass, petroleum coke, wind, and photovoltaic and solar thermal sources.

[c] Includes nonbiogenic municipal wastes and electricity imports.

[d] Population and electricity divisions used in projected energy analysis by the EIA cover an area in the western United States that contains but is not exactly matched with the study area.

Source: EIA (2008).

Climate Change

There is a growing consensus in the scientific community that human activity is contributing substantially to the increase in the Earth's surface temperature (IPCC 2007). The phenomenon is very likely due to human-generated increases in GHG concentrations. GHGs include water vapor, CO_2, methane, O_3, N_2O, and several fluorine- and chlorine-containing gases. Of these gases, CO_2 is believed to be contributing the most to recent warming. In the atmosphere, GHGs trap heat that would otherwise escape into space, creating a "greenhouse effect." Since the inception of the industrial era, the burning of fossil fuels and clearing of forests have greatly intensified the natural greenhouse effect, causing global average temperatures to rise at a fast rate; for example, in the United States, average temperatures have risen at a rate of nearly 0.6°F (0.3°C) per decade in the past few decades (National Science and Technology Council 2008).

TABLE 6.5-20 Total Water Withdrawals by Source, 2005[a,b,c]

State	Population (thousands)	Water Withdrawals (million gal/day) Groundwater	Surface Water	Total[d]	Water Withdrawals (thousand ac-ft/yr) Total
Arizona	5,940	3,050	3.200	6,240 (48.9)	7,000
California	36,100	11.000	34,800	45,700 (24.1)	51,300
Colorado	4,670	2,520	11,100	13,600 (18.5)	15,300
Nevada	2,410	981	1,400	2,380 (41.2)	2,670
New Mexico	1,930	1,680	1,650	3,330 (50.5)	3,740
Utah	2,550	955	4,160	5,120 (18.7)	5,730
Total	53,600	20,186	56,310	76,370 (26.4)	84,740

[a] Figures may not add up to totals because of independent rounding.

[b] Totals for groundwater and surface water include both fresh and saline sources.

[c] To convert gal to L, multiply by 3.785. To convert ac-ft to m^3, multiply by 1,234.

[d] Number in parentheses represents percentage groundwater.

Source: Kenny et al. (2009).

This effect is sometimes referred to as global warming; however, because the warming phenomenon is not distributed evenly across the Earth's surface, it is increasingly referred to as "global climate change." Climate change is a more flexible term, reflecting the fact that changes in the climate due to warming are not universal across the globe—some regions will warm, others will cool. Some of the critical climate changes already observed in the United States are increased numbers of heat waves; changes in annual precipitation and drought, with significant regional variability; regional changes in snow cover; sea level rises along the Atlantic and Gulf coasts; and increases in the number and intensity of tropical storms and hurricanes.

The physical effects of climate change in the western United States include warmer springs (with earlier snowmelt), melting glaciers, longer summer drought, and increased wildland fire activity (Westerling et al. 2006). All these factors contribute to detrimental changes to ecosystems (e.g., increases in insect and disease infestations, shifts in species distribution, and changes in the timing of natural events). Adverse impacts on human health, agriculture (crops and livestock), infrastructure, water supplies (reduced stream flow and rising stream temperatures), energy demand (due to increased intensity of extreme weather and reduced water for hydropower), and fishing, ranching, and other resource use activities are also predicted (GAO 2007; Backlund et al. 2008; National Science and Technology Council 2008).

6.5.2 Cumulative Impacts Assessment for Solar Energy Development

Cumulative impacts on important resources that would result from the construction, operation, and decommissioning of solar energy development projects, when added to other past,

TABLE 6.5-21 Total Water Withdrawals by Water-Use Category in 2000 and 2005[a]

State	Water Withdrawals (million gal/day)[b]											
	Public Supply Fresh	Domestic Fresh	Irrigation Fresh	Livestock Fresh	Aquaculture Fresh	Industrial		Mining		Thermoelectric Power		Total
						Fresh	Saline	Fresh	Saline	Fresh	Saline	
2000												
Arizona	1,080	28.9	5,400	–[c]	–	19.8	0	85.7	8.17	100	0	6,730
California	6,120	286	30,500	409	537	188	13.6	23.7	153	352	12,600	51,200
Colorado	899	66.8	11,400	–	–	120	0	–	–	138	0	12,600
Nevada	629	22.4	2,110	–	–	10.3	0	–	–	36.7	0	2,810
New Mexico	296	31.4	2,860	–	–	10.5	0	–	–	56.4	0	3,260
Utah	638	16.1	3,860	–	116	42.7	5.08	26.3	198	62.2	0	4,970
2005												
Arizona	1,170	27.2	4,810	12.6	11.5	22.4	0	101	2.61	89.9	0	9,960
California	6,990	486	24,400	197	646	72.2	23.4	53.1	255	49.6	12,600	45,700
Colorado	864	34.4	12,300	33.1	88.0	142	0	6.44	15.0	123	0	13,600
Nevada	676	37.4	1,500	8.51	15.3	5.90	0	99.1	0	36.8	0	2,380
New Mexico	286	32.0	2,810	50.7	20.2	13.2	0	58.7	0	55.9	0	3,330
Utah	607	13.9	4,000	17.8	87.7	35.4	127	5.14	162	58.0	4.18	5,120

[a] Figures may not add up to totals because of independent rounding.

[b] To convert gal to L, multiply by 3.785.

[c] Data not collected.

Sources: Hutson et al. (2004); Kenny et al. (2009).

present, and reasonably foreseeable future actions described in the previous section are discussed below. Although the locations and sizes of specific facilities are not known, on the basis of the RFDS developed for this PEIS (see Section 2.4), it is assumed that overall solar development in the six-state study area would be approximately 24,000 MW on BLM-administered lands, with an additional 8,000 MW on non-BLM lands. This level of development would require a corresponding dedicated use of about 214,000 acres (866 km^2) of BLM-administered lands and 71,000 acres (287 km^2) of non-BLM lands. As discussed in the introduction to the cumulative impacts section (Section 6.5), the RFDS is considered generally applicable to solar development occurring under any of the alternatives evaluated in this PEIS. Because of the uncertain nature of future projects in terms of size, number, location, and the types of technology that would be employed, the impacts are discussed qualitatively or semi-quantitatively, with ranges given as appropriate. Detailed cumulative impact analyses are provided for individual SEZs in Chapters 8 through 13. More detailed analyses of cumulative impacts would be performed in the environmental reviews for specific projects in relation to all other existing and proposed projects in the relevant geographic area.

6.5.2.1 Lands and Realty

Solar energy facilities, for the most part, would be built in rural areas within the six Western states covered by this PEIS in large tracks of flat, open, lands where high levels of solar insolation are present. Such lands are typically sparsely populated, often isolated, and typically lightly used, including for grazing, mineral production, limited recreation, and ROWs for wind energy development, transmission lines, other linear utilities, and roads. Placing solar energy facilities in these areas usually represents a new and different land use, creating areas of commercial/industrial character in rural environments. Utility-scale facilities would block out large tracks of land, cumulatively totaling approximately 285,000 acres (1,153 km^2) over the next 20 years, removing or limiting many current land uses. Primary effects would be on access for grazing and mining and road access for recreation or transport. Existing ROWs representing prior rights would be honored, however, and BLM land use plans would be revised to accommodate solar development.

Contributions of solar energy development to cumulative impacts on lands and realty would be in addition to those from other ROWs for transmission lines, roads, and other facilities on public lands and from other energy development on public and private lands that would further affect and limit other land uses within a given region. The intensive coverage of land surface required by solar facilities renders the land used incompatible for most other uses, including grazing, mineral development, and recreation. Although wind and geothermal facilities also encompass large areas, they are generally more compatible with such other uses, because they require less land and can accommodate multiple uses.

The magnitude of land use effects from solar development could be fairly large locally, but significantly smaller regionally, and small overall over the six-state region. On a local scale, solar facilities would dominate several square kilometers of land lying in basin flats and would introduce an industrial land use in typically an otherwise rural area. On a regional and statewide basis, while facilities would affect areas of similar topography, thus increasing their relative

impacts on such land types, the percentage of such land types affected would remain quite small for the amount of land required to meet the RFDS.

Renewable energy development is by far the largest potential new future use of rural lands. No other major contributors to cumulative impacts on lands and realty are foreseeable, beyond perhaps additional energy transmission and other linear systems, some of which would be built to serve renewable energy development. Thus, renewable energy development would be the major contributor to cumulative impacts on land use in the affected regions. Solar energy development, because of its intensive land use, would be a major contributor to those impacts.

6.5.2.2 Specially Designated Areas and Lands with Wilderness Characteristics

Lands suitable for solar energy development in the six-state area, whether public or private, are typically basin flats surrounded by mountains. As such, these lands are often located near one or more specially designated areas and lands with wilderness characteristics, which often lie in the surrounding mountains but also include protected desert areas. Potential effects of nearby solar facilities on these sensitive areas include visual impacts, reduced access, impacts on wildlife that use the developed areas, and fugitive dust during construction, which may affect visibility.

Cumulative impacts on these sensitive areas would be from increased development and visual clutter in general in the surrounding areas, reduced local and regional visibility due to construction-related air particulates, light pollution, road traffic, and impacts on wildlife and plants. As for land use noted above, renewable energy development is the major foreseeable contributor to cumulative impacts on these resources, with solar energy the primary contributor in many areas. Other future developments that could affect these areas include mining, off-road vehicle use, military and civilian aviation, and new transmission lines and other linear facilities. Most such developments would affect the viewshed and would produce fugitive dust emissions during construction, while mining and aviation would also have noise and vibration effects. While all solar technologies would produce visual effects, other impacts would depend on the employed solar technology, with PV having generally the lowest overall impacts. Solar trough and power tower technologies including a power block would have the greatest impacts, while noise from dish engine facilities might affect some nearby areas. Cumulative effects would be dominated by solar facilities in favorable areas and by renewable energy development in general. Because of the general vastness of the affected area, foreseeable impacts on specially designated areas in the six-state region under the RFDS assuming a total of approximately 285,000 acres (1,153 km^2) of land disturbance would be relatively small overall, but moderate to large in localized areas for individual specially designated areas, especially with respect to visual impacts. Several design features required under the BLM action alternatives would minimize the impacts from solar development, including (1) siting solar facilities as far as possible from key observation points (KOPs) and (2) limiting fugitive dust generation during construction through best management practices and proper timing of work.

6.5.2.3 Rangeland Resources

Solar facilities will be located in areas that are currently grazed, while some may also affect areas managed for wild horses and burros. However, the number of affected grazing allotments is generally small, and in many cases the allotments would incur only a small reduction in size. Indirect impacts could result from disruption of livestock movement or access to water sources. A small number of permit holders could be significantly affected, although permit holders could be compensated for losses. Solar energy facilities would be a major contributor to foreseeable impacts on grazing, since wind and geothermal energy facilities and other foreseeable development are generally more compatible with grazing. Cumulative impacts on grazing would, however, be small.

Similarly, wild horse and burro management areas could be affected by solar facilities if management areas are located within the area of indirect effects, nominally within 5 mi (8 km) of the facilities. Solar facilities would generally not be sited directly within herd management areas. Design features required under the BLM action alternatives would also require protective measures for wild horses and burros as needed, such as the provision of movement corridors, traffic management, and fencing. Cumulative impacts on wild horse and burro management areas would be small overall, as would any contributions from solar facilities. Wild horse and burro management areas encompass a small fraction of total available lands, and they also include lands not suitable for solar development because of topography and other factors, thus reducing conflicts.

6.5.2.4 Recreation

Under the BLM action alternatives, special recreation management areas (SRMAs) have been excluded from solar development, so these areas could be affected only indirectly by solar facilities located close to their boundaries. SRMAs identify public lands with many of the BLM's most well known and highly used recreational opportunities, so excluding SRMAs from solar development would limit the significance of impacts to recreation. High levels of intensive recreational use generally do not occur within the basin flats suitable for solar development. The presence of solar facilities would affect mainly off-highway vehicle (OHV) use and low levels of hunting, camping, and photography, for example. In addition, access to recreational areas could be restricted by solar facilities. The level of solar energy development projected by the RFDS would occupy a relatively small portion of the BLM-administered lands in the six-state study area. Since alternative locations for such recreation are generally abundant within the six-state region, direct impacts from solar facilities on the overall availability of recreation opportunities are anticipated to be low. Future site-specific analyses of potential solar facilities would identify measures that would reduce anticipated impacts on local recreational use patterns and public access needs, which would further mitigate potential impacts to public land recreation opportunities. Other renewable energy facilities would also affect areas of low recreational use, as would most other types of foreseeable development in the region, including mining, agriculture, and linear transmission facilities. Thus, cumulative impacts on recreation from foreseeable development are expected to be small.

6.5.2.5 Military and Civilian Aviation

The air space above many of the areas suited to solar energy development is currently heavily used as military training routes. Military training routes located over prospective solar facility locations have varying airspace authorizations (i.e., specific heights designated for military use), and coordination and/or consultation with the DoD may identify restrictions on the height of any facilities that might be constructed within these routes. Such restrictions could constrain the types of solar technologies that might be deployed. The construction of high-voltage transmission lines could also conflict with such military airspace use, which could constrain the size and routes of such lines. Glint and glare from solar facilities and any other facilities with reflective surfaces are an additional concern to military pilots. Small cumulative impacts on military aviation could occur from general development in the region, including that from solar facilities, even with established training routes and height restrictions, because of general infringement on formerly wide-open spaces. The military has expressed concerns regarding the possible effects of solar facilities on its training mission. A policy applicable to both BLM's action alternatives requires coordination with the military regarding the location of solar power projects early in the application process.

Civilian aviation would likely be much less affected than military aviation by solar development in the six-state region. Airports are generally located near towns or cities and at some distance from prospective solar development areas. Moreover, civilian aviation would not involve low-altitude flights and the attendant need for height restrictions on infrastructure. No cumulative effects on civilian aviation are expected.

6.5.2.6 Geologic Setting and Soil Resources

The primary concern for geologic and soil resources from solar development is the large acreages that would be disturbed for the construction of utility-scale facilities. While the topography of suitable areas is necessarily flat in general, the entirety of areas where solar fields are built would have to be graded to produce a very smooth, very flat surface for solar collectors. Such grading would render large areas susceptible to soil erosion. This would be particularly of concern in areas where biological soil crusts are present. While soil erosion mitigation measures would be in place, some soil loss would be unavoidable, given the large acreages disturbed, typically dry soil conditions, and occurrence of high winds in development areas. Solar energy development would be a major contributor to cumulative impacts on soil from foreseeable development in the six-state region. Other foreseeable actions that would contribute to soil erosion are road construction, including that associated with solar and other renewable energy development, transmission lines, pipelines, mining, agriculture, and OHV use. Overall foreseeable cumulative impacts on soil would be small to moderate with appropriate mitigations in place and given the relatively small fraction of total land area potentially affected by all development.

6.5.2.7 Mineral Resources

Recoverable minerals that may occur in prospective solar energy development areas include oil and gas, coal, copper, silver, gold, sodium minerals, and sand and gravel. Numerous existing mining interests lie within prospective solar development areas that represent prior existing rights. Solar facilities would be incompatible with most types of mineral production because of the intensive land coverage required. Underground mining might remain viable beneath solar facilities, as would oil and gas recovery using directional drilling. Geothermal resources might also be recoverable in solar development areas. Other foreseeable development, which generally requires less land than solar development, would contribute small additional impacts on mineral resources.

6.5.2.8 Water Resources

Solar thermal energy technologies that employ a conventional steam turbine generator within a power block (mainly trough and power tower technologies) can require large quantities of water for cooling unless air cooling or hybrid cooling is employed. Far smaller quantities of water are required by all solar technologies for mirror or panel washing and for potable water uses. Water-cooled facilities would typically rely on groundwater within the six-state region, because surface water sources are scarce. Recirculating wet-cooled facilities would be practical only in locations with ample groundwater supplies of suitable water quality where water rights could be obtained as well as the approval of state and local water authorities. SEZ-specific design features would not allow wet cooling at solar facilities on most of the SEZs, and it is unlikely that facilities using wet cooling would be permitted in most locations within the study area.

Where groundwater or surface water use for cooling was available, the operation of solar energy facilities could affect surface water flows and groundwater supplies and water levels. Environmental effects from such use could include effects on aquatic, riverine, and wetland habitats and communities, municipal and agricultural water supplies, and ground surface subsidence. Effects could occur at significant distances downgradient from the point of use, depending on local hydrology. A design feature under the BLM action alternatives would require developers to conduct hydrologic studies and avoid impacts on surface water features from groundwater use. Other design features would require long-term monitoring of groundwater resources. Overall, the impacts on water supplies from dry-cooled solar thermal facilities and dish engine facilities would likely be minor, since such facilities would not be permitted unless studies had shown that there would be no significant impacts on the hydrologic system. PV facilities would have minor impacts on water supplies.

Wind energy facilities would not require water for operation. Water would be required for other energy generation and development activities, including coal, natural gas, and geothermal power plants, mining, oil shale and tar sands development in some of the affected states, and possibly biofuels production. All new construction would require water for fugitive dust control. Solar facilities, in particular, require large volumes of water during construction to

control dust emissions over large acreages. An additional large increase in water use in the area would be associated with increased domestic use as the population increases.

Cumulative impacts on water supplies in the six-state region from foreseeable development could range from small to moderately high. Impacts will be constrained by the limited availability of water rights, and via oversight by state and local water authorities. Large drawdowns due to solar energy demands are not expected under the RFDS given state and locale oversight of groundwater supplies and fully allocated supplies in most regions. However, pressure on water supplies will continue to grow from multiple demands. In addition, changes in regional precipitation and temperature that have been attributed to global climate change are expected to reduce total water supplies in the southwestern United States (USGCRP 2009). Some water demand will be met by increased reuse of municipal wastewater, while water conservation measures will be increasingly applied. Effects of diversion of water use from agriculture to solar energy development could appear as effects on land use or as socioeconomic effects.

6.5.2.9 Ecological Resources

6.5.2.9.1 Vegetation

The construction of solar energy facilities will require the total removal of vegetation over large portions of land. Most of this land is located in arid or semiarid regions where restoration of vegetation is difficult and where the introduction of invasive species is a significant concern. Development of an integrated vegetation management plan is a design feature applicable under both BLM action alternatives. This plan would require long-term control of invasive species through several means, including monitoring, use of certified weed-free seed and mulching, treating infestations, and integrated pest management.

The main cover types affected are typically abundant in the affected regions, so impacts to these plant communities would not be large. However, a number of minor species, associated with rare or limited habitats, such as dunes, woodland, or riparian areas in desert regions, might incur greater impacts if not avoided or protected. Biological soil crusts also could incur greater impacts that would be long-term or possibly irreversible. Design features applicable under the BLM action alternatives require that projects not be sited in critical habitat or occupied habitat for sensitive plant species, and that sensitive habitats be protected to the extent possible. Coordination with appropriate federal and state agencies to identify these habitats would be required. While solar facilities would avoid wash areas and wetlands to the extent practicable, some sensitive areas could still be affected by the facilities or by access roads, transmission lines, or pipelines that traverse them.

Cumulative direct impacts on plant communities from foreseeable development in the six-state region could be moderate for some sensitive species. Because of the large land areas disturbed and the presence of sensitive communities, solar energy facilities could be a significant contributor to such impacts. Mitigation measures, including avoidance, could protect most sensitive plant communities. Cumulative impacts on primary cover species would be small due

to their abundance in the region and the relatively small portion of total lands required under the RFDS.

Plant communities outside of the areas directly affected by solar facilities could be indirectly affected by dust deposition from construction activities, increased surface water runoff and related erosion, or through the introduction of invasive species. Development of a dust abatement plan with extensive measures to limit dust generation during construction and operations is a design feature applicable under both BLM action alternatives. Similarly, multiple design features require the control of surface water runoff and erosion. Spread of invasive species would be addressed through integrated vegetation management as discussed above. With implementation of these measures, indirect cumulative impacts to vegetation are expected to be small.

6.5.2.9.2 Wildlife and Aquatic Biota

Potentially affected wildlife in solar development areas includes numerous species of amphibians and reptiles, birds, mammals, and aquatic biota. Species would be affected by loss of habitat, disturbance, loss of food and prey species, loss of breeding areas, effects on movement and migration, introduction of new species, noise, and habitat fragmentation. Solar facilities could affect bird migration patterns and attract birds to retention ponds. Transmission towers provide nesting and perching sites, while conductors present collision hazards to birds. Aquatic species could be affected by changes in drainage patterns due to site grading and the implementation of storm water management systems that might divert flows. Groundwater drawdown could dry up wetlands or other areas hosting aquatic species. Design features to address these impacts include timing of activities to avoid affecting breeding seasons and winter use areas, use of noise reduction devices, use of fencing to protect wildlife, traffic control, and preservation of wetlands. These design features would reduce, but not eliminate impacts.

Cumulative impacts on wildlife and aquatic biota from foreseeable development in the six-state region would be small provided mitigation measures to preserve important habitat and migration corridors are implemented (or sufficient alternative lands are set aside as compensation). This assessment assumed that solar development would affect the largest amount of acreage in the study area in comparison with other activities, on the basis of the assessment of other foreseeable actions and projects in the study area (see Section 6.5.1). However, based on the RFDS land use projections, solar development would still affect a relatively small fraction of total BLM-administered lands in the study area, and solar facilities would affect mainly flat basin floors, habitat that is abundant in the region. Design features required under the BLM action alternatives would also require the avoidance of rare habitats. Effects on aquatic habitats from drainage changes and sedimentation from soil erosion would be mitigated but not eliminated. Effects from groundwater drawdown would depend largely on solar cooling technologies employed. Large drawdowns due to solar energy demands are not expected under the RFDS given state and local oversight of groundwater supplies and fully allocated supplies in most regions.

6.5.2.9.3 Special Status Species

Special status species, those given special protections under the Endangered Species Act (ESA) or identified as sensitive species by the affected states or the BLM, are present in much of the area suited for solar development. The ESA protects individual animals or plants, as well as critical habitat. The ESA requirements are reflected in and expanded on in the design features applicable for both BLM action alternatives. Design features include requirements for project developers to identify and protect listed and sensitive species through field surveys and other measures prior to breaking ground. Designated and proposed critical habitat must be avoided wherever feasible. Wherever feasible, projects also must avoid surface water or groundwater uses that affect habitats occupied by special status species. If avoiding or minimizing impacts on occupied habitats is not possible, translocation of individuals from areas of direct effect or compensatory mitigation of direct effects on occupied habitats could reduce impacts. A comprehensive mitigation strategy for special status species that uses one or more of these options to offset the impacts of development should be developed in coordination with the appropriate federal and state agencies.

Cumulative impacts from foreseeable development in the six-state region could be small to moderate for some species, with solar development being a major contributor to cumulative impacts. A few species would be of concern in many areas, including the desert tortoise, Western burrowing owl, and ferruginous hawk. Impacts on individuals would be the most difficult to mitigate. Contributions to cumulative impacts from solar development owe to the large, continuous, areas disturbed and disturbance from associated roads, transmission lines, and pipelines.

6.5.2.10 Air Quality and Climate

6.5.2.10.1 Local and Regional Impacts

Air quality would be affected locally and temporarily from fugitive dust emissions during construction of solar facilities; associated particulate matter (PM) concentrations could temporarily exceed ambient air quality standards near construction areas and possibly affect visibility in pristine areas such as national parks. Application of measures included in an extensive dust abatement plan (a design feature for both BLM action alternatives) would substantially reduce the PM levels generated during construction. The operation of solar facilities would produce very few emissions. Power-block facilities in solar thermal plants could produce some cooling tower drift if water cooling were used, as well as small levels of pollutants from natural gas or propane combustion from backup generators, as well as occasionally from emergency diesel generators. Portions of facilities that are maintained vegetation-free during operations could be a source of windblown fugitive dust, although design features requiring dust minimization would reduce this source. There also would be limited emissions from vehicles and natural gas-fired pre-heat boilers (if used).

Overall, however, emissions from solar facilities are low and would not contribute to local or regional air pollution problems. Contributions to cumulative effects on air quality would likewise be low, and cumulative effects from other foreseeable development in most solar development regions would be low, given that renewable energy facilities are the major type of new development expected to occur in the generally remote areas where solar facilities would be built. Portions of the study area have well-known ongoing air quality problems, primarily Southern California. Solar developments in such regions would not worsen air quality, except for particulate matter during construction. To the extent that solar facility operations offset energy production from fossil fuels, pollutants loads would be reduced for combustion-related pollutants such as CO, SO_2, and NO_x.

6.5.2.10.2 Global Climate Change

As discussed in Section 6.5.1.2.2, increasing atmospheric levels of GHGs (primarily CO_2) are linked to global climate change (IPCC 2007; USGCRP 2009). Utility-scale solar energy development contributes relatively minor GHG emissions as a result of emissions from heavy equipment, primarily used during the construction phase; vehicular emissions; and natural gas or propane combustion from backup generators. The removal of plants from within the footprint of solar energy facilities would reduce the amount of carbon uptake by terrestrial vegetation, but only by a small amount (about 1% of the CO_2 emissions avoided by a solar energy facility compared to fossil-fuel generation facilities [see Section 5.11.4]).

Utility-scale solar energy production over the next 20 years may result in fewer CO_2 emissions from utilities by offsetting emissions from new fossil fuel energy sources. CO_2 emission offsets related to increased solar energy production could range from a few percentage points to more than 20% in some of the study area states if future fossil energy production were offset by solar energy. Table 6.5-22 provides a comparison of the CO_2 emissions of different generation technologies during facility operations.

TABLE 6.5-22 Comparison of CO_2 Emissions from Different Generation Methods per Average Megawatt

Type of Energy Generation	CO_2 Emissions (ton/MW)
Wind	0
Solar	0
Hydropower	0
Geothermal	636
Coal	7,551–8,843
Natural gas combined-cycle	3,313–5,142
Nuclear	0
Wood-fired co-generation	11,959
Solid-waste-fired co-generation	13,256

Source: BPA (2003).

In the near term, solar facilities would tend to offset facilities serving peak loads rather than baseline loads served by large fossil fuel plants. Emissions from future fossil fuel plants serving peak loads, typically natural gas–fired plants, would nevertheless be offset. The addition of thermal energy or electrical storage to solar facilities could allow offsets of baseload fossil fuel plants in the long term.

Because GHG emissions are aggregated across the global atmosphere and cumulatively contribute to climate change, it is not possible to determine the specific impact on global climate from GHG emissions associated with solar energy development on BLM-administered lands over the next 20 years. It is possible to predict, however, that increased solar energy generation could cumulatively result in fewer GHG emissions if it offsets electricity generation from new fossil fuel facilities.

6.5.2.11 Visual Resources

The introduction of solar facilities in remote rural areas would alter the landscape and produce dramatic changes in the visual character of many affected areas. In addition, suitable solar energy production locations are in basin flats surrounded by mountains or highlands where sensitive viewing locations exist. Thus, visual impacts could be acute for some observers, including hikers and park visitors, and also for certain groups, including Native American tribes or other ethnic groups who live in affected areas.

In addition to visual impacts from solar facilities, impacts would accrue from associated transmission lines, roads, pipelines, and lighting—all of which can have high visual impacts over long distances. Thus, solar development would be a major contributor to cumulative visual impacts from foreseeable development in the six-state region. Overall, cumulative impacts for all development could be significant, including impacts from wind and geothermal development, new roads, transmission lines, pipelines, canals, fences, communication systems, mining, agriculture, commercial development, aviation, road traffic, and OHV use. Visual impacts from solar facilities would be mitigated to the extent practical through the implementation of design features and through careful siting of facilities relative to sensitive viewing sites. Concerns for visual impacts could also affect solar technology selection, including, for example, concerns related to the height of solar tower facilities.

6.5.2.12 Acoustic Environment

Noise effects from heavy equipment and power tools during construction of solar facilities would be similar to those from any large construction project. Such impacts would depend on the type of solar technology being installed, with the lowest noise impacts for PV and dish engine installation and the greatest noise impacts and ground vibration associated with power block construction for solar energy facilities. Facility construction typically requires from 1 to 3 years, with intermittent noise nuisance effects possible on nearby residents and/or wildlife. Facilities would generally not be located near sensitive noise receptors such as schools, hospitals, or residential areas but could affect individual residences. Design features under the BLM action

alternatives to address noise during construction include limiting the daily hours of activities, construction of noise barriers if needed and practicable, and coordination with nearby residents.

Noise for solar facility operations would be generally low and depend on the solar technology. PV facilities would produce little or no noise. Solar thermal facilities would produce low levels of continuous noise from power blocks and from cooling towers or cooling fans in air-cooled plants. Power blocks represent a localized noise source typically located near the center of a solar facility and far from facility boundaries. Dish engine facilities present the greatest concern for noise, because each dish represents a single, distributed noise source. While a single dish engine produces modest noise levels, a solar facility might employ thousands of them, presenting a significant noise concern near facility boundaries. Careful siting would mitigate such impacts. For example, SEZ-specific design features generally require siting of dish engine solar fields from 1 to 2 mi (2-3 km) from residential areas. Since noise impacts are short range and solar development areas are mainly sparsely populated and otherwise largely undeveloped, few cumulative noise impacts would occur.

6.5.2.13 Paleontological Resources

Paleontological resources, mainly fossils, can be affected by construction excavation for solar facilities. Such effects can be mitigated by collecting or documenting fossils when encountered, with the aid of a paleontologist, or by avoiding areas rich in fossils. Many prospective solar areas have not been surveyed for fossils, and the presence of fossils can be inferred only by the types of geological deposits and soils present. Such areas would be surveyed prior to facility construction. Because of the vastness of the area, cumulative effects on paleontological resources in the six-state area from foreseeable development are expected to be small, while solar development could represent a major contribution to these small effects because of the large acreages disturbed for construction. However, while large in size, much of the area encompassed by solar arrays would not require deep excavation and thus would not likely disturb buried fossils. Foundations for solar collectors, reflectors, or dish engines typically involve minor or no excavation or employ a single piling driven into the ground. Deep excavations would occur for power block foundations, retention ponds, and other structures for some types of solar facilities. Shallow to moderately deep excavations for underground utilities and energy collector lines would be required at most facilities.

6.5.2.14 Cultural Resources

Cultural resources are subject to loss during construction of solar facilities and associated roads and transmission lines. Historic properties, including prehistoric and historic archaeological sites, structures, and features and traditional cultural properties, that have been listed in or are eligible for listing in the *National Register of Historic Places* (NRHP) are of concern. Cultural resource surveys, evaluations, and any necessary mitigation of NRHP-eligible resources adversely affected by a project must be conducted prior to construction. Consultation with affected local Native American Tribes regarding their knowledge of and/or concerns for cultural resources in a given project area must be implemented early and often throughout the

project development process. In the event that cultural resources are unexpectedly encountered during construction activities, provisions should be in place (e.g., a historic properties treatment plan, mitigation and monitoring plan) to address the appropriate evaluation and treatment of such cultural resource discoveries. Areas rich in cultural resources would be avoided if possible. Cumulative effects on cultural resources from foreseeable development in the six-state region are expected to be small because of the relatively small fraction of total land disturbed. Solar energy development could be a major contributor to these impacts. However, for the most part, solar facilities could, and would wherever possible, be sited away from areas rich in cultural resources. Such areas would include individual properties (sites, structures, features, traditional cultural properties) and districts listed in the NRHP, National Historic Landmarks, National Historic Trails, and prehistoric and historic sites possessing significant scientific, heritage, or educational values.

6.5.2.15 Native American Concerns

Solar development areas lie on or near lands of current and historical interest to numerous Native American Tribes. Solar energy facilities could be of concern to Tribes because of an array of potential impacts. Foremost among these would be impacts on the landscape, which would be dramatically altered by solar facilities. Other resources of concern include trails, sacred sites, burial sites, as well as traditionally collected plants and game. Water bodies and aquatic habitats are also of concern. Consultation with affected Tribes is required prior to siting and construction of solar facilities. Mitigations of impacts would involve any and all mitigations otherwise identified for the affected resources. Cumulative impacts on Native American concerns from foreseeable development in the six-state region are currently unknown, because consultation is still ongoing (see Appendix K for concerns that have been raised to date). Solar development could make a significant contribution to impacts, as would wind and geothermal development. Other future development that would affect the visual landscape, ecological communities, water resources, or cultural resources would also contribute to cumulative impacts.

6.5.2.16 Socioeconomics

On the basis of the RFDS projection of 24,000 MW of solar energy generation, the number of construction jobs created would range from approximately 7,700 to 84,000, and the number of permanent operations jobs would range from about 450 to 10,000, depending on the mix of solar energy technologies employed. PV facilities require the fewest workers, and parabolic solar thermal trough technologies the most. The total income estimated to result from solar development under the RFDS varies by state. In California, the largest of the six states, total estimated construction income would be $2,544 million for build-out with PV technology and $28 billion for parabolic trough technology. Total operations annual income would be $750 million in California. Construction income would be realized over an assumed development period of 20 years (approximately through 2030), while operations income would be ongoing.

As a point of comparison, the gross domestic product of California in 2008 was $1,545 billion, so the new income related to permanent operations jobs from solar development in the state over the study period would be a small percentage of the state's gross domestic product, roughly 0.05%. However, for all the states, the economic impact would occur in areas of low population, resulting in relatively larger local economic benefits. The relatively small operations workforce would not be expected to strain local services or cause significant social impacts in communities. During the build-out phase, however, large numbers of construction workers might cause temporary social disruption in small communities.

Cumulative social impacts for all development would likely be minor, due to the slow pace of other types of development in the rural areas that would be utilized for solar and other renewable energy development. However, the overall cumulative economic activity related to general development in the study area would benefit the economies of any of the affected localities.

6.5.2.17 Environmental Justice

Environmental justice effects concern any disproportionately high and adverse human health or environmental effects of federal actions, programs, or policies on minority and low-income populations. Solar energy development has potential for such effects where minority or low-income populations may be affected. Such effects may derive from air pollution, noise, land use, cultural, or socioeconomic impacts. These effects may be negative, as in the case of increased noise levels or altered land use patterns, or positive, as in the case of local or regional economic benefits resulting from increased jobs and revenue. Mitigation of effects would include surveys to identify potentially affected minority and low-income populations, direct mitigation of effects on natural resources, and social programs to mitigate economic and social effects. Cumulative effects on environmental justice from foreseeable development in the six-state study area are expected to be small. Contributions from solar development would likely be small, due to the low level of health and environmental effects associated with solar facilities, sparse populations in solar areas, and the availability of effective mitigation.

6.5.2.18 Transportation

Effects on transportation systems from solar development would occur mainly during construction of facilities and would affect primarily local road systems and traffic flow. Such effects would be temporary and could be mitigated through minor road improvements at access points and through reduction in traffic congestion through car pooling and coordination of shift changes. Only minor contributions to cumulative effects on transportation would be expected in the six-state study area during the development of solar facilities. Because of the small number of workers required to operate plants and the relatively low level of delivery traffic to and from facilities required for operation, cumulative impacts on transportation systems during facility operations would be minimal.

6.6 OTHER NEPA CONSIDERATIONS

6.6.1 Unavoidable Adverse Impacts

Utility-scale solar development under the action alternatives and under the no action alternative would result in some unavoidable adverse impacts, as follows:

- Short-term air quality impacts due to dust generated during site-preparation and construction, and noise impacts due to use of heavy construction equipment;
- Short-term influx of workers and transportation-related impacts (e.g., increased traffic) during the construction phase;
- Long-term loss of grazing allotments;
- Long-term reduction in available water supply (relatively insignificant for PV facilities);
- Long-term loss of soil, vegetation, and habitat for wildlife (including sensitive species) and, potentially irreversible impacts to biological soil crusts;
- Long-term impacts on some species, both at the population level and on individual organisms;
- Long-term visual impacts on residents of communities near solar facilities, users of roads passing near solar facilities, and patrons of specially designated areas within the viewshed of solar facilities; and
- Long-term noise impacts for solar dish engine facilities and trough or power tower facilities employing thermal energy storage.

The magnitude of these adverse impacts would to some degree depend on a specific project and would be decreased by implementing the programmatic design features required under the action alternatives (e.g., siting facilities away from the most sensitive resources), although the extent to which these impacts could be mitigated cannot be assessed, except at the project level, and it is possible these impacts could not be completely avoided.

6.6.2 Short-Term Use of the Environment and Long-Term Productivity

For this assessment, short-term uses are defined as those occurring over a 2- to 3-year period, generally applicable to site characterization/preparation and construction phases. Long-term uses and productivity are those that occur throughout the 20-year time frame considered in this PEIS.

Although land disturbance within the footprint of solar energy generation facilities would be long term, additional areas affected during the construction of the generation facilities and related infrastructure (e.g., roads, transmission lines, and natural gas or water pipelines) would result in relatively short-term disturbance. Land clearing and grading and construction and operation activities would disturb surface soils and wildlife and their habitats, and affect local air and water quality, visual resources, and noise levels within and around the solar facility areas and on additional lands used for project-related infrastructure. Short-term influxes of construction workers would affect the local socioeconomic setting.

The lands used for solar facilities long term would produce electricity generated from a renewable source and would result in reduced emissions of GHGs and combustion-related pollutants, assuming the solar facilities offset electricity generated by fossil fuel power plants. These facilities would generate stable jobs and income for nearby communities (although at a lower rate than during the short-term construction phase), sales and income tax revenues, and income for the Federal Government in the form of ROW rental revenues over the life of the projects.

6.6.3 Irreversible and Irretrievable Commitment of Resources

Solar energy development on BLM-administered lands would result in the consumption of sands, gravels, and other geologic resources, as well as fuel, structural steel, and other materials, some of them special-use materials (i.e., metals used in PV solar cells). At decommissioning, some of these materials would be available for reuse.

Water resources would be consumed during the construction phase and during operations, with the extent of water use varying by the technology selected; this would be an irreversible and irretrievable loss.

For most plant and animal species, population-level effects would be unlikely, based on the assumption that required design features are implemented; however, population-level effects are possible for some species. Additionally, during construction, operation, and decommissioning, individual plants and animals would be affected. Site-specific and species-specific analyses conducted at the project level for all project phases would help ensure that the potential for such impacts would be minimized to the fullest extent possible. There would be long-term reductions in habitat due to fencing of large areas during the operational period; this impact would be partially mitigated through siting in locations that do not contain critical habitat. Additional programmatic policies (e.g., requiring long-term monitoring and related additional mitigation) and design features would reduce the impacts over time. However, it is unknown whether irreversible and irretrievable impacts to species would occur.

Biological soil crusts are fragile and damage to them could constitute an irreversible and irretrievable impact. When these biological soil crusts are removed, the underlying soils may be subject to increase erosion by both wind and water. Programmatic design features that minimize the amount of land disturbance could be applied to reduce the impacts to these resources.

Cultural and paleontological resources are nonrenewable. Impacts on these resources would constitute an irreversible and irretrievable commitment; however, implementation of the programmatic design features would minimize the potential for these impacts to the extent possible.

Impacts on visual resources in specific locations could constitute an irreversible and irretrievable commitment. Implementation of the programmatic design features would minimize the potential for these impacts to the extent possible; additional mitigation efforts would be undertaken at the project level with stakeholder input.

6.6.4 Mitigation of Adverse Effects

An extensive set of required programmatic design features addressing impacts on important resources and resource uses from solar development has been assembled and is presented in Section A.2 of Appendix A. These design features would be implemented for all solar facilities issued ROW authorizations on BLM-administered lands. In addition, SEZ-specific design features, presented in Section A.2 of Appendix A, would be implemented to ensure that unique issues and conditions are addressed. This comprehensive set of mitigation requirements would ensure that impacts from solar energy development on BLM-administered lands would be mitigated to the fullest extent possible. Any potential adverse impacts that could not be addressed at the programmatic level would be addressed at the project level, where resolution of site-specific and species-specific concerns is more readily achievable.

Under both action alternatives, the BLM would incorporate adaptive management strategies to ensure that new data and lessons learned about the impacts of solar energy projects would be used to avoid, minimize, or mitigate impacts to acceptable levels. The program administration and authorization policies and design features would be updated and revised as new data on the impacts of solar power projects become available. At the project level, operators would be required to develop monitoring programs, to establish metrics against which monitoring observations can be measured, to identify additional potential mitigation measures, and to establish protocols for incorporating monitoring observations and additional mitigation measures into standard operating procedures and project-specific stipulations.

6.7 REFERENCES

Note to Reader: This list of references identifies Web pages and associated URLs where reference data were obtained for the analyses presented in this PEIS. 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. The original information has been retained and is available through the Public Information Docket for this PEIS.

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7 ANALYSIS OF DOE'S ALTERNATIVES

Through this programmatic environmental impact statement (PEIS), the U.S. Department of Energy (DOE) is evaluating two alternatives: a proposed action (action alternative) and a no action alternative (see Section 2.3).

Under the proposed action (action alternative), DOE would develop programmatic guidance to further integrate environmental considerations into its analysis and selection of solar projects that it will support. DOE would use the information about environmental impacts provided in this PEIS to appropriately amend its programmatic approaches to facilitate the advancement of solar energy development. This proposed action has been developed to support DOE in meeting the mandates discussed in Section 1.1.1 that provide the purpose and need for agency action. Specifically, these mandates are established by Executive Order 13212, "Actions to Expedite Energy-Related Projects" (*Federal Register,* Volume 66, page 28357, May 22, 2001); Executive Order 13514, "Federal Leadership in Environmental, Energy, and Economic Performance" (*Federal Register,* Volume 74, page 52117, Oct. 5, 2009); and Section 603 of the Energy Independence and Security Act of 2007 (EISA) (Public Law 109-58). Collectively, these mandates require DOE to promote, expedite, and advance the production and transmission of environmentally sound energy resources, including renewable energy resources and solar energy and, in particular, cost-competitive solar energy systems at the utility scale.

Under the no action alternative, DOE would continue to conduct environmental reviews of DOE-funded solar projects on a case-by-case basis. It would not develop programmatic guidance, with explicit environmental practices and mitigation recommendations to apply to DOE-funded solar projects.

This chapter presents an analysis of DOE's two alternatives in terms of their effectiveness in meeting the mandates established for the agency. Specifically, the alternatives are analyzed in terms of their potential to affect the pace and cost of solar energy development, environment, and socioeconomic setting.

Sections 7.1 and 7.2 present the analysis of the two alternatives. Section 7.3 discusses the cumulative impacts of the alternatives. Section 7.4 discusses the other NEPA considerations related to the proposed action, including unavoidable adverse impacts, short-term uses of the environment and long-term productivity, irreversible and irretrievable commitment of resources, and mitigation of adverse impacts.

7.1 IMPACTS OF DOE'S PROPOSED ACTION

Under DOE's proposed action, the department would develop guidance to amend its programmatic approaches, as appropriate, to facilitate the advancement of solar energy development. Investment and deployment strategies would incorporate guidance with recommended environmental practices and mitigation measures into the decision-making process; the guidance would be based on information concerning environmental impacts and

potentially applicable mitigation measures provided in this PEIS. With this guidance, DOE would have the tools for making more informed, environmentally sound decisions on projects.

One advantage of the guidance would be to better enable DOE to comprehensively determine where to make technology and resource investments to minimize the environmental impacts of solar technologies. For example, the guidance would promote investments in projects that address water requirements and total land disturbance of specific technologies. Over time, such investments could result in the development of commercially deployable technologies with reduced environmental impacts. Projects using such technologies might be more quickly approved by regulatory agencies, as well as more acceptable to stakeholders.

A second element of the guidance would enable DOE to establish environmental mitigation recommendations to be considered by project proponents seeking financial assistance from DOE. These recommendations, which would be based upon the analysis of impacts of solar energy development and potentially applicable mitigation measures presented in Chapter 5 of this PEIS, would help DOE ensure that environmental impacts of DOE-funded solar projects would be avoided, minimized, or mitigated. In addition, promoting the application, as appropriate to DOE projects, of a comprehensive set of mitigation measures consistent with the mitigation requirements that the BLM proposes to establish through its new Solar Energy Program (see Section 2.2.2) would likely streamline project-specific environmental impact analyses and bring consistency to the application of mitigation measures to DOE-supported projects.

Collectively, streamlined environmental reviews, quicker project approval processes, and reduced opposition to solar energy development would likely increase the pace of such development and reduce the costs to industry, regulatory agencies, and stakeholders. These outcomes would support the mandates of Executive Orders 13212 and13514 and Section 603 of the Energy Independence and Security Act of 2007 (EISA).

Increasing the pace of solar energy development would, in turn, translate into other benefits. As discussed in Section 5.11.4, utility-scale solar energy development would result in reduced emissions of greenhouse gases (GHGs) and combustion-related pollutants, if the development offsets electricity generation by new fossil fuel power plants. If the pace of solar energy development is faster as a result of DOE's proposed action, the potential beneficial impacts of reduced GHG emissions would be realized at a faster rate.

As discussed in Section 5.17.2, utility-scale solar energy development would result in local and regional economic benefits in terms of both jobs and income created. The associated transmission system development and related road construction would also translate into new jobs and income. These benefits would occur as both direct impacts, resulting from the wages and salaries, procurement of goods and services, and collection of state sales and income taxes, and indirect impacts, resulting from new jobs, income, expenditures, and tax revenues subsequently created as the direct impacts circulate through the economy. Increasing the pace of solar energy development would cause these economic benefits to be realized at a faster pace as well.

As discussed in Section 5.17.1.1, there may be some adverse socioeconomic impacts resulting from changes in recreation, property values, and environmental amenities (e.g., environmental quality, rural community values, or cultural values), and disruption potentially associated with solar development. There could also be beneficial socioeconomic impacts in these areas resulting from economic growth and a positive reception to the presence of a renewable energy industry. At the programmatic level, it is difficult to quantify these impacts. Increasing the pace of solar energy development would also speed up the pace of these types of socioeconomic changes.

In summary, the guidance that DOE would develop under its proposed action would be used specifically to promote the reduction of environmental impacts of solar energy development and to streamline environmental reviews for DOE-funded projects. As a result, the pace of solar energy development could increase and the associated costs could decrease. More rapid penetration of utility-scale solar energy development would likely result in quicker decreases in GHG emissions and combustion-related pollutants and quicker realization of economic benefits at both the regional and local levels.

7.2 IMPACTS OF THE NO ACTION ALTERNATIVE

Under the no action alternative, DOE would continue its existing case-by-case process for addressing environmental concerns for DOE-supported solar projects. It would not develop programmatic environmental guidance to apply to DOE-funded solar projects. As a result, DOE would not undertake any specific efforts to programmatically promote (i.e., programmatic environmental guidance) the reduction of environmental impacts of solar energy development or streamline environmental reviews for DOE-funded projects. Such achievements, and the potential benefits in terms of increased pace of solar energy development and decreased associated costs, might occur under the no action alternative, but they would not be explicitly promoted by DOE (by issuance of programmatic environmental guidance with recommended environmental practices and mitigation measures).

7.3 CUMULATIVE IMPACTS

As discussed in Section 6.5, the purpose of this cumulative impact assessment is to determine how the environmental, social, and economic conditions within the six-state study area may be incrementally affected by DOE's alternatives over the next 20 years. The Council on Environmental Quality (CEQ), in its regulations implementing the procedural provisions of the National Environmental Policy Act of 1969 (NEPA; 40 CFR 1500-1508), defines cumulative effects as follows:

> "... the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions" (40 CFR 1508.7).

Typically, the "incremental impact of the action" is characterized in terms of a specific, quantifiable set of activities. In a programmatic impact analysis, this type of characterization might be based on a projected amount of development expected to occur as a result of the proposed action. DOE and the BLM developed a reasonably foreseeable development scenario (RFDS) for solar energy development in the six-state study area over the next 20 years (see Section 2.4), which projects the amount of solar energy in megawatts that might be developed in each state by about 2030. The RFDS analysis also estimates how many acres of land might be required to support the projected development. The projected levels of development and estimated acres developed are presented in Table 2.4-1. Across the six-state study area, the RFDS projects between about 6,000 to 32,000 MW of solar energy capacity would be developed over the next 20 years on BLM-administered lands as well as other federal, state, Tribal, or private lands. On the basis of the highest projection, assuming 9 acres/megawatt, this amount of development could require approximately 285,500 acres (1,155 km^2) of land.

Although DOE certainly has an influence over the amount of solar energy development that occurs in the United States and it has designed its proposed action specifically to shape some aspects of its influence, it is not possible to calculate how much of the projected RFDS development and associated land use would be directly attributable to DOE's proposed action. Conversely, because the BLM is evaluating a new Solar Energy Program that would determine how it manages such development on BLM-administered lands, including the identification of lands that would be excluded from and lands that would be available for development, the RFDS identifies which portion of the projected development might occur on BLM-administered lands over the next 20 years. It is assumed that this development would be facilitated in large measure by the BLM's new program, and therefore the development is considered to be a result of the BLM's proposed action. Of the total 32,000 MW of solar capacity projected by the RFDS, 75%, or approximately 24,000 MW, is assumed to be developed on BLM-administered lands; this equates to about 214,000 acres (866 km^2) of land.

The cumulative impact analysis of BLM's alternatives, presented in Section 6.4, evaluates the full amount of development projected by the RFDS. It defines the "incremental impact" of the agency's action as that portion of the RFDS projected on BLM-administered lands (i.e., 24,000 MW of solar energy capacity and 214,000 acres [866 km^2]), and the rest of the RFDS projected development as the "reasonably foreseeable" solar energy development resulting from the actions of others. Consequently, the full RFDS projected level of development is considered in the cumulative impact analysis of BLM's alternatives.

In all likelihood, only a small percentage of utility-scale solar energy development projected in the RFDS would be directly attributable to DOE's proposed action. While the cumulative impact analysis presented in Section 6.4 is not representative of what would occur as a result of DOE's proposed action, it does present an upper bound description of potential cumulative impacts related to solar energy development in the six-state study area. Consequently, a separate cumulative impact analysis has not been prepared for DOE's alternatives.

7.4 OTHER NEPA CONSIDERATIONS

7.4.1 Unavoidable Adverse Impacts

Utility-scale solar development would result in some unavoidable adverse impacts, as follows:

- Short-term air quality impacts due to dust generated during site preparation and construction, and noise impacts due to use of heavy construction equipment;
- Short-term influx of workers and transportation related impacts (e.g., increased traffic) during the construction phase;
- Long-term loss of grazing allotments;
- Long-term reduction in available water supply (relatively insignificant for photovoltaic [PV] facilities);
- Long-term loss of soil, vegetation, and habitat for wildlife (including sensitive species) and, potentially irreversible impacts on biological soil crusts;
- Long-term impacts on some species, both at the population level and to individual organisms;
- Long-term visual impacts on residents of communities near solar facilities, users of roads passing near solar facilities, and patrons of specially designated areas within the viewshed of solar facilities; and
- Long-term noise impacts for solar dish engine facilities and trough or power tower facilities employing thermal energy storage.

The magnitude of these adverse impacts would to some degree depend on a specific project and would be decreased through mitigation, although the extent to which this is possible cannot be assessed except at the project level, and it is possible that these impacts could not be avoided completely.

7.4.2 Short-Term Use of the Environment and Long-Term Productivity

For this assessment, short-term uses are defined as those occurring over a 2- to 3-year period, generally applicable to the site characterization/preparation and construction phases. Long-term uses and productivity are those occurring throughout the 20-year time frame considered in this PEIS.

Although land disturbance within the footprint of solar energy generation facilities would be long-term, additional areas affected during the construction of the generation facilities and related infrastructure (e.g., roads, transmission lines, and natural gas or water pipelines) would result in relatively short-term disturbance. Land clearing and grading and construction and operation activities would disturb surface soils and wildlife and their habitats, and affect local air and water quality, visual resources, and noise levels within and around the solar facility areas and on additional lands used for project-related infrastructure. Short-term influxes of construction workers would affect the local socioeconomic setting.

The lands used for solar facilities long term would produce electricity generated from a renewable source and would result in reduced emissions of GHGs and combustion-related pollutants, assuming the solar facilities offset electricity generated by fossil fuel power plants. These facilities would generate stable jobs and income for nearby communities (although at a lower rate than during the short-term construction phase), sales and income tax revenues, and income for the Federal Government in the form of ROW rental revenues over the life of the projects.

7.4.3 Irreversible and Irretrievable Commitment of Resources

Solar energy development would result in the consumption of sands, gravels, and other geologic resources, as well as fuel, structural steel, and other materials, some of them special-use materials (i.e., metals used in PV solar cells). At decommissioning, some of these materials would be available for reuse.

Water resources would be consumed during the construction phase and during operations, with the extent of water use varying by technology selected; this would be an irreversible and irretrievable loss.

For most plant and animal species, population-level effects would be unlikely, based on the assumption that mitigation measures would be implemented; however, population-level effects are possible for some species. Additionally, during construction, operation, and decommissioning, individual plants and animals would be affected. Site-specific and species-specific analyses conducted at the project level for all project phases would help ensure that the potential for such impacts would be minimized to the fullest extent possible. There would be long-term reductions in habitat due to fencing of large areas during the operational period; this impact would be partially mitigated through siting in locations that do not contain critical habitat. Additional mitigation measures (e.g., conducting long-term monitoring and related additional mitigation) would reduce the impacts over time, if implemented. However, it is unknown whether irreversible and irretrievable impacts on species would occur.

Biological soil crusts are fragile and damage to them could constitute an irreversible and irretrievable impact. When removed, the underlying soils may be subject to increased erosion by both wind and water. Mitigation measures that minimize the amount of land disturbance could be applied to reduce the impacts on these resources.

Cultural and paleontological resources are nonrenewable. Impacts on these resources would constitute an irreversible and irretrievable commitment; however, implementation of appropriate mitigation measures would minimize the potential for these impacts to the extent possible.

Impacts on visual resources in specific locations could constitute an irreversible and irretrievable commitment. Implementation of appropriate mitigation measures would minimize the potential for these impacts to the extent possible; additional mitigation efforts would be undertaken at the project level with stakeholder input.

7.4.4 Mitigation of Adverse Effects

Under the proposed action, DOE would develop programmatic environmental guidance with recommended environmental best management practices and mitigation measures that could be applied to all DOE-funded solar projects. These recommended measures would likely be consistent with the mitigation requirements that would be adopted by the BLM under its action alternatives. BLM's proposed requirements are presented in Section A.2 of Appendix A. By recommending a comprehensive set of mitigation measures, the DOE would help ensure that impacts from solar energy development would be mitigated to the fullest extent possible. Any potential adverse impacts that could not be addressed by DOE's programmatic guidance would be addressed at the project level, where resolution of site-specific and species-specific concerns are more readily achievable.

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14 CONSULTATION AND COORDINATION UNDERTAKEN TO SUPPORT PREPARATION OF THE PEIS

14.1 PUBLIC SCOPING

The U.S. Department of the Interior Bureau of Land Management (BLM) and U.S. Department of Energy (DOE) sponsored two separate public scoping periods to support preparation of this programmatic environmental impact statement (PEIS). The first scoping period solicited comments on the development of the PEIS, including its overall scope and objectives, as well as issues and concerns regarding solar energy development in the six-state study area. The second scoping period solicited comments on the 24 solar energy study areas that were identified by the BLM for in-depth study.

14.1.1 Initial PEIS Scoping

The BLM and DOE published a Notice of Intent (NOI) to prepare a PEIS to evaluate solar energy development in six western states in the *Federal Register* (Volume 73, page 30908) on May 29, 2008. The NOI 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 agencies conducted the initial scoping from May 29, 2008, through July 15, 2008.

The public was offered three methods for submitting scoping comments or suggestions about the PEIS:

- The online comment form on the project Web site,
- Mail, and
- Open public scoping meetings.

Public scoping meetings were held at 11 locations during the scoping period: Riverside, California (June 16); Barstow, California (June 17); Las Vegas, Nevada (June 18); Sacramento, California (June 19); Denver, Colorado (June 23); Phoenix, Arizona (June 24); Salt Lake City, Utah (June 25); Albuquerque, New Mexico (June 26); Tucson, Arizona (July 8); San Luis Obispo, California (July 9); and El Centro, California (July 10). The scoping meetings drew 595 registered participants.

Nearly 15,900 individuals, organizations, and government agencies provided comments on the scope of the PEIS by testifying at public scoping meetings or submitting comments via the project Web site or mail; some people used more than one method to submit comments. Nearly 12,700 comment documents were received through the Wilderness Society as part of a comment campaign. Similarly, the Defenders of Wildlife sent approximately 2,280 comment documents. The BLM and DOE considered the comments in developing the alternatives and analytical issues

contained in this PEIS; all comments received equal consideration regardless of their mode of delivery.

Comments were received from 9 federal agencies, 13 state agencies (within the states of Arizona, California, Colorado, and New Mexico), and 14 local government agencies (within the states of Arizona, California, Nevada, New Mexico, and Utah). Several elected officials, more than 50 environmental groups, and approximately 40 industry groups provided comments.

Comments were received from all 50 states and the District of Columbia; approximately 40% originated from the six states within the study area, with California (*n* = 3,430) and Colorado (*n* = 1,200) providing the most comments. Comments were also received from Canada, American Samoa, Guam, and Puerto Rico.

Comments received during the initial scoping period largely fell into several key categories: environmental, socioeconomic, siting and technology, stakeholder involvement, cumulative impact analyses, impact mitigation, policy, land use planning, alternatives to be analyzed, and coordination with ongoing regional and state planning efforts. The agencies prepared a report that summarized and categorized all comments received during this initial scoping period (DOE and BLM 2008). The scoping summary report and copies of all written comments submitted by mail, via an online comment form, or in person at public meetings are available on the Solar Energy Development Programmatic Environmental Impact Statement project Web site (http://solareis.anl.gov). Transcripts from the public meetings are also available on the Web site.

14.1.2 Solar Energy Study Areas Scoping

The second scoping period was announced by the BLM and DOE through a NOI published on June 30, 2009, in the *Federal Register* (Volume 74, page 31307). This scoping period was initiated to solicit public comments on 24 specific tracts of BLM-administered land—the solar energy study areas—to receive in-depth study for solar development in the PEIS. Specifically, the agencies solicited comments about environmental issues, existing resource data, and industry interest with respect to the study areas. The 24 solar energy study areas were identified in response to Order 3285A1, first issued in March 2009 and amended in February 2010 (Secretary of the Interior 2010), which announced a policy goal of identifying and prioritizing specific locations best suited for large-scale production of solar energy.

The June 30 NOI also announced the availability of maps of the solar energy study areas through the project Web site (http://solareis.anl.gov) and at BLM offices in the six states hosting the study areas. The solar energy study areas scoping period was from June 30 to September 14, 2009. Comments could be submitted electronically or through the mail.

Nearly 300 comments were received during the scoping period; about 20% of the comments contained items specific to the individual study areas. About 75% of the comments came from individuals or organizations in the six-state area containing the solar energy study areas, with the most comments from California (*n* = 130). Comments were received from

4 federal agencies, 7 state agencies (within the states of California, New Mexico, and Nevada), 7 Tribal governments, and 11 industry/ranching groups.

Comments received during the second scoping period are contained in a searchable database, available through the project Web site (http://solareis.anl.gov). A summary of the comments specific to solar energy study areas is provided in the following subsections. The U.S. Department of Defense raised concerns for almost every study area regarding the possible height limitations that may be required.

14.1.2.1 Arizona Study Areas

A commentor observed that the use of Arizona Fish and Game Department data may have overstated the amount of wildlife habitat that is needed, and therefore the boundaries of all areas may require alteration. Others suggested reconfiguring the boundaries to preserve wash and drainage areas and to include trust lands.

One commentor recommended that impacts on sacred landscapes and historic trails be considered in the analysis of all three study areas but did not suggest altering the study areas. A commentor recommended closing the existing grazing allotment in the Brenda study area because the soil in that area was compacted and over-utilized. Resource conflicts in the Bullard Wash area, including three grazing allotments and the presence of tortoise and bighorn sheep, were noted by commentors. Similar resource conflicts were noted for the Gillespie study area, which also hosts a Sonoran Desert viewshed. No recommendations for alteration of the study areas were made on the basis of these concerns.

14.1.2.2 California Study Areas

The presence of cultural sites, wetlands and riparian areas, and threatened and endangered species and habitats and the potential for visual impacts in areas surrounding the study areas prompted some commentors to note that all four study areas should be either deleted from future study or reduced in size. However, other commentors suggested that the Imperial East study area should be expanded to the northwest and doubled in size, and that the Pisgah area be expanded to the west and north to include private, disturbed lands.

Other commentors expressed concerns regarding the four study areas but did not suggest that they be eliminated from the PEIS or modified. The presence of the flat-tailed horned lizard in the Imperial East study area was an issue of interest for one commentor, and another expressed concern that consideration be given to the area's cultural properties and the impacts of water use on Tribal water rights. The protection of sacred landscapes and cultural areas and the presence of tortoise and threatened and endangered species in the Iron Mountain study area were of concern to several commentors.

A commentor pointed out the need for a cultural inventory of the Pisgah study area and others expressed concern about the presence of tortoise habitat, migratory birds, and cultural

resources in the area. Cultural resource and tourism concerns were raised in relation to the Riverside East study area.

14.1.2.3 Colorado Study Areas

A commentor recommended that all four study areas be eliminated from consideration because they are located with the Sangre de Cristo National Heritage Area. Other commentors suggested altering all the study areas to exclude prairie dog colonies with a 0.5-mi (0.8-km) buffer and to give consideration to the Los Caminos Antiguos scenic byway. Alteration of the De Tilla Gulch study area was recommended to take into account elk severe winter range and pronghorn winter concentration areas. Alteration of the boundaries of the Fourmile East and Los Mogotes East study areas was recommended to protect the Old Spanish National Historic Trail.

While not advocating study area boundary alteration, some commentors made observations regarding the four study areas. They suggested that development in the Antonito Southeast and Los Mogotes East study areas will require plans for transmission access and power purchase agreements. A commentor favored developing solar and wind projects in the Antonito Southeast area. Developing mitigations for Paleoindian sites that have not been evaluated for *National Register of Historic Places* eligibility and collecting baseline data and monitoring performance were suggested for the De Tilla Gulch and Fourmile East study areas.

14.1.2.4 Nevada Study Areas

Commentors suggested that the Amargosa Valley study area be eliminated from review in the PEIS because of potential impacts on the Ash Meadow National Wildlife Refuge and Death Valley National Park. They also added that the study area is home to many sensitive biological resources including tortoise.

Commentors advised altering the Dry Lake study area by excluding the southern portion of the area to preserve the high biodiversity there and extending the northern portion eastward to protect tortoise and beardtongue and avoid impacts on the Old Spanish Trail and migratory bird habitat.

Without stating a recommendation for study area size adjustment, commentors suggested that assessments should be conducted in the Dry Lake study area regarding impacts on numerous sensitive species, as well as impacts from groundwater use on the Lake Mead National Recreation Area (NRA). Similarly, comments submitted regarding the Amargosa Valley study area stated that wet cooling should not be allowed, a no-net-water-drawdown stipulation should be implemented, and a detailed water impact analysis should be conducted. A commentor urged that assessments be conducted regarding impacts on sensitive species, and another stated that a full biological inventory was needed for the Amargosa Valley study area.

Commentors noted that the East Mormon Mountain study area should be eliminated from PEIS review because of the presence of tortoise habitat, concerns over grazing, and proximity to the Toquap Conservation site. They also stated that the Delamar Valley and Dry Lake Valley North study areas should be removed from review because groundwater is fully appropriated, thereby precluding development due to lack of groundwater.

Other commentors suggested limiting the East Mormon Mountain study area to 3,780 acres (15 km^2) to accommodate needs of the livestock industry and to avoid conflicts with tortoise and plant habitat, but they also suggested adding fire-disturbed areas. Suggestions were also made to limit the Delamar Valley study area to 5,760 acres (23 km^2) north and northwest of Delamar Lake. Commentors suggested reducing the Dry Lake Valley North study area because of conflicts with grazing and water rights and socioeconomic issues. Another commentor advised reducing the size of the study area to exclude sensitive habitat.

Without recommending specific boundary modifications, commentors raised concerns about the East Mormon Mountain, Delamar Valley, and Dry Lake Valley North study areas. They suggested studying impacts on numerous species, including tortoise and buckwheat, and on the Lake Mead NRA from groundwater use in the East Mormon Mountain study area. Regarding the Delamar Valley study area, commentors raised concerns about impacts on bighorn migration, water, eagles, rock art, tortoise, and White River fish. Concerns about the impacts on water, bighorn sheep, milkvetch, and Heritage Program species (e.g., fishhook cactus, milkweed, and the kangaroo mouse) were also raised for the Dry Lake Valley North study area. Concerns about impacts on the livestock industry in all three study areas were also raised.

A commentor suggested altering the Millers study area to exclude the sand dunes in the northeast portion of the area because of diverse small mammal habitat and to avoid impacts on lizards and birds. The Millers study area was also the subject of concerns regarding water use, wildlife, and impacts on milkvetch, bighorn sheep, and prairie falcons; however, no recommendations were made regarding alteration of the study area. A commentor also raised a social justice issue—the economic benefits of projects would go to a county that did not host the solar projects. Another commentor suggested that projects be restricted to photovoltaic technologies that require little water.

A commentor observed that water use and transmission line access could be of concern at the Gold Point study area but did not recommend a change to the study area.

14.1.2.5 New Mexico Study Areas

Several commentors suggested eliminating the Mason Draw and Red Sands study areas because they contain good grassland and wildlife habitat. Other commentors recommended reducing the size of Mason Draw to avoid sensitive areas and exclude roadless and wilderness quality lands. Suggestions were offered to reduce the Red Sands study area by dropping the southern and northwestern portions because of grassland quality and excluding BLM habitat restoration areas.

Redrawing the Afton study area was suggested to avoid an area of high reptilian diversity in the eastern part of the study area, but it also was suggested that new areas to the east could be considered.

Although no recommendations regarding perimeter alteration of the Afton study area were made, the following concerns were raised: potential air quality issues (dust), negative visual impacts, potential impacts on the Aden Lava Flow Area of Critical Environmental Concern and wilderness inventory unit, and proximity to infrastructure and Las Cruces. For the Red Sands study area, visual impact, air quality, and impacts of development and water use were concerns mentioned, but boundary modification was not suggested.

14.1.2.6 Utah Study Areas

Commentors recommended that all three study areas be altered to avoid adverse direct and indirect impacts on the Old Spanish National Historic Trail. Additional recommendations were to avoid occupied or historic prairie dog colonies, pygmy rabbit population areas, and past or currently occupied owl dens in the Escalante Valley study area and to avoid sage grouse leks and brood areas in the Milford Flats South study area.

While not recommending alterations to study area size, commentors made several recommendations regarding the Milford Flats South and Wah Wah Valley study areas. Concerns were raised about the sage grouse, pygmy rabbit, and potential prairie dog populations in the Milford Flats South study area. One commentor mentioned that the southern part of the study area overlaps the Utah watershed restoration initiative and that five sensitive species were present on-site.

The Wah Wah Valley study area was described as being too close to proposed wilderness areas and wild undisturbed lands; concerns about visual and recreation impacts were raised. Five species were identified as being in the study area, and a sage grouse impact assessment was recommended.

A commentor mentioned that raptor management guidelines should be followed at all three study areas.

14.2 GOVERNMENT-TO-GOVERNMENT CONSULTATION

The Federal Government works on a government-to-government basis with Native American Tribes. The government-to-government relationship was formally recognized on November 6, 2000, with Executive Order 13175 (*Federal Register*, Volume 65, page 67249). As a matter of practice, the BLM coordinates with all Tribal governments, associated Native communities and Native organizations, and Tribal individuals whose interests might be directly and substantially affected by activities on public lands. In addition, Section 106 of the National Historic Preservation Act (NHPA) requires federal agencies to consult with Indian Tribes for undertakings on Tribal lands and for historic properties of significance to the Tribes that may be

affected by an undertaking (Title 36, Part 800.2 (c)(2) of the *Code of Federal Regulations*). BLM Manual 8120 (BLM 2004a) and BLM Handbook H-8120-1 (BLM 2004b) provide guidance for Native American consultations. The BLM has given substantial consideration to the proper conduct of government-to-government consultations for this project in order to provide for multiple opportunities for Tribal consultation.

Executive Order 13175 stipulates that Tribes identified as "directly and substantially affected" be consulted by federal agencies during the National Environmental Policy Act (NEPA) process. In June 2008, letters originating from the BLM state offices in the six-state study area were sent to 253 Tribes, Chapters, and Bands identified by the state offices, inviting those Tribes to be cooperating parties and offering government-to-government consultation. On July 1, 2009, with the expansion of the PEIS to include 24 specific solar energy study areas, a second letter was sent to 316 Tribes, Chapters, and Bands identified by the BLM, seeking comments on the proposed action and solar energy study areas and indicating that the Section 106 consultation process of the NHPA would be conducted concurrently with the NEPA process and government-to-government consultation requirements. The BLM followed up with additional letters, phone calls, e-mails, and meetings for Tribes whose traditional use areas are closest to the proposed study areas. These communications were sent to a broad range of Tribes to determine levels of interest in further discussions regarding the Solar PEIS.

As of August 2010, 36 Tribes had responded by letter, e-mail, or telephone or had met with local BLM personnel. Written responses were received from 15 Tribes or Tribal organizations either directly in response to the BLM letters or through the NEPA scoping process for the PEIS. Three Tribes contacted the BLM Washington Office directly by telephone. Five Tribes (Quechan, Soboba Band of Luiseño Indians, Pueblo of Zuni, Cheyenne-Arapaho Tribes of Oklahoma, and Paiute Indian Tribes of Utah) requested either consultation or further information on the PEIS. The Agua Caliente Band of Cahuilla Indians, Cabazon Band of Cahuilla Mission Indians, and the Cheyenne-Arapaho Tribes of Oklahoma also made inquiries about becoming a cooperating agency or party for the PEIS. A list of Tribes contacted and a summary of the responses as of August 2010 are provided in Appendix K, along with copies of correspondence with Native American Tribes.

Government-to-government consultation for the Solar PEIS is ongoing. The BLM will continue to consult with interested Tribes and will continue to keep all Tribal entities informed about the NEPA process for the PEIS. In addition, the BLM will continue to implement government-to-government consultation on a case-by-case basis for site-specific solar energy development projects on BLM-administered lands.

14.3 COORDINATION OF BLM STATE AND FIELD OFFICES

This PEIS was prepared by the BLM Washington Office to evaluate a program that will determine how solar energy development is administered in each of the six states in the study area. Regular conference calls and other communications were held with BLM state and field office staff to share information about the Solar PEIS. State and field office staff provided much of the geographic information system data that allowed mapping of the BLM-administered lands

and special status areas. The PEIS team visited each of the states to tour the 24 proposed solar energy zones (SEZs), collect field data, interact with state and field office staff, and facilitate other data sharing. In addition, BLM state and field office staff were involved in reviews of preliminary, internal draft sections of text.

Coordination with the state and field office staff will continue throughout the preparation of the Final PEIS to ensure that the analysis adequately reflects state- and local-level concerns and issues regarding solar energy development. In addition, BLM Washington Office staff will work with state and field office staff following the release of the Record of Decision (ROD) to support implementation of the new Solar Energy Program.

14.4 AGENCY COOPERATION, CONSULTATION, AND COORDINATION

The BLM and DOE invited federal, Tribal, state, and local government agencies to participate in preparation of the Solar PEIS as cooperating agencies. A total of 19 agencies, listed in Section 1.5, are working with the BLM and/or DOE as cooperating agencies. These agencies include six federal agencies, six state agencies, and seven counties. In addition, the State of California has established an Interagency Working Group as a means of coordinating federal, state, and county agency participation in the PEIS process for that state; this working group includes additional state agencies and counties beyond those that have signed Memorandums of Understanding. Interactions with the cooperating agencies have included periodic briefings and reviews of preliminary, internal draft sections of text. The BLM and DOE will continue to engage these cooperating agencies throughout the preparation of the PEIS.

In accordance with the requirements of Section 106 of the NHPA, the BLM is coordinating with and soliciting input from the State Historic Preservation Offices (SHPOs) in each of the six states in the study area and from the Advisory Council on Historic Preservation. In addition, the National Council of SHPOs, the National Trust for Historic Preservation, and Tribal Governments (also see Section 14.2) have been invited to consult on the PEIS and the preparation of a National Programmatic Agreement (PA) regarding solar energy development. The PA will provide for a phased consultation process related to historic, traditional, and cultural resources for the PEIS and subsequent activities that could tier from the PEIS ROD. Details regarding the consultation process, including correspondence, are presented in Appendix K; the PA will also be provided in Appendix K when it becomes available.

In accordance with the requirements of Section 7 of the Endangered Species Act, the BLM would consult with the U.S. Fish and Wildlife Service to ensure that the BLM's proposed action would not jeopardize the continued existence of any listed threatened or endangered species. These consultations are ongoing and are anticipated to result in programmatic biological assessments and biological opinions for each of the proposed SEZs. Ongoing coordination regarding the consultation approach for the programmatic component of the PEIS continues to occur.

In addition, the BLM has initiated activities to coordinate and consult with the governors in each of the six states and with state agencies. Additional coordination will be conducted

during review of the Draft PEIS. Prior to approval of the proposed plan amendments, the governor of each state will be given the opportunity to identify any inconsistencies between the proposed plan amendments and state or local plans and to provide recommendations in writing (during the 60-day consistency review period).

14.5 REFERENCES

Note to Reader: This list of references identifies Web pages and associated URLs where reference data were obtained for the analyses presented in this PEIS. 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. The original information has been retained and is available through the Public Information Docket for this PEIS.

BLM (Bureau of Land Management), 2004a, *Manual 8120—Tribal Consultation under Cultural Resources*, Release 8-74, U.S. Department of the Interior. Available at http://www.blm.gov/pgdata/etc/medialib/blm/wo/Information_Resources_Management/policy/blm_manual.Par.80216.File.dat/8120.pdf.

BLM, 2004b, *Handbook H-8120-1—General Procedural Guidance for Native American Consultation*, Release 8-75, U.S. Department of the Interior. Available at http://www.blm.gov/pgdata/etc/medialib/blm/wo/Information_Resources_Management/policy/blm_handbook.Par.86923.File.dat/h8120-1.pdf.

DOE (U.S. Department of Energy) and BLM (Bureau of Land Management), 2008, *Summary of Public Scoping Comments Received during the Scoping Period for the Solar Energy Development Programmatic Environmental Impact Statement*, Washington, D.C., Oct.

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/app_so/act_getfiles.cfm?order_number=3285A1.

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15 LIST OF PREPARERS

Table 15-1 lists the U.S. Department of the Interior (DOI) Bureau of Land Management (BLM) and U.S. Department of Energy (DOE) management team members for the Solar Programmatic Environmental Impact Statement (Solar PEIS). Table 15-2 lists the names, education, and expertise of the Solar PEIS preparers.

TABLE 15-1 Agency Management Team

Name	Office/Title
Bureau of Land Management	
Ray Brady	Minerals and Realty Management Directorate Manager, Energy Policy Team
Linda Resseguie	Minerals and Realty Management Directorate, Realty Specialist
Jessica Rubado	Renewable Resources and Planning Directorate; Wildlife Biologist
Shannon Stewart	Renewable Resources and Planning Directorate; Senior Planning and Environmental Analyst
U.S. Department of Energy	
Mark Lausten	Senntech
Dr. Jane Summerson	Energy Efficiency and Renewable Energy, PEIS Document Manager
Mark Wieringa	Western Area Power Administration, Environmental Protection Specialist
Frank Wilkins	Concentrating Solar Power, Solar Energy Technologies Program, Team Leader

TABLE 15-2 Solar PEIS Preparers

Name	Education/Expertise	Contribution
Argonne National Laboratory		
Timothy Allison	M.S., Mineral and Energy Resource Economics; M.A., Geography; 20 years of experience in regional analysis and economic impact analysis.	Technical lead for socioeconomic analysis and environmental justice
Georgia Anast	B.A., Mathematics/Biology; 16 years of experience in environmental assessment.	Comment/response manager
Halil Avci	Ph.D., Nuclear Engineering; 25 years of experience in environmental assessment, waste management, and project management.	Technical lead for cumulative impacts analysis—Colorado and Utah
Kevin J. Beckman	B.S., Mathematics and Computer Science; 1 year of experience in Web programming and visual impact analysis.	Public Web site development and technical support for visual impact analysis
Bruce Biwer	Ph.D., Chemistry; 20 years of experience in environmental assessment and transportation risk analysis.	Transportation impacts
Matthew Braun	B.S., Anthropology and Psychology, 3 years of archaeological field experience.	Cultural resources analysis
Brian L. Cantwell	B.S., Forestry; 25 years of experience in cartography and GIS mapping.	Technical lead for GIS mapping
Adrianne Carr	Ph.D., Geological and Environmental Sciences; 4 years of experience in hydrological studies and impact analysis.	Water resources analysis
Youngsoo Chang	Ph.D., Chemical Engineering; 20 years of experience in air quality and noise impact analysis.	Technical lead for air quality and emissions, noise
Roberta S. Davidson	M.S., Forest Biometrics; 16 years of experience in environmental assessment, environmental and logistics modeling, and software verification and validation.	Socioeconomics and cumulative impacts analysis
John DePue	M.S., Biology; 36 years of experience in technical editing and environmental assessment document production.	Editor
John Gasper	M.S., M.P.H., Environmental Health Science; 31 years of experience in environmental and energy assessment and program management.	Project management; document review

TABLE 15-2 (Cont.)

Name	Education/Expertise	Contribution
Linda Graf	Desktop publishing specialist; 39 years of experience in creating, revising, formatting, and printing documents.	Document assembly and production
Hal P. Greenwood	B.S., Geography; 12 years of experience in cartography and GIS mapping.	GIS mapping
Mark A. Grippo	Ph.D., Biology; 4 years of experience in aquatic resource studies and impact analysis.	Ecological resources analysis (aquatic)
Antonio C. Guerrero	Certificate in Geographic Information Analysis; 1 year of GIS analysis.	Technical support for visual impact analysis; public Web site, and GIS database maintenance
Heidi M. Hartmann	M.S., Environmental Toxicology and Epidemiology; 23 years of experience in environmental assessment, exposure and risk analysis, and environmental impact assessment.	Project Manager, programmatic analyses, health and safety assessment
John Hayse	Ph.D., Zoology; 23 years of experience in ecological research and environmental assessment.	Ecological resources analysis (aquatic)
Elizabeth Hocking	J.D.; 17 years of experience in regulatory and policy analysis.	Regulatory requirements
Irene Hogstrom	M.A., Geography and Environmental Studies; B.L.A., Landscape Architecture; 21 years of experience in landscape architecture, including design, regional planning, and ecological restoration.	Visual resources research analysis
Amanda Hollingsworth	B.A.; 4 years of experience in GIS analysis and mapping.	Spatial analysis and map compilation
Patricia Hollopeter	B.A., Religion; M.A., Philosophy; 25 years of experience in technical editing and environmental assessment document production.	Lead editor
Ronald Kolpa	M.S., Inorganic Chemistry; B.S., Chemistry; 36 years of experience in environmental regulation, auditing, and planning.	Technical lead for hazardous materials and waste management and technology overview; health and safety assessment analysis

TABLE 15-2 (Cont.)

Name	Education/Expertise	Contribution
Thomas J. Kotek	M.S., Computer Science; 35 years of experience in data management and database-driven Web applications.	Webmaster and data management for PEIS online comment submisssions
Kirk E. LaGory	Ph.D., Zoology, M.En., Environmental Science; 33 years of experience in ecological research, 22 years in environmental assessment.	Technical lead for ecological resources analysis; threatened and endangered species
Janet M. Lyons	Records management specialist; 10 years experience in records management for environmental programs and projects.	Administrative records management; administrative support to Tribal consultation activities
Gary Marmer	Ph.D., Physics; 38 years of experience in environmental assessment.	Cumulative impacts analysis
Tony Martinez	J.D., Law; 27 years in the practice of law, with an emphasis on water law.	Water demand analysis—Colorado
James E. May	M.S., Water Resources Management; B.A., Zoology; 32 years of experience in natural resources management; 4 years of consulting experience in land use planning and NEPA compliance.	Technical lead for lands and realty, specially designated areas and lands with wilderness character, livestock grazing, wildland fire, recreation, military and civilian aviation, and minerals assessments
Mary Moniger	B.A., English; 33 years of experience in editing and writing.	Editor
H. Robert Moore	B.S., Forest Management and Engineering; 40 years of experience in natural resource management; 13 years in natural resource program management and coordination.	Management team consultation
Ellen Moret	M.P.P., Public Policy; B.A., Environmental Studies; 6 years of experience in environmental assessment.	Document technical content management; technology overview analysis
Michele Nelson	Graphic designer; 32 years of experience in graphical design and technical illustration.	Graphics
Lee Northcutt	A.A., General Studies/English; 22 years of experience in program/editorial assistance, and environmental impact statements.	Glossary, list of preparers

TABLE 15-2 (Cont.)

Name	Education/Expertise	Contribution
Ben L. O'Connor	Ph.D., Civil Engineering; 4 years of experience in hydrological studies and impact analysis.	Technical lead for water resources
Katherine Obmascik	M.B.A., Marketing Communications Management; B.A., Journalism; 27 years of experience in technical writing and editing.	Editor
Terri Patton	M.S., Geology; 22 years of experience in environmental research and assessment.	Technical lead for geological resources; contributor for cumulative impacts analysis
Edwin D. Pentecost	Ph.D., Zoology, Ecology; M.S., Biology; 32 years of environmental assessment experience and ecological impact evaluation.	Cumulative impacts analysis
Kurt Picel	Ph.D., Environmental Health Sciences; 31 years of experience in environmental health analysis and 17 years in environmental assessment.	Technical lead for cumulative impact analyses; overall document technical content management
Pamela Richmond	M.S., Computer Information Systems; 15 years of experience in Web site development and related technology.	Public Web site development and technical support for visual impact analysis
Judy Robson	Desktop publishing specialist; 30 years of experience in creating, revising, formatting, and printing documents.	Document assembly and production
Barbara Salbego	Desktop publishing specialist; 31 years of experience in creating, revising, formatting, and printing documents.	Document assembly and production
Lorenza Salinas	Desktop publishing specialist; 28 years of experience in creating, revising, formatting, and printing documents.	Document assembly and production
Kerri Schroeder	Desktop publishing specialist; 30 years of experience in creating, revising, formatting, and printing documents.	Document assembly and production
Barbara Simmons	B.A., technical writing; E.L.S. certification by the Board of Editors in the Life Sciences; Fellow of the Society for Technical Communication; 45 years of experience in technical editing and publications management.	Editor

TABLE 15-2 (Cont.)

Name	Education/Expertise	Contribution
Vicki Skonicki	Desktop publishing specialist; 16 years of experience in creating, revising, formatting, and printing documents.	Document assembly and production.
Albert E. Smith	Ph.D., Physics; 36 years of experience in policy analysis, air and noise impact assessment, and regulatory analysis.	Air quality analysis
Karen P. Smith	M.S., B.A., Geology; B.S., Anthropology; more than 21 years of experience in energy and environmental regulatory and policy analysis.	Program Manager, programmatic analyses; Appendix C (Proposed BLM Land Use Plan Amendments), Appendix D (Related Programs), and Appendix G (Transmission Constraints)
Carolyn M. Steele	B.A., English; B.A., Rhetoric; 4 years of experience in technical writing and editing.	Editor
Robert Sullivan	M.L.A., Landscape Architecture; 21 years of experience in visual impact analysis and simulation; 13 years in Web site development.	Technical lead for visual impact analysis; public Web site development
David Tomasko	Ph.D., Civil Engineering—Water Resources; 35 years of experience doing water related studies.	Groundwater resources analysis
Jack C. VanKuiken	M.S., Systems Science; 35 years of experience in electrical power systems modeling, optimization, and analysis.	Analysis for Appendix D (Related Programs), Appendix E (RPS-based RFDS), and Appendix G (Transmission Constraints)
Robert A. Van Lonkhuyzen	B.A., Biology; 20 years of experience in ecological research and environmental assessment.	Ecological resources analysis (plant communities/habitats)
Bruce Verhaaren	Ph.D., Archaeology; 20 years of experience in archaeological analysis; 16 years in environmental assessment and records management.	Native American concerns analysis; records management
William S. Vinikour	M.S., Biology with environmental emphasis; 34 years of experience in ecological research and environmental assessment.	Ecological resources analysis (wildlife, wild horses and burros)

TABLE 15-2 (Cont.)

Name	Education/Expertise	Contribution
Walston, Leroy J., Jr.	M.S., Biology; 5 years of experience in ecological research and environmental assessment.	Ecological resources analysis (special status species)
Patricia Weikersheimer	M.F.A., English-Writing; 22 years of experience in technical editing.	Editor
Konstance L. Wescott	M.A., Anthropology; 23 years of experience in archaeological research and 20 years of experience in environmental assessment.	Technical lead for paleontology, cultural resources, and Native American concerns
Suzanne Williams	B.S., Communication Studies with concentration in English; 26 years of experience in technical communications.	Editor
C. Ron Yuen	Ph.D., Geology; 23 years of experience in engineering geology, environmental geology, and hydrogeology.	Surface water resources, water demand analysis
Emily A. Zvolanek	B.A., Environmental Science; 2 years of experience in GIS mapping.	GIS mapping

Argonne Student Interns: Renee R. Francese, Texas A&M; Alexander Jamerson, Syracuse University; William Sterne, Colorado State University; Gerina Tsosie, Arizona State University

National Renewable Energy Laboratory

Nate Blair	MBA, Tech. Management; M.S., Mechanical Engineering; B.A., Physics; 18 years of experience in system modeling and simulation in renewable energy.	Solar development forecasting (Chapter 2), Appendix E
Doug Dahle	B.S., Mechanical Engineering; 10 years of experience in solar power project development.	Solar development forecasting (Chapter 2), Appendix E
Donna Heimiller	M.F., Spatial Data Analysis; B.S., Natural Resources; 12 years of experience in geospatial analysis and electric sector modeling.	Solar development forecasting (Chapter 2), Appendix E
Matthew Mowers	M.S., Mechanical Engineering-Energy Systems; B.S., Mechanical Engineering; 1.5 years of experience in electric sector modeling.	Solar development forecasting (Chapter 2), Appendix E

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16 GLOSSARY

100-year floodplain: The area that would be inundated by water during a flood event, having a one-percent chance of being equaled or exceeded in magnitude, in any given year.

AADT: *See* Average Annual Daily Traffic.

Abiotic: Non-living or non-biological; includes chemical and physical environments and processes.

AC: *See* Alternating current.

Acceleration (peak horizontal): A measure of earthquake acceleration (i.e., shaking) on the ground surface expressed in g, the acceleration due to the Earth's gravity.

Access roads: Gravel or dirt roads (rarely paved) that provide overland access to transmission line and pipeline rights-of-way (ROWs) and facilities for construction, inspection, maintenance, and decommissioning. Access roads have an average distance of 5 mi or less, have a nominal width of 15 ft, and exist within the center of a nominal 25-ft-wide ROW.

Acid deposition: A comprehensive term for the various ways acidic compounds precipitate from the atmosphere and deposit onto surfaces. It can include wet deposition by means of acid rain, fog, and snow; and dry deposition of acidic particles (aerosols).

Active Management Areas (AMAs): Active Management Areas were established in Arizona to provide long-term management and conservation of limited groundwater supplies. In order to accomplish this, the AMAs administer state laws, explore ways of augmenting water supplies to meet future needs, and routinely work to develop public policy to promote efficient use and an equitable allocation of available water supplies.

Active volcano: A volcano that is erupting. Also, a volcano that is not presently erupting, but that has erupted within an historical time and is considered likely to erupt in the future.

Acute: Resulting in immediate impacts; short-term.

Adequate Water Supply Program: The Arizona Adequate Water Supply Program requires anyone who offers subdivided land outside of an Active Management Area for sale or lease to obtain a determination from the Arizona Department of Water Resources regarding the availability of water supplies before the land may be marketed to the public as defined in *Arizona Administrative Code* R12-15-715 et seq.

Adverse environmental impacts: Impacts that are determined to be harmful to the environment. *See also* Effects.

AERMOD: A refined, steady-state plume model that incorporates air dispersion on the basis of a state-of-the-art planetary boundary layer turbulence structure and scaling concepts, and that builds wake effects and plume downwash for point sources. AERMOD is one of the EPA's preferred and recommended models for many regulatory applications.

Affected Environment: For an environmental impact statement, a description of the existing environment covering information necessary to assess or understand the impacts. It must contain enough detail to support the impact analyses and must highlight environmentally sensitive resources (e.g., floodplains, wetlands, threatened and endangered species, and archeological resources).

Aftershocks: Earthquakes that follow the largest shock of an earthquake sequence. They are smaller than the mainshock and within one to two rupture lengths distance from the mainshock. Aftershocks can continue over a period of weeks, months, or years. In general, the larger the mainshock, the larger, and more numerous the aftershocks, and the longer they will continue.

Aggregate: The sum total.

Agricultural fires: Fires ignited to meet specific management objectives on agricultural lands.

Air pollutant: Any substance in the air which could, if in high enough concentration, harm humans, other animals, vegetation, or material. Pollutants may include almost any natural or artificial composition of matter capable of being airborne.

Air Quality Control Region (AQCR): An interstate or intrastate area designated by the U.S. Environmental Protection Agency for the attainment and maintenance of National Ambient Air Quality Standards.

Air quality: Measure of the health-related and visual characteristics of the air to which the general public and the environment are exposed.

Air quality standards: The legally prescribed level of constituents in the outside air that cannot be exceeded during a specific time in a specified area.

Albedo (effects): The fraction of solar radiation reflected by a surface or object, often expressed as a percentage. Snow-covered surfaces have a high albedo; the albedo of soils ranges from high to low; vegetation-covered surfaces and oceans have a low albedo. The Earth's albedo varies mainly through varying cloudiness, snow, ice, leaf area, and land-cover changes.

Aliquot (parts): The standard subdivisions of a section (usually 640 acres [2.6 km^2]) of land, such as a half section, quarter section, or quarter-quarter section.

Alkali: A mixture of soluble salts found in arid soils and some bodies of water, and as pure deposits in dry lake beds; detrimental to agriculture.

Alkali sink: A land basin in which water evaporation produces high salt concentrations that may, or may not, support salt marsh vegetation.

All-American Canal: The All-American Canal System, located in the southeastern corner of California, consists of the Imperial Diversion Dam and Desilting Works, the 80-mile-long All-American Canal, the 123-mile-long Coachella Canal, and appurtenant structures. The system has the capacity, through water diversions from the Colorado River at Imperial Dam, to provide irrigation water for nearly 600,000 acres of land in the Imperial and Coachella Valleys. No power is developed on the system by the Federal Government. The Imperial Irrigation District (IID), which operates the All-American Canal, has constructed small hydroelectric power plants at several locations along the canal to provide electricity throughout the IID service area.

All-American Roads: A National Scenic Byway is a road recognized by the U.S. Department of Transportation for its archeological, cultural, historic, natural, recreational, and/or scenic qualities. The most scenic of the roads are called All-American Roads. The designation means they have features that do not exist elsewhere in the United States and are scenic enough to be tourist destinations unto themselves. As of September 2005, there are 99 National Scenic Byways and 27 All-American Roads located in 44 states.

Allotment: An area of land where one or more livestock operators graze their livestock. Allotments generally consist of BLM lands but may also include other federally managed, state owned, and private lands. An allotment may include one or more separate pastures. Livestock numbers and periods of use are specified for each allotment.

Alluvial: Formed by the action of running water; of or related to river and stream deposits.

Alluvial fan: A fan-shaped depositional landform consisting of alluvial deposits that formed where a flowing stream slows and spreads out (depositing its load), typically at the base of a mountain range where there is a marked change in slope. Fan deposits tend to be coarse-grained at their mouths, but grade to finer-grained material toward their edges.

Alluvian fan terrace: A relict landform consisting of thick gravel, sand, and boulder deposits occurring along mountain fronts. Fan terraces are no longer areas of deposition as active alluvial fans are (due either to tectonic uplift or entrenchment of main washes).

Alluvial flats: A small flat area or plain (with slopes of less than 5 or 10 feet per mile) built of fine sediments deposited during flooding events. *See also* Alluvial plains.

Alluvial plains: A small flat area or plain (with slopes of less than 5 or 10 feet per mile) built of fine sediments deposited during flooding events. *See also* Alluvial flats.

Alluvial valley: An alluvium-filled basin, usually occurring between mountain ranges.

Alluvium: Deposits of clay, silt, sand, gravel, or other particulate materials that have been deposited by a stream or other body of running water in a streambed, on a flood plain, on a delta, or at the base of a mountain.

Alpine: Refers to high mountain areas above the timberline (where trees cease to inhabit extremely cold environments).

Alpine tundra: Vegetation in montane habitats above the tree line. Vegetation consists of perennial forbs, grasses, sedges, and short woody shrubs. Alpine tundra is distinguished from Arctic tundra, because alpine tundra typically does not have permafrost, and alpine soils are generally better drained than arctic soils.

Alquist-Priolo Earthquake Fault Zoning Act: California seismic zoning act passed in 1972, in response to the 1971 San Fernando earthquake, to prevent building across the traces of active faults.

Alternating current (AC): An electric current that reverses its direction at regularly recurring intervals.

Alternative: A mix of management prescriptions applied to specific land areas to achieve a set of goals and objectives. Each alternative represents a different way of achieving a set of similar management objectives. Sometimes the term "action alternative" is used when it is desirable to recognize that there is a "no action" alternative under which the proposed activity would not take place.

Ambient air: The surrounding atmosphere as it exists around people, plants, and structures.

Ambient Air Quality Standards: Regulations prescribing the levels of airborne pollutants that may not be exceeded during a specified time in a defined area.

American Indian Religious Freedom Act of 1978 (AIRFA): Act requiring federal agencies to consult with tribal officials to ensure protection of religious cultural rights and practices.

Amphibian: A cold-blooded, smooth-skinned vertebrate of the class Amphibia, such as a frog, toad, or salamander, that characteristically hatches as an aquatic larva with gills. The larva then transforms into an adult with air-breathing lungs.

Andesite: Volcanic rock (or lava), characteristically medium dark in color and containing 54 to 62 percent silica and moderate amounts of iron and magnesium (intermediate composition).

Angle of view: The angle, both vertical and horizontal, between a viewer's line of sight and the landscape being viewed. *See also*: Horizontal angle of view; Vertical angle of view.

Animal Unit: A unit of measure for rangeland livestock equivalent to one mature cow or five sheep or five goats, all over 6 months of age. An animal unit is based on average daily forage consumption of 26 pounds of dry matter per day.

Animal Unit Month (AUM): A standardized unit of measurement of the amount of forage required by an animal unit for one month. Also, the measurement of the privilege of grazing one animal for one month.

Anthropogenic emissions: Made by people or resulting from human activities. Usually used in the context of emissions that are produced as a result of human activities.

Anthropomorphic: Described or thought of as having human form or human attributes.

Anthropomorphism: Ascribing human qualities, characteristics, or behavior to inanimate objects, animals, or natural phenomena.

Application for Certification (AFC): Document required for submission to the California Energy Commission by proponents of power-generating facilities in California that have nameplate ratings of 50 MW or greater and that utilize steam.

Appropriate Management Level (AML): The maximum number of animals (wild horses or burros) sustainable on a yearlong basis.

Appropriation Doctrine: The system of water law primarily used in the western United States under which: 1. The right to water is acquired by diverting water and applying it to a beneficial use; and 2. An existing right to water use is superior to a right developed later in time.

Appropriations: Refers to the process of divvying out water right allotments and beneficial uses within a water management district.

Aquaculture: Farming of plants and animals that live in water, such as fish, shellfish, and algae.

Aquatic biota: Collective term describing the organisms living in or depending on the aquatic environment.

Aquatic ecosystem: The distinctive ecosystem dominated by water, aquatic plants, or aquatic animals. Usually the substrate for plant and microorganism growth is water, not soil in the usual sense. This is distinct from the riparian ecosystem, which is a terrestrial ecosystem, and water-dependent, but where the substrate is soil. In the aquatic ecosystem, producers include phytoplanktonic algae, and autotrophic consumers include crustaceans, rotifers, and fish. Heterotrophic consumers include benthic insects, mollusks, and crustaceans.

Aquatic habitats: Areas associated with water that provide food and cover and other elements critical to the completion of an organism's life cycle (e.g., bogs, swamps, riparian areas and streams).

Aquatic opportunists: Species that occupy both temporary and permanent waters.

Aquifer: A water-bearing rock that readily transmits water to a well or spring.

Aquifer-basin-fill: An aquifer located in a basin surrounded by mountains and composed of sediments and debris shed from those mountains. Sediments are typically sand and gravel with some clay.

Aquifer-carbonate rock: An aquifer found in limestone and dolomite rocks. Carbonate aquifers typically produced hard water, that is, water containing relatively high levels of calcium and magnesium.

Aquifer-confined: Soil or rock below the land surface that is saturated with water. There are layers of impermeable material both above and below it and it is under pressure so that when the aquifer is penetrated by a well, the water will rise above the top of the aquifer.

Aquifer-unconfined: An aquifer whose upper water surface (water table) is at atmospheric pressure, and thus is able to rise and fall.

Aquifer-volcanic rock: An aquifer in which the rock matrix is composed of volcanic rocks, (e.g., tuffs or basalt flows).

Arable lands: Refers to all lands generally under rotation whether it is under temporary crops, temporarily fallowed, or used as temporary meadows.

Archaeological site: Any location where humans have altered the terrain or discarded artifacts during prehistoric or historic times.

Arctic tundra: A treeless area between the icecap and the tree line of Arctic regions that has permanently frozen subsoil and supports low-growing vegetation such as lichens, mosses, and stunted shrubs.

Area of Potential Effect (APE): The geographic area or areas within which an undertaking (project, activity, program, or practice) may cause changes in the character or use of any cultural resources that are present.

Area sources (emissions): Any source of air pollution that is released over a relatively small area but which cannot be classified as a point source. Such sources may include vehicles and other small engines, small businesses and household activities, or biogenic sources such as a forest that releases hydrocarbons.

Areas of Critical Environmental Concern (ACECs): These areas are managed by the Bureau of Land Management and are defined by the Federal Land Policy and Management Act of 1976 as having significant historical, cultural, and scenic values, habitat for fish and wildlife, and other public land resources, as identified through the Bureau of Land Management's land-use planning process.

Arid: A region that receives too little water to support agriculture without irrigation. Less than ten inches of rainfall a year is typically considered arid.

Arizona Water Banking Authority (AWBA): The AWBA was established in 1996 to increase utilization of the state's Colorado River entitlement and to develop long-term storage credits for the state. AWBA stores or "banks" unused Colorado River water to be used in times of shortage to firm (or secure) water supplies for Arizona. These water supplies help to benefit municipal and industrial users and communities along the Colorado River, fulfill the water management objectives of the state, store water for use as part of water rights settlement agreements among Indian communities, and assist Nevada and California through interstate water banking.

Arrays: *See* Photovoltaic (PV) array.

Arroyo: A Spanish word for brook that refers to a dry river, creek, or stream bed that temporarily or seasonally fills and flows after sufficient rain. Also referred to as a wash.

Artesian water (**artesian pressure):** Groundwater that is under pressure when tapped by a well and is able to rise above the level at which it is first encountered. It may or may not flow out at ground level. The pressure in such an aquifer commonly is called artesian pressure, and the formation containing artesian water is an artesian aquifer or confined aquifer.

Artifact: An object produced or shaped by human beings and of archaeological or historical interest.

Atlatl: A wood or bone shaft implement, held in one hand, and used to throw a spear. The tool functions as a lever, giving greater thrust and distance.

Atmosphere: The gaseous envelope surrounding the Earth, which consists almost entirely of nitrogen (78.1% volume mixing ratio) and oxygen (20.9% volume mixing ratio), together with a number of trace gases, such as argon (0.93% volume mixing ratio), radiatively active greenhouse gases such as carbon dioxide (0.035% volume mixing ratio), and air pollutants such as ozone. In addition, the atmosphere contains water vapor, whose amount is highly variable (up to 4% volume mixing ratio), clouds, and aerosols.

Atmospheric absorption: Attenuation of sound during its passage through air, during which its sound energy is gradually converted into heat by a number of molecular processes in the air. The attenuation depends strongly on frequency and relative humidity, less strongly on temperature, and slightly on the ambient pressure.

Attainment: An area considered to have air quality as good as or better than the National Ambient Air Quality Standards for a given pollutant. An area may be in attainment for one pollutant and in nonattainment for others. *See also* In attainment.

Attenuation: The reduction in level of sound.

Augmentation Plan: A court-approved plan that allows a junior water user to divert water out of priority so long as adequate replacement is made to the affected stream system, preventing injury to the water rights of senior users.

Augmentation water: Water used for the replacement of out of priority depletions.

Average Annual Daily Traffic (AADT): A measurement representing the total number of vehicles passing a given location, based upon 24-hour counts taken over an entire year. Mechanical counts are adjusted to an estimate of annual average daily traffic figures, taking into account seasonal variance, weekly changes, and other variables.

Background level noise: Noise in the environment (other than noise emanating from the source of interest).

Bajada: A broad sloping deposit caused by the joining together of alluvial fans. These occur on the lower slopes of mountains and are often characterized by loose sediment and poor soil development.

Bald and Golden Eagle Protection Act: This Act was originally enacted in 1940 as the Bald Eagle Protection Act to protect bald eagles and later amended to include golden eagles. It prohibits the taking or possession of and commerce in bald and golden eagles, parts, feathers, nests, or eggs, with limited exceptions. The definition of take includes pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest, or disturb. Bald eagles may not be taken for any purpose unless a permit is issued prior to the taking. Permits must be obtained from the U.S. Department of the Interior to relocate nests that interfere with resource development or recovery.

Base camp: A site occupied by several families or more on either a year round or a seasonal basis. Identified archaeologically by primary and secondary tools and other artifacts, as well as floral and faunal remains from subsistence activities. Characterized by extensive scatters and quantities of debris such as potsherds, fire-cracked rock, whole and broken flaked stone tools, chipping waste, charred bone, milling tools, house structures, hearths, rock rings, and sometimes rock art or burials.

Basalt: Volcanic rock (or lava), characteristically dark in color and containing 45 to 54% silica and generally rich in iron and magnesium (mafic composition).

Basement complex: The suite of mostly crystalline igneous and/or metamorphic rocks that generally underlies the sedimentary rock sequence.

Basement rock: The oldest rocks in a given area; a complex of metamorphic and igneous rocks that underlies the sedimentary deposits. Usually Precambrian or Paleozoic in age.

Basin: (1) A depression in the Earth's surface that collects sediment. (2) The area of land that drains to a particular river.

Basin-fill aquifer: *See* Aquifer-basin fill.

Battery: Two or more electrochemical cells enclosed in a container and electrically interconnected in an appropriate series and/or parallel arrangement to provide the required operating voltage and current levels. Under common usage, the term battery also applies to a single cell if it constitutes the entire electrochemical storage system.

Battery capacity: The maximum total electrical charge, expressed in ampere-hours, which a battery can deliver to a load under a specific set of conditions.

Bedrock: General term referring to the solid rock or ledge underlying other unconsolidated material, i.e., soil, loose gravel, etc.

Bench: A relatively level step, excavated into a slope on which fill is to be placed. Its purpose is to provide a firm stable contact between the existing material and the new fill which is to be placed.

Beneficial use of water: A use of water resulting in appreciable gain or benefit to the user, consistent with state law, which varies from one state to another. Most states recognize the following uses as beneficial: domestic, municipal, and industrial uses; irrigation; mining; hydroelectric power; navigation; recreation; stock raising; public parks; and wildlife and game preserves.

Benthic: Living in or occurring at the bottom of a body of water.

Best Management Practices (BMP): A practice or combination of practices that are determined to provide the most effective, environmentally sound, and economically feasible means of managing an activity and mitigating its impacts.

Biface: A stone tool that has been flaked on both sides.

Big game: Those species of large mammals normally managed as a sport-hunting resource.

Biogenic source (emissions): Biological sources such as plants and animals that emit air pollutants such as volatile organic compounds. Examples of biogenic sources include animal management operations, and oak and pine tree forests.

Biological soil crusts: Commonly found in semiarid and arid environments, biological soil crusts are formed by living organisms and their by-products, creating a crust of soil particles bound together by organic materials. Crusts are predominantly composed of cyanobacteria (formerly called blue-green algae), green and brown algae, mosses, lichens, and bryophytes, which live within or on top of the uppermost millimeters of soil. Biological soil crusts are also known as cryptogamic, microbiotic, cryptobiotic, and microphytic crusts.

Biomass: Combustible solid, liquid, or gas that is derived from biological processes.

Biota: Plants and animals.

BLM: The Bureau of Land Management.

BLM land: Land administered by the Bureau of Land Management.

Block-faulted (mountains): Landforms formed by the movement (uplift and tilting) of large crustal blocks during an extensional episode. Such mountains often have a steep front side and a sloping back side.

Block Groups (BGs): A cluster of census blocks having the same first digit of their four-digit identifying numbers within a census tract. For example, block group 3 (BG 3) within a census tract includes all blocks numbered from 3000 to 3999. BGs generally contain between 600 and 3,000 people, with an optimum size of 1,500 people. Most BGs were delineated by local participants as part of the U.S. Census Bureau's Participant Statistical Areas Program. The U.S. Census Bureau delineated BGs only where a local, state, or tribal government declined to participate or where the U.S. Census Bureau could not identify a potential local or tribal participant.

Blowdown: Periodic removal of water from an evaporative cooling system (also known as a wet closed-cycle cooling system) to control the buildup of impurities and maintain the concentration of dissolved minerals in the circulating water. Blowdown typically involves the release of less than 10% of the total water volume in the cooling system and typically occurs after completion of as many as five cycles. Blowdown is either discharged to a surface water body under a permit that limits both chemical content and temperature, or directed to an evaporation pond where mineral residues are later collected and removed for disposal.

Blowdown Waste: *See* Blowdown.

Blowdown Water: *See* Blowdown**.**

Blowout: A wind-eroded section of a sand dune caused by a disturbance or removal of the vegetation.

Bolson (floor): A term applied to an internally drained (closed) intermontane basin in arid regions where drainages from adjacent mountains converge toward a central depression.

Boreal: Living in and adapted for living in the extreme northern areas of the world. This area is located just below tundra conditions.

Boron: The chemical element commonly used as the dopant in a photovoltaic device or cell material.

Borrow material: Material such as soil or sand that is removed from one location and used as fill material in another location.

Borrow pit: A pit or excavation area used for gathering earth materials (borrow) such as sand or gravel.

B.P.: Before present year.

Braided streams: Braided streams have multiple channels that are interlaced in a braided pattern, with very low stream gradient (<0.5% channel slope) and high sediment loading. Braided streams generally have broad, shallow valleys, with well-defined floodplains.

Broadband noise: Noise that has a continuous spectrum, that is, energy is present over a wide range of frequencies.

Breccia: A sedimentary rock formed of coarse-grained material consisting of sharp fragments embedded in clay or sand.

Browse: Twigs, leaves, and young shoots of trees and shrubs that animals eat.

Bryozoan: Aquatic colonial animals with branching, mossy or fan-like growth. They resemble corals but have more complex nervous, muscular, and digestive systems.

Build out: The estimated extent of residential, commercial, and industrial development in a given geographic area; usually related to the upper limit of the population to be served by water resource development.

Build-out capacity: The maximum total percentage of development in a watershed; typically determined assuming current zoning holds indefinitely into the future.

Bunchgrass: A grass having a bunched growth form and lacking rhizomes.

Burrow: A hole made by an animal, usually for shelter or to move through by digging.

Bureau of Land Management: An agency of the U.S. Department of the Interior that is responsible for managing public lands.

Cadastral survey system: A survey that creates, marks, defines, retraces, or re-establishes the boundaries and subdivisions of the public land of the United States.

Cadmium (Cd): A chemical element used in making certain types of solar cells and batteries.

Cadmium Telluride (CdTe): A polycrystalline thin-film photovoltaic material.

Cairn: A mound of stones erected as a memorial or marker.

Calcareous: Of, containing, or like calcite (calcium carbonate).

Caldera: A large, usually circular depression at the summit of a volcano, formed when magma is erupted from a shallow underground magma reservoir. The removal of large volumes of magma may result in loss of structural support for the overlying rock, thereby leading to collapse of the ground and formation of a large depression (called a collapsed caldera). Calderas are different from craters, which are smaller circular depressions created primarily by explosive excavation of rock during eruptions.

Caliche: A sedimentary deposit, commonly made of calcium carbonate, and formed from the leaching of minerals from the top layers of soil. Caliche deposits characterize arid and semi-arid environments.

California Ambient Air Quality Standard (CAAQS): A legal limit that specifies the maximum level and time of exposure in the outdoor air for a given air pollutant and which is protective of human health and public welfare (Health and Safety Code section 39606b). CAAQSs are recommended by the California Office of Environmental Hazard Assessment and adopted into regulation by the California Air Resources Board. CAAQSs are the standards which must be met per the requirements of the California Clean Air Act (CCAA).

Cancer: A group of diseases characterized by uncontrolled cellular growth. Increased incidence of cancer can be caused by exposure to radiation and some chemicals.

Candidate Species: Plants and animals for which the U.S Fish and Wildlife Service has sufficient information on their biological status and threats to propose them as endangered or threatened under the Endangered Species Act, but for which development of a listing regulation is precluded by other higher priority listing activities.

CAP: *See* Central Arizona project (CAP) Aqueduct.

Capacity factor: An empirical dimensionless number that represents the ratio of the amount of power produced by a generating facility over a given period of time, to the amount of power that would have been produced over that time period had the facility operated at its rated capacity.

Carbon dioxide (CO_2): A colorless, odorless, nonpoisonous gas that is a normal part of the Earth's atmosphere. Carbon dioxide is a product of fossil fuel combustion as well as other processes. It is the most prominent greenhouse gas that traps heat radiated into the atmosphere.

Carbon monoxide (CO): A colorless, odorless gas that is toxic if breathed in high concentrations over an extended period of time. Carbon monoxide is listed as a criteria air pollutant under Title I of the Clean Air Act.

Carbon sink: A reservoir that absorbs or takes up released carbon from another part of the carbon cycle. The four sinks, which are regions of the Earth within which carbon behaves in a systematic manner, are the atmosphere, terrestrial biosphere (usually including freshwater systems), oceans, and sediments (including fossil fuels).

Carbonate rock: Rocks (such as limestone or dolostone) that are composed primarily of minerals (such as calcite and dolomite) containing the carbonate ion (CO_3^{2-}).

Carbonate-rock aquifer: See Aquifer-carbonate rock.

Carrying capacity: The maximum density of wildlife that a particular area or habitat can sustain without deterioration of the habitat.

Catchment basin: A topographic region in which all water drains to a common outlet; a watershed.

Cavity: A hole or hollow area, especially inside a tree. Many animals, such as woodpeckers and raccoons, live in them.

Cell (solar): *See* Photovoltaic (PV) cell.

Cenozoic: An era of geologic time from the beginning of the Tertiary period (65 million years ago) to the present. Its name is from the Greek and it means "new life."

Census block: Census blocks are defined by the U.S. Bureau of Census and are the smallest geographic unit for which the Census Bureau tabulates data. Blocks contain data from the 2000 Census of Population, including total population, population by race and ethnicity, age, marital status, population density, and the number and composition of households, and information on housing unit types. Many blocks correspond to individual city blocks bounded by streets, but blocks – especially in rural areas – may include many square miles and may have some boundaries that are not streets. The Census Bureau established blocks covering the entire nation for the first time in 1990. More than 8 million blocks are identified for Census 2000.

Census block groups: Geographic entities consisting of groups of individual census blocks. Census blocks are grouped together so that they contain between 250 and 550 housing units.

Center pivot irrigation: A form of sprinkler irrigation consisting of several segments of pipe (usually galvanized steel or aluminum) that are joined together and supported by trusses, mounted on wheeled towers with sprinklers positioned along its length. The system moves in a circular pattern and is fed with water from the pivot point at the center of the arc. These systems are found and used in all parts of the nation and allow irrigation of all types of terrain.

Central Arizona Project (CAP) Aqueduct: A 336-mi (541-km) long diversion canal operated by the Central Arizona Water Conservation District that diverts water from the Colorado River into central and southern Arizona. The CAP is the largest and most expensive aqueduct system ever built in the United States.

CEQ: *See* Council on Environmental Quality.

CERCLA: *See* Comprehensive Environmental Response, Compensation, and Liability Act of 1980.

Change-out: The routine replacement of chemicals contained in process equipment, in accordance with schedules established by the manufacturer, or as a result of inspections and evaluations of equipment, as a means of preserving or guaranteeing performance.

Channel incision: The process of downcutting into a stream channel leading to a decrease in the channel bed elevation. Incision is often caused by a decrease in sediment supply and/or an increase in sediment transport capacity. A decrease in base level can cause headcutting that migrates upstream and produces incision upstream and initiating aggradation downstream.

Chaparral: A plant community of shrubs and low trees adapted to annual drought and often extreme summer heat and also highly adapted to fires recurring every 5 to 20 years.

Chert: A hard, dense, fine-grained type of sedimentary rock; a microcrystalline aggregate of silica (quartz). It was formed from deposits of silica-based skeletons of microscopic marine organisms (including zooplankton, and other organic matter). Also referred to as flint. Native Americans shaped chert by carefully striking it with stone or bone hammers.

Chronic effects: Effects resulting from exposure to low levels of a stressing factor (e.g., contaminant, disease, electromagnetic field, noise, and radionuclides) over long periods.

Cienega: A perennially wet area supported by a spring or other water source; also called wetland, marsh, or swamp.

Cinder cone: A conical hill formed around a volcanic vent by the accumulation of loose cinders and other pyroclastics ejected during a volcanic eruption, normally basaltic or andesitic in composition. Slopes generally exceed 20 percent.

Class I Area: As defined in the Clean Air Act, the following areas that were in existence as of August 7, 1977: national parks with more than 6,000 acres, national wilderness areas, national memorial parks with more than 5,000 acres, and international parks.

Class II Area: Areas of the country protected under the Clean Air Act, but identified for somewhat less stringent protection from air pollution damage than a Class I area, except in specified cases.

Clay: A very fine-grained rock or mineral fragment of any composition that has a diameter of less than 0.002 mm. Moist clay is sticky and forms a ribbon when pressed between the thumb and forefinger.

Clean Air Act (CAA): The comprehensive federal law which regulates air emissions. The goal of the law was to develop a national ambient air quality standard (NAAQS) that protects public health and the environment. The original CAA was passed in 1963, but the national air pollution control program is actually based on the 1970 version of the law. The 1990 CAA Amendments, in large part, were intended to deal with previously unaddressed or under-addressed problems such as acid rain, ground level ozone, ozone depletion, and air toxics.

Clean Water Act (CWA): Requires National Pollutant Discharge Elimination System (NPDES) permits for discharges of effluents to surface waters, permits for storm water discharges related to industrial activity, and notification of oil discharges to navigable waters of the United States.

Clearing and grubbing: Cleaning a site to prepare it for construction. Involves removing debris, structures, shrubbery, trees, obstructions, and objectionable and unsuitable materials. It may also involve handling and disposing of non-hazardous and hazardous waste.

CLFR: *See* Compact Linear Fresnel Reflector.

Climate: The composite or generally prevailing weather conditions of a region throughout the year, averaged over a series of years.

Closed basin: A basin draining to some depression or a pond within its area, from which water is lost only by evaporation or percolation. A basin without a surface outlet for flowing into another body of water.

Closed-loop cooling system: Also known as a wet closed-cycle cooling system, a system that circulates water between a steam condenser and a cooling tower to cool steam condensate at a thermoelectric power plant; the circulating water interacts with a counterflow (or crossflow) of ambient air at the cooling tower and is cooled through the principle of evaporation where a small fraction of the water is evaporated. The evaporated amount is continually replaced to maintain the total volume of water in the system. *See also* Blowdown.

Clovis Complex: Characteristic of Paleoindian finds located near Clovis, NM, such as specific fluted points.

CO: *See* Carbon Monoxide.

CO_2: *See* Carbon Dioxide.

Code of Federal Regulations (CFR): A publication in codified form, of all federal regulations in force.

Collection: The capture or obtaining of plant or animal specimens. This can include obtaining specimens for scientific study, pets, or illegal trade.

Collector: *See* Solar collector.

Color: The property of reflecting light of a particular intensity and wavelength (or mixture of wavelengths) to which the eye is sensitive. It is the major visual property of surfaces.

Colluvium: A general term to include loose rock and soil material that accumulates at the base of a slope as the result of mass wasting processes.

Colluvium: Loose earth material (such as rock fragments, sand, etc.) that accumulates on steep slopes or at the base of talus slopes, through the action of gravity.

Community: An assemblage of plant and animal populations occupying a given area.

Compact: An agreement between states apportioning the water of a river basin to each of the signatory states.

Compact Linear Fresnel Reflector (CLFR): A type of Concentrated Solar Power (CSP) technology similar to a parabolic trough design, where the sun's heat energy is reflected onto a receiver positioned above the mirrors and containing water; the water is converted to steam and delivered to a Rankine cycle steam turbine-generator (STG) for production of electricity.

Compensation: A type of mitigation in which the impacts to a species or habitat are offset by protecting, restoring, or creating suitable habitat elsewhere.

Compensatory Mitigation: (For purposes of the Clean Water Act Section 404 and Rivers and Harbors Act Section 10 regulatory programs), compensatory mitigation is the restoration, creation, enhancement, or, in exceptional circumstances, preservation of wetlands and/or other aquatic resources for the purpose of compensating for unavoidable adverse impacts which remain after all appropriate and practicable avoidance and minimization has been achieved.

Composite noise level: A single noise level summed on an energy basis from many noise sources (e.g., Stirling engine, electric generator, cooling fan, and air compressor for a Stirling dish engine).

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA): An Act providing the regulatory framework for the remediation of past contamination from hazardous waste. If a site meets the Act's requirements for designation, it is ranked along with other Superfund sites on the National Priorities List. This ranking is the U.S. Environmental Protection Agency's way of determining the priority of sites for cleanup.

Concentrating PV (CPV): *See* PV Module; PV System.

Concentrating solar collector: A solar collector that uses reflective surfaces to concentrate sunlight onto a small area, where it is absorbed and converted to heat or, in the case of solar photovoltaic (PV) devices, into electricity. Concentrators can increase the power flux of sunlight hundreds of times. The principal types of concentrating collectors include: compound parabolic, parabolic trough, fixed reflector moving receiver, fixed receiver moving reflector, Fresnel lens, and central receiver. A PV concentrating module uses optical elements (Fresnel lens) to increase the amount of sunlight incident onto a PV cell. Concentrating PV modules/arrays track the sun and use concentrating devices to reflect direct sunlight onto the solar cell to produce electricity directly. Concentrating solar collectors in Concentrated Solar Power (CSP) facilities concentrate sunlight onto a receiver where it heats a heat transfer fluid that subsequently exchanges its absorbed heat to water to produce steam to power a steam turbine-generator (STG) to produce electricity.

Concentrating Solar Power (CSP): *See* Concentrating Solar Power (CSP) Technologies.

Concentrating Solar Power (CSP) Technologies: Any of a family of solar energy technologies that reflect and concentrate the sun's energy to produce heat that is subsequently used to produce steam to power a steam turbine-generator (STG), or drive a reciprocating engine, to produce electricity. There are three different types of CSP systems: parabolic trough systems, power tower systems, and solar dish engine systems. Parabolic trough and power tower systems convert sunlight to heat to produce steam, while the solar dish engine system converts sunlight to heat to drive a reciprocating engine.

Concentration: Amount of a chemical in a particular volume or weight of air, water, soil, or other medium.

Concentrator: A photovoltaic module, which includes optical components such as lenses (Fresnel lens) to direct and concentrate sunlight onto a solar cell. Most concentrator arrays must directly face or track the sun. They can increase the power flux of sunlight hundreds of times, allowing greatly increased amounts of power to be generated from relatively small areas of solar cells.

Conditional Use Permit (CUP): In California, this is a permit that is required to be obtained from the county government authority in which a solar energy facility is to be located.

Cone of Depression: A depression in the water table that develops around a pumped well.

Confined aquifer: *See* Aquifer-confined.

Conglomerate: A sedimentary rock made of rounded rock fragments, such as pebbles, cobbles, and boulders, in a finer-grained matrix. To call the rock a conglomerate, some of the constituent pebbles must be at least 2 mm (about 1/13th of an inch) across.

Conifer: A plant commonly having needlelike, persistent leaves and a woody cone for a fruit.

Consumptive use: (1) Any use of water that permanently removes water from the natural stream system. (2) Water that has been evaporated, transpired, incorporated into products, plant tissue, or animal tissue and is not available for immediate reuse. (3) Consumption of water for residential, commercial, institutional, industrial, agricultural, power generation, and recreational purposes. Naturally occurring vegetation and wildlife also consumptively use water. Water consumed is not available for other uses within the system.

Contrast: Opposition or unlikeness of different forms, lines, colors, or textures in a landscape.

Contrast level: A description of the relative amount of visual contrast resulting from a change in the visible landscape. Contrast levels define the degree to which a management activity affects the visual quality of a landscape and provides a means for determining visual impacts and for identifying measures to mitigate these impacts. Contrast levels are determined as part of the Visual Contrast Rating procedures BLM utilizes to analyze potential visual impacts of proposed projects and activities. In the Visual Contrast Rating process, contrast levels are defined as None, Weak, Moderate, or Strong. In this PEIS, an additional contrast level (minimal) is used.

Corona discharge: Electrical discharge accompanied by ionization of surrounding atmosphere around high-voltage transmission lines, occurring mostly under wet conditions.

Corona/Corona noise: The electrical breakdown of air into charged particles. The phenomenon appears as a bluish-purple glow on the surface of and adjacent to a conductor when the voltage gradient exceeds a certain critical value, thereby producing light, audible noise (described as crackling or hissing), and ozone.

Corridor: A strip of land through which one or more existing or potential facilities may be located.

Corridor-transmission: *See* Transmission corridor.

Corridor-wildlife: *See* Wildlife corridor.

Council on Environmental Quality (CEQ): Established by National Environmental Policy Act (NEPA), CEQ regulations (40 CFR Parts 1500-1508) describe the process for implementing NEPA, including preparation of environmental assessments and environmental impact statements, and the timing and extent of public participation.

Cover: Vegetation, rocks, or other materials used by wildlife for protection from predators or weather.

Crater: A steep-sided, usually circular depression formed by either explosion or collapse at a volcanic vent.

Creep (rate): Relatively slow movement along a fault. It is sometimes called “seismic creep” to distinguish it from the slumping of rock or soil on slopes (which is also known as creep). Creep is only known to occur on strike-slip faults.

Crescents: Quarter-moon-shaped (hence crescent) artifacts that may have been in the form of blades, scrapers, or projectile points.

Criteria air pollutants: Six common air pollutants for which National Ambient Air Quality Standards (NAAQS) have been established by the U.S. Environmental Protection Agency under Title I of the Clean Air Act (CAA). They are sulfur dioxide, nitrogen oxides, carbon monoxide, ozone, particulate matter (PM 2.5 and PM10), and lead. Standards were developed for these pollutants on the basis of scientific knowledge about their health effects.

Critical habitat: The specific area within the geographical area occupied by the species at the time it is listed as endangered or threatened. The area in which physical or biological features essential to the conservation of the species is found. These areas may require special management or protection.

Crucial winter range: The portion of the winter range to which a wildlife species is confined during periods of heaviest snow cover or that portion of the year-long range which is crucial to survival because it is where big game find food and/or cover during the most inclement and difficult winter weather.

Crustaceans: Aquatic animals with hard external skeletons and segmented limbs, belonging to the class Crustacea; includes cladocerans, shrimp, crayfish, fairy shrimp, isopods, amphipods, lobsters, and crabs.

Crustal spreading center: A linear zone in the Earth's crust whose opposite sides are moving away from one another.

Cryptogamic soil crusts: A soil crust dominated by a community of algae, lichens, or mosses. *See also* Biological soil crusts.

Cryptobiotic: *See* Biological soil crusts.

CSP: *See* Concentrating solar power.

Cuesta: An elongated ridge formed by gently tilting sedimentary strata. The landform has a steep slope (escarpment or cliff) where the strata are exposed on their edges and a gentle slope (dip slope) on the other side of the ridge.

Cultural disturbance: *See* Cultural modification.

Cultural modification: Any human-caused change in the land form, water form, vegetation, or the addition of a structure which creates a visual contrast in the basic elements (e.g., form, line, color, or texture) of the naturalistic character of a landscape.

Cultural Resources: Archaeological sites, structures, or features; traditional use areas; and Native American sacred sites or special use areas that provide evidence of the prehistory and history of a community.

Cumulative impacts: The impacts assessed in an environmental impact statement that could potentially result from incremental impacts of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (federal or nonfederal), private industry, or individual undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Cut-and-Fill: The process of earth grading by excavating part of a higher area and using the excavated material for fill to raise the surface of an adjacent lower area.

Cyanobacteria: Blue-green algae, prokaryotic, photosynthetic organisms that generally have a blue-green tint and lack chloroplasts.

Day-night average noise level: Twenty-four-hour average noise level, obtained after the addition of a 10-dB penalty for environmental noise occurring from 10 p.m. to 7 a.m. to account for the increased annoyance at night. This 10-dB penalty means that one nighttime noise event is equivalent to 10 daytime noise events of the same level.

Daytime mean rural background level: Daytime (7 a.m. to 10 p.m.) average sound level in the rural environment, from all sources other than a particular noise that is of interest.

DC: *See* Direct Current.

Debris flow: A mixture of water-saturated rock debris that flows downslope under the force of gravity (also called lahar or mudflow).

Debris flow fans: Alluvial fans prone to debris flows; a mixture of water and debris, such as mudslides, mudflows, or debris avalanches. Debris flow fans are created by the deposits of repeated debris flows at the mouth of the canyon.

Decibel (dB): A standard unit for measuring the loudness or intensity of sound. In general, a sound doubles in loudness with every increase of 10 decibels.

Decibel, A-weighted (dBA): A measurement of sound approximating the sensitivity of the human ear and used to characterize the intensity or loudness of a sound.

Deciduous: Plants that shed their leaves annually. Not evergreen.

Decommissioning: All activities necessary to take out of service and dispose of a facility after its useful life.

Deep-cycle battery: A battery with large plates that can withstand many discharges to a low state of charge.

Delta: An alluvial deposit at the mouth of a river, usually triangular in shape. An area formed from the deposition of sediments at the mouth of a river.

Demand side management: Specific actions taken by utility companies, their regulators, and other entities to induce, influence, or compel consumers to reduce their energy consumption, particularly during periods of peak demand.

Demographic: Related to the vital statistics of human populations (size, density, growth, distribution, etc.) and the effect of these on social and economic conditions.

Depletion: Net loss of water through consumption, export, and other uses to a given area, river system, or basin. The terms *consumptive use* and *depletion*, often used interchangeably, are not the same.

Deposit: Earth material that has accumulated by some natural process. For example, a flowing mixture of water and rock debris is called a debris flow, but when the flow ceases to move, a layer of fine and coarse rock is left, which is called a debris-flow deposit.

Desert: Arid region receiving less than 10 inches of precipitation annually.

Desert bench: A relatively flat terrace elevated above the surface of a desert alluvial feature, such as an ephemeral stream or wash.

Desert dune: A wind-created ridge or mound of sand that is found in deserts or near oceans and lakes.

Desert floor: The land surface in a desert valley.

Desert Focal Bird Species: Bird species whose requirements define spatial attributes, habitat characteristics, and management regimes representative of a healthy desert system.

Desert pavement: A surface layer of closely packed, loosely cemented pebbles. *See also* Pediment.

Desert riparian habitat: Habitats characterized as dense groves of low shrublike trees, or tall shrubs to woodlands of small to medium-sized trees. These habitats are found adjacent to permanent surface water, such as streams and springs.

Desert scrub: The desert scrub community is characterized by plants adapted to seasonally dry climate.

Desert varnish: The thin red to black coating found on exposed rock surfaces in arid regions. Varnish is composed of clay minerals, oxides, and hydroxides of manganese and/or iron, as well as other particles, such as sand grains and trace elements. The distinctive elements are manganese (Mn) and iron (Fe).

Desert wash: A usually dry desert streambed that flows only after periods of heavy rain.

Desiccation: Dryness resulting from the removal of water. Vegetation lost through erosion or desiccation.

Design basis: The set of conditions, dimensions, needs, and requirements used to design a solar energy facility.

Design features: Measures or procedures incorporated into the proposed action or alternatives which could avoid or reduce adverse impacts. Potential mitigation measures selected as required are then considered to be design features.

Designated Roads and Trails: Specific roads and trails identified by the agencies where some type of motorized vehicle use is appropriate and allowed, either seasonally or yearlong.

Detritus: Loose natural materials, such as rock fragments or organic particles, that result directly from disintegration of rocks or organisms.

Dewatering: The removal or separation of a portion of the water in a sludge or slurry to dry the sludge so that it can be handled and disposed of; removal or draining the water from a tank or a trench.

Diagnostic: An item that is indicative of a particular time and/or cultural group.

Differential compaction: May occur over a large area when the compaction of soil or deeper sediments occurs at different rates and degrees. Differential compaction may result in different rates and degrees of land subsidence, causing damage to structures on the ground surface.

Diorite: A coarse-grained intrusive (or plutonic) igneous rock, less mafic than gabbro, but more mafic than granite and granodiorite; the plutonic equivalent of andesite.

Dip: The angle that a planar geologic surface, for example, a fault, is inclined from the horizontal.

Direct Current (DC): A steady current that flows in one direction only. The current from batteries is an example of direct current.

Direct effects: Effects on the environment which occur at the same time and place as the initial cause or action.

Direct impact: Impacts occurring at the place of origin and at the time of the proposed activity. An effect that results solely from the construction or operation of a proposed action without intermediate steps or processes. Examples include habitat destruction, soil disturbance, and water use. *See also* Impact.

Direct Normal Insolation (DNI): Sunlight that directly strikes a surface. DNI does not include refracted sunlight that strikes clouds, dust, or the ground first.

Directional drilling: The practice of drilling non-vertical wells. Also called slant drilling.

Discharge: The volume of water that passes a given location within a given period of time. Usually expressed in cubic feet per second.

Dish engine: The dish engine is a concentrating solar power (CSP) technology that produces electricity, typically in the range of 3 to 25 kilowatts, by using a parabolic array of mirrors to reflect sunlight to heat a working gas (typically hydrogen) in a closed container, causing it to expand and drive a reciprocating engine connected to an electric generator. The dish engine is unique among CSP systems because it uses mechanical energy rather than steam to produce electricity.

Dish engine system: *See* Dish engine.

Dish engine technologies: *See* Dish engine**.**

Dispatchable power (dispatchability): The ability of a power-producing facility to provide required amounts of power (at or below the facility's nameplate rating) on demand of the grid operator and consistent with the terms of the existing Power Purchase Agreement (PPA), regardless of the time of day or weather conditions.

Disposal: The act of placing unwanted materials in an area with the intent of not recovering them in the future.

Distance zones: A subdivision of the landscape as viewed from an observer position. The BLM defined zones include foreground, middleground, background, and seldom seen.

Distributed generation: The installation of small-scale solar energy facilities at individual locations that are at or near the point of consumption (e.g., use of solar PV panels on a business or home to generate electricity for on-site consumption). Distributed generation systems typically generate less than 10,000 kW. Other terms for distributed generation include on-site generation, dispersed generation, and distributed energy.

Disturbance (land): *See* Land disturbance.

Diversion: Water diverted from supply sources such as streams, lakes, reservoirs, springs, or wells for a variety of uses including cropland irrigation as well as residential, commercial, institutional, and industrial purposes. The terms diversion and *withdrawal* are often used interchangeably.

DNI: *See* Direct Normal Insolation.

Dolomite: A magnesium-rich carbonate sedimentary rock. Also, a magnesium-rich carbonate mineral ($CaMgCO_3$).

Dome, volcanic: Rounded, steep-sided mounds built by very viscous magma, usually either dacite or rhyolite. Such magmas are typically too viscous (resistant to flow) to move far from the vent before cooling and crystallizing. Domes may consist of one or more individual lava flows. Volcanic domes are also referred to as lava domes. *See also* Rhyolite.

Domestic solid waste: Solid wastes of the type routinely generated by households.

Domestic water use: Water used for household purposes such as drinking, food preparation, bathing; washing clothes, dishes, and dogs; flushing toilets; and watering lawns and gardens. About 85% of domestic water is delivered to homes by public-supply facilities, such as county water departments. About 15% of the Nation's population supplies their own water, mainly from wells.

Down-dropped basin: *See* Graben.

Drawdown: Lowering of a reservoir's water level; process of depleting reservoir or groundwater storage.

Drill: An oblong tool made of flaked stone used in drilling holes in wood, leather or hides. Oftentimes, drills were made from well-used projectile points which were near the end of life and thus, many drills maintain the stem and hafting area of the original point type.

Drop structure: An in-stream structure of various materials designed to reduce the energy and force of stream flow.

Dry closed-loop cooling: *See* Dry cooling system.

Dry cooling: *See* Dry cooling system.

Dry cooling system: Also known as dry closed-loop cooling; a technology for rejecting heat from the steam condensate of a thermoelectric plant. Cooling water circulates in a closed loop between a steam condenser where it accepts heat from steam condensate and a dry condenser located in an outdoor location. Fans are used to establish a flow of ambient air across the surface of the dry condenser, allowing the heated cooling water inside the dry condenser to transfer heat to the ambient air before cycling back to the steam condenser.

Dry lake: An ephemeral lake of an arid or semiarid region, typically found at low elevation points in desert valleys. They are topographically flat areas, support sparse vegetation, and contain fine-grained, consolidated sediments that are deposited during precipitation runoff events where the water temporally ponds and then infiltrates to groundwater aquifers or evaporates. The surface sediments of dry lakes can often have high concentrations of dissolved minerals.

Dry wash: A natural drainage channel that is typically dry, but conveys water following significant rainfall events and is subject to rapid flow during flash flooding.

Dune: Mounds of unconsolidated sand grains shaped by wind. Often temporary and non-stationary.

Dunnage: Package waste. Loose packing material.

Duripan: A subsurface soil horizon cemented by silica (usually derived from a volcanic source such as ash). Duripans occur in arid and semi-arid environments and make cultivation of the land difficult.

Early Archaic: The period 7,500 to 5,000 years B.P.

Earthern cattle tank: A watering area or basin for cattle that is usually created in a natural drainage area by obstructing natural water flows with berms of soil.

Earthquake: Ground shaking caused by the sudden release of energy stored in rock beneath the Earth's surface.

Ecological Resources: Biota (fish, wildlife, and plants) and their habitats, which may be land, air, or water.

Ecological segmentation: Development that fragments animal habitat and does not provide corridors for movement.

Ecoregion: A geographically distinct area of land that is characterized by a distinctive climate, ecological features, and plant and animal communities.

Ecosystem: A group of organisms and their physical environments, interacting as an ecological unit.

Ecotones: The borders between two different types of ecosystems or communities (e.g., a forest and a grassland) containing characteristic species of each.

Edge habitat: The transitional zone where one cover type ends and another begins.

Edge-on: A descriptor for the appearance of solar facility collector/reflector arrays when viewed at very low vertical angles, such that the viewing angle is at or very close to horizontal.

Effects: Environmental consequences (the scientific and analytical basis for comparison of alternatives) as a result of a proposed action. Effects may be either direct, which are caused by the action and occur at the same time and place, or indirect, which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable, or cumulative.

Efficiency: Ratio of "power out" divided by "power in." The definitions of power out and power in are specific to a given technology and depend on whether the efficiency value describes a total system efficiency or an individual component's efficiency.

Effigy: An object bearing the likeness of an animal or human.

Effluent: Wastewater discharges.

Electric and Magnetic Fields (EMFs): Electric and magnetic fields are generated when charged particles (e.g., electrons) are accelerated. Charged particles in motion produce magnetic fields. Electric and magnetic fields are typically generated by alternating current in electrical conductors. Also referred to as electromagnetic fields.

Electrolytes (battery): A nonmetallic (liquid or solid) conductor that carries current by the movement of ions (instead of electrons) with the liberation of matter at the electrodes of an electrochemical cell.

Electron: A subatomic particle with a negative electric charge. Electrons form part of an atom and move around its nucleus.

Eligible properties: *See* Historic properties.

Embryotoxicity: Adverse effects on the embryo due to a substance that enters the maternal system and crosses the placental barrier. The effects of the substance may be expressed as embryonic death or an abnormal development of one or more body systems, and can be deleterious to maternal health.

Emergent: Aquatic plants having some or most of the leaf area extending out of the water.

Emergent wetlands: The Emergent wetland class is characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. This vegetation is present for most of the growing season, in most years. These wetlands are usually dominated by perennial plants.

Emission factor: The relationship between the amount of pollution produced and the amount of raw material processed.

Emissions: Substances that are discharged into the air from industrial processes, vehicles, and living organisms. A release into the outdoor atmosphere of air contaminants.

Endangered Species: Any species (plant or animal) that is in danger of extinction throughout all or a significant part of its range. Requirements for declaring a species endangered are found in the Endangered Species Act of 1973 (ESA). *See also* Special Status Species.

Endangered Species Act of 1973 (ESA): Requires consultation with the U.S. Fish and Wildlife Service and/or the National Marine Fisheries Service to determine whether endangered or threatened species or their habitats will be impacted by a proposed activity and what, if any, mitigation measures are needed to address the impacts.

Endemic: Native to and restricted to a particular geographic region.

Entrainment: The incorporation of fish, eggs, larvae, and other plankton with intake water flow entering and passing through a cooling water intake structure and into a cooling water system.

Entry: An application to acquire title to public lands.

Environmental Assessment (EA): A concise public document that a federal agency prepares under the National Environmental Policy Act to provide sufficient evidence and analysis to determine whether a proposed action requires preparation of an Environmental Impact Statement (EIS) or whether a Finding of No Significant Impact can be issued. An EA must include brief discussions on the need for the proposal, the alternatives, the environmental impacts of the proposed action and alternatives, and a list of agencies and persons consulted.

Environmental Impact Statement (EIS): A document required of federal agencies by the National Environmental Policy Act for major proposals or legislation that will or could significantly affect the environment.

Environmental Justice: The fair treatment of people of all races, cultures, incomes, and educational levels with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

Environmental media: Soil, water, air, biota, or any other parts of the environment that can contain contaminants.

Eolian: Refers to the processes of wind erosion, transport, and deposition. For example, sand dunes are landforms produced by eolian processes in arid environments.

EPA: *See* U.S. Environmental Protection Agency.

Ephemeral allotment: A BLM grazing allotment in areas of the Hot Desert Biome (Region) that do not consistently produce enough forage to sustain a livestock operation, but from time to time produce sufficient forage to accommodate livestock grazing.

Ephemeral stream: A stream that flows only after a storm or during snowmelt, and whose channel is, at all times, above the water table; groundwater is not a source of water for the stream. Many desert streams are ephemeral.

Erosion: The wearing away of land surface by wind or water, intensified by land-clearing practices related to farming, residential or industrial development, road building, or logging.

Eruption: The process by which solid, liquid, and gaseous materials are ejected into the Earth's atmosphere and onto the Earth's surface by volcanic activity. Eruptions range from the quiet overflow of liquid rock to the tremendously violent expulsion of pyroclastics.

ESA: *See* Endangered Species Act of 1973.

Escarpment: A cliff or the steep slopes of a plateau edge.

Ethnobotany (ethnobotanical): The plant lore and agricultural customs of a people; the study of such lore and customs.

Eutectic: Of, relating to, or formed at the lowest possible temperature of solidification for any mixture of specified constituents.

Evaporation ponds: Shallow man-made ponds designed to contain liquid effluents and concentrate the residual waste through evaporation.

Evaporation ponds: Artificial ponds designed to efficiently evaporate water by sunlight and exposure to ambient temperatures.

Evaporation rate: In hydrologic terms, the quantity of water, expressed in terms of depth of liquid water, which is evaporated from a given surface per unit of time. It is usually expressed in inches depth, per day, month, or year. *See also* Pan evaporation.

Evapotranspiration: Plants absorb water through their roots and emit it through their leaves. This movement of water is called "transpiration." Evaporation, the conversion of water from a liquid to a gas, also occurs from the soil around vegetation and from trees and vegetation as they intercept rainfall on leaves and other surfaces. Together, these processes are referred to as *evapotranspiration*, which lowers temperatures by using heat from the air to evaporate water.

Exceedance: A measured level of an air pollutant that is higher than the national or state ambient air quality standards. *See also* NAAQS and CAAQS.

Excessive grades: Ground surface inclines relative to the horizon beyond which the ground may become unstable. The excessiveness of a slope is determined by its instability, which is influenced by the type of material on the slope.

Excessive slopes: *See* Excessive grades.

Executive Order: A president's or governor's declaration which has the force of law, usually based on existing statutory powers, and requiring no action by the Congress or state legislature.

Extensional (structural features or faults): Refers to tectonic forces that extend or stretch the Earth's crust.

Exposure: Contact of an organism with a chemical, radiological, or physical agent.

Extirpation: The elimination of a species or subspecies from a particular area, but not from its entire range.

Extremely Low Frequency (ELF): Refers to a band of frequencies from 30 to 300 Hz.

Facultative wetland vegetation species: A species that can occur both in wetlands and uplands.

Fall-line: Direction that water flows down a hill.

Fan: *See* Alluvial fan.

Fan apron: A sloping alluvial fan surface made of sediment deposited by streams at the mouth of a canyon between a mountain and the adjacent alluvial valley floor. *See also* Alluvian fan.

Fan piedmonts: A sloping alluvial fan surface made of sediment deposited by streams at the mouth of a canyon between a mountain and the adjacent alluvial valley floor.

Fan remnants: An erosional remnant (or fossil) of a once active and more extensive alluvial fan.

Fan terrace: *See* Alluvial fan terrace.

Fast-track: Projects on public land for which the environmental review and public participation process is underway and the application could be approved by December 2010.

Fault: A fracture along which blocks of the Earth's crust on either side have moved relative to one another. *See also* strike-slip fault; potentially active fault; zoned fault.

Fault block: A rock mass that is bounded by normal faults. Fault blocks on either side of the fault are elevated or depressed, relative to each other.

Fault plane: The plane that best approximates the fracture surface of a fault.

Fault, left-lateral: A strike-slip fault on which displacement of the block opposite the observer is to the left. *See also* Strike-slip fault.

Fault, normal: A fault occurring usually as a result of extensional forces, such as when a hanging wall drops down relative to the footwall forming a graben or half graben.

Fault, Potentially Active: Generally denotes that a fault has shown evidence of surface displacement during Quaternary time.

Fault, right-lateral: A strike-slip fault on which displacement of the block opposite the observer is to the right. *See also* Strike-slip fault.

Fault trace: The expression of a fault on the ground surface.

Fault, transform: A strike-slip fault forming the boundary between tectonic plates (e.g., the San Andreas Fault system is a transform fault zone that marks the boundary between the Pacific and North American Plates). *See also* Strike-slip fault.

Fault, zoned: Under the Alquist-Priolo Act, zoned faults include those that are "sufficiently active," showing evidence of surface displacement within the past 11,000 years along one or more of its segments or branches, and "well-defined," having a clearly detectable trace at or just below the ground surface.

Fauna: The community of animals in a specific region or habitat.

Feature: A large, complex artifact, or part of a site, such as a hearth, cairn, housepit, rock alignment, or activity area.

Federal land: Land owned by the United States, without reference to how the land was acquired or which Federal agency administers the land, including mineral and coal estates underlying private surface.

Federal Land Policy and Management Act of 1976 (FLPMA): Act requiring the Secretary of the Interior to issue regulations to manage public lands and the property located on those lands for the long term.

***Federal Register*:** The official daily publication for rules, proposed rules, and notices of Federal agencies and organizations, as well as executive orders and other presidential documents.

Fill: Man-made deposits of soil and rock and/or waste material.

Fire emissions: Emissions caused by wildfires, prescribed fires, agricultural fires, and structural fires.

Fire-cracked rock: Burned rocks, typically fractured during intense heating in a fire hearth or remnants of rocks associated with cooking. Fairly common at prehistoric archaeological sites.

Fire-tolerant species: Species of plants that can withstand certain frequency and intensity of fire.

First in time, first in right: *See* Prior Appropriation Doctrine.

Fissure, Earth or ground: Surface fractures resulting from subsidence, often due to the withdrawal of groundwater and compaction of an aquifer.

Flake: A thin, flattened piece or chip of stone, intentionally removed from the core rock by chipping with either a stone or bone hammer.

Flash flood: A sudden flood event through a valley, canyon, or wash, following a short duration, high-intensity rainfall.

Flat-plate PV: A type of photovoltaic solar energy technology that uses a flat plate onto which are installed solar cells. Sunlight strikes the solar cells directly without being reflected or concentrated. Flat plate systems can be either fixed (stationary) or designed to track the sun's movement over the course of the day.

Flat-plate reflector (heliostat): One of many components of a CSP Power Tower facility consisting of a large nearly-flat mirror, mounted on a support structure that tracks the sun's movement and reflects sunlight onto a receiver located at the top of a centrally located tower. CSP Power Tower systems typically consist of hundreds of heliostats arrayed around the central tower.

Flats: Level or nearly level areas of land marked by little or no relief.

Flats wetland: A level landform composed of unconsolidated sediments, usually mud or sand. Flats are unvegetated or support sparse plant communities, often composed of annual species.

Flood irrigation: Water is pumped or brought to the fields and is allowed to flow along the ground among the crops.

Floodplain: A generally flat, low-lying area adjacent to a water body that is subjected to inundation during high flow or rainfall events. The relative elevation of floodplain areas determines their frequency of flooding, which ranges from rare, severe, storm events to flows experienced several times a year.

Flora: Plants, especially those of a specific region, considered as a group.

FLPMA: Federal Land Policy and Management Act of 1976.

Fluvial: Pertaining to a river. Fluvial sediments are deposited by rivers.

Flyway: A seasonal route followed by birds migrating to and from their breeding areas.

Footprint: The land or water area covered by a project. This includes direct physical coverage (i.e., the area on which the project physically stands) and direct effects (i.e., the disturbances that may directly emanate from the project, such as noise).

Forage: Forms of vegetation available for animal consumption. Food for animals, especially when taken by browsing or grazing. Vegetation used for food by wildlife, particularly big-game wildlife and domestic livestock.

Forbs: Herbaceous (non-woody), broad-leaved flowering plants; non-graminoid (grasses, sedges, and rushes) herbaceous plants. *See also* Graminoid herbaceous.

Form: The mass or shape of an object or objects that appears unified, such as a vegetative opening in a forest, a cliff formation, or a water tank.

Fossil: Remains of ancient life forms, their imprints or behavioral traces (e.g., tracks, burrows, or residues) and the rocks in which they are preserved.

Fossil fuels: Natural gas, petroleum, coal, and any form of solid, liquid, or gaseous fuel derived from such materials for the purpose of creating useful heat.

Fragmentation: Process by which habitats are increasingly subdivided into smaller units, resulting in their increased insularity as well as losses of total habitat area.

Fragmentation of habitat: The breaking up of a single habitat area into two or more smaller habitat patches that are separated from each other.

Fresnel: Compact Linear Fresnel Reflector (CLFR): *See* Compact Linear Fresnel Reflector (CLFR).

Fresnel lens: As used in a solar energy facility, an optical device that focuses sunlight. The mirrors are arranged in concentric rings and are faced at slightly different angles so that light falling on any mirror is focused on the same point, resulting in a substantial concentration of the sunlight.

Friable: Said of a rock or mineral that crumbles naturally or is easily broken, pulverized, or reduced to powder, such as a soft and poorly cemented sandstone.

Fugitive dust: The dust released from any source other than a definable point source such as stack, chimney, or vent. Sources include construction activities, storage piles, roadways, etc.

Fujita scale: The official classification system for tornado damage. The scale ranges from F0 (gale tornado, minor damage, winds up to 72 mph) to F5 (devastating tornado, winds 261 to 318 mph). In the United States and in some other countries, on February 1, 2007, the Fujita scale was decommissioned in favor of what scientists believe is a more accurate Enhanced Fujita Scale, which replaces it.

Full-time equivalent (FTE): Equivalent to a full-time worker/employee. For example, two people, each working half time, constitute one FTE.

Furbearer: An animal that is hunted or farmed for its fur.

Gallium (Ga): A chemical element, metallic in nature, used in making certain kinds of solar cells and semiconductor devices.

Gap: In a visual impact analysis context, a break or interruption (as in a row of mountains) or similar topographic void through which the landscape may be viewed.

GDAs: *See* Renewable Resource Generation Development Areas.

Generalist (species): An organism that can survive under a wide variety of conditions, and does not specialize to live under any particular set of circumstances.

Geoglyphs: Ground markings of a figure or shape produced by the clearing or alignment of stones.

Geographic air basins: A land area with generally similar meteorological and geographic conditions throughout. To the extent possible, air basin boundaries are defined along political boundary lines and include both the source and receptor areas.

Geographic Information System (GIS): A computer system for performing geographical analysis. GIS has four interactive components: an input subsystem for converting into digital form (digitizing) maps and other spatial data; a storage and retrieval subsystem; an analysis subsystem; and an output subsystem for producing maps, tables, and answers to geographic queries.

Geology: The science that deals with the study of the materials, processes, environments, and history of the Earth, including the rocks and their formation and structure.

Geometric spreading: As the sound moves away from the source, the area that the sound energy covers becomes larger and thus sound intensity decreases. This is referred to as "geometric spreading," which is independent of frequency and plays a major role in sound propagation situations. Due to geometric spreading, the sound level is reduced by 6 dB and 3 dB for each doubling of distance from the point (e.g., fixed equipment) and line (e.g., road traffic) sources, respectively.

Geotechnical: Refers to the use of scientific methods and engineering principles to acquire, interpret, and apply knowledge of earth materials for solving engineering problems.

Geotextile mats: Permeable fabrics that interact with soils in manners used to reinforce soil surfaces for erosion, as well as act as filters for water, solutes, and fine sediments.

Geothermal energy: Natural heat from within the Earth, captured for production of electric power.

Geothermal generating plant: A plant in which the prime mover is a steam turbine. The turbine is driven either by steam produced from hot water or by natural steam that derives its energy from heat found in rocks or fluids at various depths beneath the surface of the Earth.

Geothermal resources: Typically underground reservoirs of hot water or steam created by heat from the Earth, but also include subsurface areas of dry hot rock.

GHGs: *See* Greenhouse gases.

GIS: *See* Geographic Information System.

Glacial till: An unsorted, unstratified mixture of fine and coarse rock debris deposited by a glacier.

Glare: The sensation produced by luminances within the visual field that are sufficiently greater than the luminance to which the eyes are adapted, which causes annoyance, discomfort, or loss in visual performance and visibility. *See als*o Glint

Glint: A momentary flash of light resulting from a spatially localized reflection of sunlight. *See also* Glare.

Global warming: An increase in the near-surface temperature of the Earth. Global warming has occurred in the distant past as the result of natural influences, but the term is today most often used to refer to the warming that many scientists predict will occur as a result of increased anthropogenic emissions of greenhouse gases.

Graben (fault-bounded basins): An elongated crustal block that is relatively depressed (down dropped) between two parallel normal faults or horsts. *See also* Half-graben.

Graminoid herbaceous: A grass or plant of similar growth form, such as sedges, rushes, and others.

Grandfathered rights: In Arizona, grandfathered water rights are based on historic use of groundwater for five years prior to the designation of an Active Management Area. Most grandfathered rights are appurtenant to the land, but some are not and may be purchased or leased from the owner.

Granite: A coarse-grained felsic intrusive (or plutonic) igneous rock with at least 65% silica. Quartz, plagioclase feldspar, and potassium feldspar make up most of the rock and give it a fairly light color; the plutonic equivalent of rhyolite.

Granodiorites: A plutonic igneous rock, formed by an intrusion of silica-rich magma, which cools in batholiths or stocks below the Earth's surface. It is usually only exposed at the surface after uplift and erosion have occurred. The volcanic equivalent of granodiorite is dacite.

Grasslands: Grasslands are characterized as lands dominated by grasses rather than large shrubs or trees.

Graver: A small tool with a sharp tip that was used to engrave bone, stone, wood, or other materials.

Grazing: Consumption of native forage from rangelands or pastures by livestock or wildlife.

Grazing allotment: An area where one or more livestock operators graze their livestock. An allotment generally consists of federal land but may include parcels of private or state-owned land.

Grazing lease: An authorization that permits the grazing of livestock on public lands outside the grazing districts during a specified period of time (Section 15 of the Taylor Grazing Act).

Great Basin: An area covering most of Nevada and much of western Utah, as well as portions of southern Oregon and southeastern California, consisting primarily of arid, high elevation, desert valleys, sinks (playas), dry lake beds, and salt flats. The Great Basin is characterized by the fact that all surface waters drain *inward* to terminal lakes or sinks. The Great Basin cultural area extends beyond the physiographic Great Basin to include traditional areas of tribes who speak languages related to those spoken in the Great Basin and who traditionally pursued a similar lifestyle. These include the Utes of the Colorado Plateau in eastern Utah and western Colorado.

Greenhouse gases (GHGs): Heat-trapping gases that cause global warming. Natural and human-made greenhouse gases include water vapor, carbon dioxide, methane, nitrogen oxides, ozone, and chlorofluorocarbons.

Grid: A term used to describe an electrical utility distribution network.

Ground: An edge or surface that was smoothed by abrasion.

Ground failure: Permanent ground displacement capable of damaging structures that may occur as a result of differential settlement, liquefaction, lateral spreading, or landslides.

Ground fault mats: Mats made of insulating materials that do not conduct electricity.

Ground motion (shaking): The movement of the Earth's surface from earthquakes. Ground motion is produced by seismic waves that are generated by a sudden slip on a fault and travel through the Earth and along its surface.

Groundwater: The supply of water found beneath the Earth's surface, usually in porous rock formations (aquifers), which may supply wells and springs. Generally, it refers to all water contained in the ground.

Groundwater basin: (1) A general term used to define a groundwater flow system that has defined boundaries and may include permeable materials that are capable of storing or furnishing a significant water supply. The basin includes both the surface area and the permeable materials beneath it. (2) The underground area from which groundwater drains. The basins could be separated by geologic or hydrologic boundaries.

Groundwater overdraft: The condition in which water extractions from an aquifer exceed recharge processes in such excess as to cause substantial and sustained decreases in groundwater flows and groundwater elevations.

Groundwater recharge: Inflow of water to a ground-water reservoir from the surface. Infiltration of precipitation and its movement to the water table is one form of natural recharge. Also, the volume of water added by this process.

Grubbing: *See* Clearing and grubbing.

Gypsum: A soft mineral composed of hydrated calcium sulfate ($CaSO_4 \cdot 2H_20$); occurs as an evaporite residue from ancient lakes in arid basins (e.g., Tularosa Basin in New Mexico).

Gypsum badlands: Badlands dominated by soils derived from the mineral gypsum (hydrated calcium sulfate).

Habitat: The place, including physical and biotic conditions, where a plant or animal lives. *See also* Aquatic habitat.

Habitat alteration: A change in the particular environment or place where an organism or species lives. Usually implies changes made to the environment that adversely affect the function of the ecosystem, although not completely or permanently.

Habitat degradation: Decline in habitat quality that accompanies non-natural forms of disturbance.

Habitat generalist (species): *See* Generalist.

Habitat type: An aggregation of all land areas potentially capable of producing similar plant communities at climax.

Half-graben: A geological term that describes a sedimentary basin where one side is bounded by a normal (extensional) fault.

Harassment: The intentional or unintentional disturbance of individual animals causing them to flee a site or avoid use of an area.

Hardpan: A dense, often impermeable soil horizon cemented with silica, iron oxides, calcium carbonate, or organic matter.

Hazardous Air Pollutants (HAPs): Substances that have adverse impacts on human health when present in ambient air.

Hazardous material: Any material that poses a threat to human health and/or the environment. Hazardous materials are typically toxic, corrosive, ignitable, explosive, or chemically reactive.

Hazardous waste: By-products of society that can pose a substantial or potential hazard to human health or the environment when improperly managed. Possesses at least one of four characteristics (ignitability, corrosivity, reactivity, or toxicity) or appears on special U.S. Environmental Protection Agency lists.

Headwater: (1) The source and upper reaches of a stream; also the upper reaches of a reservoir; (2) the water upstream from a structure or point on a stream; (3) the small streams that come together to form a river. Also may be thought of as any and all parts of a river basin other than the mainstream river and main tributaries.

Heat exchanger: Any device that transfers heat from one fluid (liquid or gas) to another or to the environment.

Heat Transfer Fluid (HTF): Fluids that transfer heat generated at the solar collectors to a heat exchanger where steam is produced to run a steam generator.

Heavy metals: Metallic elements with high atomic weights (e.g., mercury, chromium, cadmium, arsenic, and lead); can damage living things at low concentrations and tend to accumulate in the food chain.

Hedonic – (modeling approach): The hedonic method is a regression technique used to estimate the prices of qualities or models that are not available on the market in particular periods, but whose prices in those periods are needed in order to be able to construct price relatives.

Hedonic statistical framework: A method of assessing the impact of various structural (number of bedrooms, bathrooms, square footage, age, etc.) and locational attributes (local amenities, fiscal conditions, distance to workplace, etc.) on residential housing prices.

Heliostat: One of many components of a CSP Power Tower facility; a large, nearly flat mirror, usually on a tracker, pedestal, or other support structure, that allows it to continuously reflect the sun's rays onto a central receiver at the top of a centrally positioned tower over the course of the day. *See also* Flat-plate reflector.

Herbaceous: The plant strata that contain soft, not woody, stemmed plants that die to the ground in winter.

Herbicide: Chemicals used to kill undesirable vegetation.

Herd Area (HA): Following passage of the Wild Free-Roaming Horses and Burros Act (WFRHBA) in 1971, the Bureau of Land Management was directed to identify areas where wild horses and burros were located. These areas were designated as *Herd Areas* (areas where horses and burros were in 1971). Herd areas are not managed for wild horses and burros.

Herd Management Area (HMA): An area that has been designated for management of wild horses and/or burros.

Herpetofauna: Amphibian and reptile species including frogs, toads, salamanders, turtles, lizards, and snakes.

Hertz (Hz): The unit of measurement of frequency, equivalent to one cycle per second.

High liquefaction potential: Refers to the susceptibility of soils to liquefy when subjected to sudden loading, such as intense ground shaking from an earthquake. Liquefaction hazards are associated with saturated, sandy, and silty soils with low plasticity, such as those in the San Francisco Bay Area and along various inland water bodies in earthquake-prone areas. *See also* Liquefaction.

Highly discordant land use: Refers to development that is at variance with the existing condition of the land. It might also be described as incongruous.

Historic: The time period after the appearance of written records. In the New World, this generally refers to the time period after the beginning of European settlement at approximately 1600 A.D.

Historic properties: Any prehistoric or historic districts, sites, buildings, structures, or objects included in, or eligible for inclusion in, the National Register of Historic Places maintained by the Secretary of the Interior. They include artifacts, records, and remains that are related to and located within such properties.

Historic resources: Material remains and the landscape alterations that have occurred since the arrival of Euro-Americans.

Historic trails: A general term used to define a groundwater flow system that has defined boundaries and may include permeable materials that are capable National Historic Trails.

Hogbacks: An eroded steep ridge of resistant rocks produced by erosion of the broken edges of highly tilted strata.

Holocene: The past 10,000 years of geologic time. The most recent epoch of the Quaternary period. Together the Holocene and Pleistocene make up the Quaternary Period.

Horizontal angle of view: The angle of landscape viewed in sharp focus, measured along the horizon, without turning the head. *See also* Vertical angle of view; Angle of view.

Horizontal field of view: *See* Horizontal angle of view.

Horizon line: The apparent line in the landscape formed by the meeting of the visible land surface and the sky.

Horst: An elongated crustal block that is relatively raised between two parallel normal faults or grabens. *See also* Half-graben.

Hunter gatherers: A term applied to people whose diet is based on hunting, fishing, and gathering, as opposed to domesticating animals or plants.

Hunting: Includes big- and small-game hunting, waterfowl hunting, and trapping.

Hybrid (wet-dry cooling) systems: A variation on a dry cooling system. In this hybrid system, small amounts of water are sprayed as a fine mist into the flow of ambient air being directed over the surface of a dry condenser. The water evaporates, cooling the air as it does so. Alternatively, water is deluged over the surface of the dry condenser where it evaporates after interacting with the overflowing ambient air stream, cooling that air. Wet/dry hybrid systems consume only minor amounts of water (compared to wet closed-loop cooling) but offer significantly better performance than dry cooling systems, especially in hot climates with low relative humidity.

Hydraulic gradient: In an aquifer, the rate of change of total head per unit of distance of flow at a given point and in a given direction. In a stream, the slope of the hydraulic grade line.

Hydro-compactable, collapsible soil (settlement): Low-density soils that undergo appreciable loss of volume when wetted or subjected to increased load (or both). Settlement of these types of soils can be rapid and have devastating effects on structures and facilities.

Hydrofluorocarbons (HFCs): Man-made chemicals, many of which have been developed as alternatives to ozone-depleting substances (ODS) for industrial, commercial, and consumer products.

Hydrology: The study of water that covers the occurrence, properties, distribution, circulation, and transport of water, including groundwater, surface water, and rainfall.

Hydrostratigraphic: Grouping of rock and sedimentary units based on the capacity of the rock, sediment, or soil to transmit water.

Hz: A general term used to define a groundwater flow system that has defined boundaries and may include permeable materials that are capable Hertz.

Igneous rock: A crystalline rock formed by the cooling and solidification of molten or partly molten material (magma). Igneous rock includes volcanic rock (rock solidified above the Earth's surface) and plutonic rock (rock solidified at considerable depth).

Impact: The effect, influence, alteration, or imprint caused by an action.

Impermeable: Refers to a rock matrix that water cannot infiltrate.

Impingement: The entrapment of aquatic organisms on the outer part of an intake structure or against a screening device during periods of intake water withdrawal.

IMPLAN: Input-output economic model based on economic accounts showing the flow of commodities to industries from producers and institutional consumers. The accounts also show consumption activities by workers, owners of capital, and imports from outside the region.

Impoundment (surface): A body of water or sludge confined by a dam, dike, floodgate, or other barrier.

Impulsive noise: Noise from impacts or explosions (e.g., from a pile driver, forging hammer, punch press, or gunshot), which is brief and abrupt, and its startling effects cause great annoyance.

In attainment: In compliance with air-quality standards. Areas that are in attainment have air quality that is as good as or better than specified in the National Ambient Air Quality Standards for a given pollutant. An area may be in attainment for one pollutant and nonattaining for others.

Incidental take permit: A permit issued under Section 10 of the Federal Endangered Species Act to private parties undertaking otherwise lawful projects that might result in the take of an endangered or threatened species. Application for an incidental take permit is subject to certain requirements, including preparation by the permit applicant of a conservation plan, generally known as a Habitat Conservation Plan or HCP.

Indian trust assets: Lands, natural resources, or other assets held in trust or restricted against alienation by the United States for Native American Tribes or individual Native Americans.

Indian trust resources: Those natural resources, either on or off Indian lands, retained by or reserved by or for Indian Tribes through treaties, statutes, judicial decisions, and E.O.s, which are protected by a fiduciary obligation on the part of the United States.

Indirect effects: Secondary effects which occur in locations other than the initial action or significantly later in time.

Indirect impact: Impacts that occur away from the place of origin (see Chapter 8 of the text). An effect that is related to, but removed from, a proposed action by an intermediate step or process. An example would be changes in surface-water quality resulting from soil erosion at construction sites.

Induration: The hardening of a rock, usually sedimentary, by drying, pressure, or cementation.

Industrial waste: Materials discarded from industrial operations or derived from manufacturing processes.

Infiltration: The movement of water (usually precipitation) from the ground surface into the subsurface.

Infiltration pond: A shallow impoundment designed to infiltrate stormwater into the soil. Also referred to as an infiltration basin.

Inflow: Water that flows into a surface water or groundwater body. The amount of water entering a reservoir expressed as a volume per time.

In-migration: People moving into an area.

In-situ: In its natural position or place; unmoved, unexcavated, remaining at the site or subsurface.

Inset fans: An alluvial fan that occurs on top of an older alluvial fan.

Insolation: The solar power density incident on a surface of stated area and orientation, usually expressed as watts per square meter or btu per square foot per hour.

Intaglios: An impression, design, or figure created on the ground by man through the placement of rocks or mounding of earth.

Interbasin flow: Surface water or groundwater flow between two hydrologic basins.

Interbasin transfers: The transfer of water to another water management basin.

Interbasin transfer of water: A transfer of water rights and/or a diversion of water (either groundwater or surface water) from one drainage or hydrographic basin to another.

Interdune flats: The area between dunes, generally flat and often erosion-resistant.

Intermittent streams: A stream that flows for a portion of the year but occasionally is dry or reduced to a pool stage when losses from evaporation or seepage exceed the available streamflow.

Intermontane basin: An alluvium-filled valley between mountain ranges, often formed over a graben.

Interpretive site: Information communicated via plaques, markers, and other methods, about the natural and/or cultural resources, their history and values, that are found at a specific site or along a trail. Tours, signs, brochures, informational kiosks, and other means can be used to interpret a particular resource.

Intrusives: An igneous rock that forms under the Earth's surface. Examples include granite, diorite, and gabbro.

Invasive species: Any species, including noxious and exotic species, that is an aggressive colonizer and can out-compete indigenous species.

Invertebrate: An animal, such as an insect or mollusk, that lacks a backbone or spinal column.

Inverter: An electrical device that converts direct current (DC) into alternating current (AC).

Irradiance: *See* Insolation.

Irrigation: The controlled application of water for agricultural purposes through manmade systems to supply water requirements that are not satisfied by rainfall.

Irrigation Non-Expansion Area (INA): A geographic area in Arizona that has been designated as having insufficient groundwater to provide a reasonably safe supply for the irrigation of the cultivated lands at the current rate of withdrawal.

Junior water rights: Water rights that are more recent than older or more senior rights. *See also* Senior water rights.

Just-in-Time ordering: A strategy for managing materials used at a project that ensures materials become available as needed to support activities, but are not stockpiled at the project location in excess of what is needed at any point in time. The just-in-time approach controls costs by avoiding the accumulation of inflated inventories, reducing the potential for stockpiled materials to go out-of-date or otherwise become obsolete, and minimizing product storage and management requirements. When applied to hazardous chemicals, this approach reduces waste generation, the potential for mismanagement of materials and the overall risk of adverse impacts resulting from emergency or off-normal events involving those materials.

Key observation point(s) (KOPs): One or a series of points on a travel route or at a use area or a potential use area, where the view of a management activity would be most revealing. KOPs are typically used as viewpoints for assessing potential visual impacts resulting from a proposed management activity.

Kilowatt: A unit of electrical power equal to 1,000 watts (W).

Kiva: An underground (or partially underground) ceremonial room or chamber used in ancient and modern Pueblo villages.

Knob: A small hilltop that is round in shape.

Known Geothermal Area (KGA): A region identified by the U.S. Geological Survey as containing geothermal resources.

Laccolith: An igneous intrusion that has been forced between two layered rock units. The top of the intrusion is arched upwards and the bottom of the intrusion is nearly flat.

Lacustrine wetland: Wetlands that are generally larger than 20 acres and having less than 30% cover of vegetation such as trees, shrubs, or persistent emergent plants. Lacustrine sediments are generally made up of fine-grained particles deposited in lakes.

Lag gravel: Residual deposit of coarse material that has had the finer fraction removed by a transporting agent, usually wind or water.

Lahar: A mudflow composed of water and volcanic ash. Lahars can be triggered by the flash melting of the snow cap of a volcanic mountain or from heavy rain. Lahars are very dangerous because they can occur suddenly and they can travel at great speeds.

Land area: Includes dry land and land temporarily or partially covered by water, such as marshlands, swamps, and river flood plains; streams, sloughs, estuaries, and canals less than 1/8 of a statute mile in width; and lakes, reservoirs, and ponds having less than 40 acres of water-surface area.

Land cover: The physical coverage of land, usually expressed in terms of vegetation cover or lack of it.

Land disturbance: Discrete event or process which alters soil, and/or kills or damages vegetation. From an ecological and hierarchical perspective, disturbance is a change in the minimal structure of an ecosystem caused by a factor external to the reference structure. Examples of disturbance are habitat reduction, habitat fragmentation, and habitat alteration.

Land disturbance in natural drainage systems: Any movement (e.g., grading or excavation) of soil or sediment in a natural drainageway.

Landform: Any feature of the Earth's surface having a distinct shape and origin. Landforms include major features (such as continents, ocean basins, plains, plateaus, and mountain ranges) and minor features (such as hills, valleys, slopes, drumlins, and dunes).

Land subsidence: The sinking or settling of land to a lower level in response to various natural and man-caused factors. With respect to groundwater, subsidence most frequently results from overdrafts of the underlying water table or aquifer and its inability to fully recharge, a process called aquifer compaction. *See also* Subsidence.

Land Use: A characterization of land surface in terms of its potential utility for various activities.

Land Use Plan: A set of decisions that establish management direction for land within an administrative area, as prescribed under the planning provisions of FLPMA; an assimilation of land-use-plan-level decisions developed through the planning process outlined in 43 CFR 1600, regardless of the scale at which the decisions were developed. *See also* Resource Management Plan.

Land withdrawal: Withdrawals are governed by regulations issued under FLPMA, contained in 43 CFR Part 2300. A withdrawal is defined as: "Withholding an area of Federal land from settlement, sale, location, or entry under some or all of the general land laws, for the purpose of limiting activities under those laws in order to maintain other public values in the area or reserving the area for a particular public purpose or program; or transferring jurisdiction over an area of Federal land, other than property governed by the Federal Property and Administrative Services Act (40 U.S.C. 472), from one department, bureau or agency to another department, bureau or agency." (See 43 CFR 2300.0-5(h).)

Landforms: Any recognizable physical form of the Earth's surface, having a characteristic shape, and produced by natural causes. Landforms include major forms such as plains, plateaus, and mountains, and minor forms such as hills, valleys, slopes, and moraines. Taken together, the landforms make up the surface configuration of the Earth.

Landmark: Type of reference point external to the observer. Usually a simply defined physical object. Some are distant, seen from many angles and distances over the tops of smaller elements and used as a radial reference.

Landscape: The traits, patterns, and structure of a specific geographic area including its biological composition, its physical environment, and its anthropogenic or social patterns.

Landscape character: The arrangement of a particular landscape as formed by the variety and intensity of the landscape features and the four basic elements of form, line, color, and texture. These factors give the area a distinctive quality which distinguishes it from its immediate surroundings.

Late Archaic: The period 3,000 to 1,500 years B.P.

Latite: An igneous, volcanic (extrusive) rock.

Lava: Magma that reaches the Earth's surface and issues from volcanoes.

Lava tubes: Natural conduits through which lava moves beneath the surface of a lava flow during a volcanic eruption. In solidified lava flows, lava tubes may be seen as collapsed features or open trenches at the surface.

Lava flow: An outpouring of lava onto the land surface from a vent or fissure. Also, a solidified tongue-like or sheetlike body formed by outpouring lava.

Law of the River: A complex body of laws, court decrees, contracts, agreements, regulations and an international treaty used to govern allocation and management of Colorado River water.

Laydown area: An area that has been cleared for the temporary storage of equipment and supplies. To ensure accessibility and safe maneuverability for transport and off-loading of vehicles, laydown areas are usually covered with rock and/or gravel.

L_{dn}: The day-night average sound level. It is the average A-weighted sound level over a 24-hour period that gives additional weight to noise that occurs during the night (10:00 p.m. to 7:00 a.m.) to account for the greater sensitivity of most people to nighttime noise.

Lead: A gray-white metal that is listed as a criteria air pollutant. Health effects from exposure to lead include brain and kidney damage and learning disabilities. Sources include leaded gasoline and metal refineries.

Leasable minerals: Federal minerals such as coal, oil shale, oil, gas, phosphate, potash, sodium, tar sands, geothermal resources, potassium, asphaltic materials, and all other minerals that are subject to lease under the Mineral Leasing Act of 1920, as amended and supplemented.

Lease: A contract in legal form that provides for the right to develop and produce resources within a specific area for a specific period of time under certain agreed-upon terms and conditions.

Left-lateral fault: *See* Fault, left-lateral.

Lentic environment: An aquatic ecosystem in which the water is still and not rapidly moving, such as is found in ponds and swamps.

Lek: A communal mating area within which males of certain species hold small territories, which they use solely for courtship and copulation.

L_{eq}: Equivalent/continuous sound level. L_{eq} is the steady sound level that would contain the same total sound energy as the time-varying sound over a given time.

License: An authority granted by the United States to do a particular act or series of acts upon public lands without the licensee possessing any estate or interest in the land itself.

Light fixture: An electrical device used to create artificial light and/or illumination.

Light pollution: Any adverse effect of human-made lighting, such as excessive illumination of night-skies by artificial light. Light pollution is an undesirable consequence of outdoor lighting that includes such effects as sky glow, light trespass, and glare.

Light spillage: An undesirable condition in which light is cast where it is not wanted. (Also referred to as light trespass.)

Light trespass: *See* Light spillage.

Limestone: A sedimentary rock made mostly of the mineral calcite (calcium carbonate). Limestone is usually formed from shells of once-living organisms or other organic processes in a marine environment, but may also form by inorganic precipitation.

Line: The path, real or imagined, that the eye follows when perceiving abrupt differences in form, color, or texture. Within landscapes, lines may be found as ridges, skylines, structures, changes in vegetative types, or individual trees and branches.

Lineaments: A straight topographic feature of regional extent which is thought to represent crustal structure. Other examples include faults, a linear series of depressions or sinkholes, a straight length of a river or stream, or a line of volcanoes.

Liner: A relatively impermeable barrier designed to keep leachate inside a landfill. Liner materials include plastic and dense clay.

Liquefaction: Refers to a sudden loss of strength and stiffness in loose, saturated soils. It causes a loss of soil stability and can result in large, permanent displacements of the ground.

Lithic: Relating to stone or rock.

Lithic debitage: Debris produced during stone (lithic) tool manufacture.

Lithic scatter: A distribution of cultural items that consists primarily of lithic (stone) material. The scatter may include formed tools such as points or knives, or it may contain only chipping debris from tool-making activities.

Livestock guzzlers: A watering system for cattle and other livestock that maintains a set water level as water is used.

Livestock watering area: Water used for livestock watering, feed lots, dairy operations, fish farming, and other on-farm needs.

Loam: A soil consisting of an easily crumbled mixture of clay, silt, and sand.

Locatable Minerals: Minerals or materials subject to disposal and development through the Mining Law of 1872 (as amended). Generally includes metallic minerals such as gold, copper, lead, and silver and other materials that are not subject to lease or sale (i.e., oil and natural gas).

Lode: A mineralized ledge, vein or mineral deposit in place.

Lode mining claim: A claim based on the presumption that the valuable mineral is a part of a bed-rock lode, vein, stockwork, stratum, or intrusion and is not dominantly a physical redistribution of values by surficial processes; the latter constitutes a placer deposit.

Loess: A group of windblown soils, largely comprising silt, weakly cemented by calcite.

Low-income population: Persons whose average family income is below the poverty line. The poverty line takes into account family size and age of individuals in the family. For any family below the poverty line, all family members are considered to be below the poverty line.

Low-level magnetic fields: Fields of force that are generated whenever electric current flows. The sun's average large-scale magnetic field, and the Earth's, exhibit a north and a south pole, linked by lines of magnetic force.

Luminaire: A complete lighting unit consisting of a lamp (or lamps) and the parts designed to distribute the light, to position and protect the lamp(s), and to connect the lamp(s) to the power supply. Also referred to as a light fixture.

Maar: A volcanic crater that is produced by an explosion in an area of low relief, is generally more or less circular, and often contains a lake, pond, or marsh.

Macrophyte (aquatic): An aquatic plant that is large enough to be observed with the naked eye. It grows in or near water.

Mafic (or maphic): A term used to describe an igneous rock that has a large percentage of dark-colored minerals such as amphibole, pyroxene, and olivine. Also used in reference to the magmas from which these rocks crystallize. Mafic rocks are generally rich in iron and magnesium. Basalt and gabbro are examples of mafic rocks.

Magma: Molten rock containing liquids, crystals, and dissolved gases that forms within the upper part of the Earth's mantle and crust. When erupted onto the Earth's surface, it is called lava.

Maintenance area: Any geographic region of the United States previously designated nonattainment pursuant to the CAA Amendments of 1990 and subsequently redesignated to attainment subject to the requirement to develop a maintenance plan under section 175A of the CAA, as amended.

Mammals: A group of air-breathing animals whose skin is more or less covered with hair or fur and who have mammary glands. Young are born alive (except for the platypus and echidna) and are nourished with milk. Mammals include man, dogs, cats, deer, mice, squirrels, raccoons, bats, opossums, whales, seals, and others.

Mano: A stone with a flat side that was primarily held in one's hand or hands and used to grind edible substances, typically corn, grains, and nut meats. *See also* Metate.

Mantle: The main bulk of the Earth, between the crust and core, ranging from depths of about 40 to 3,480 kilometers. It is composed of dense mafic silicates and divided into concentric layers by phase changes that are caused by the increase in pressure with depth.

Mantle hot spot: A region of continental or oceanic crust below which a mantle plume causes melting of the overlying crust, resulting in a broad regional topographic swell (e.g., Yellowstone plume) or hot spot volcanism (e.g., the Hawaiian chain of volcanoes which represent movement of ocean crust over a stationary hot spot).

Marsh: An area of low-lying wetlands dominated by grasslike plants.

Maximum Containment Level (MCL): The highest level of a contaminant that is allowed in drinking water. MCLs ensure that drinking water does not pose either a short-term or long-term health risk.

Maximum output: *See* Nameplate capacity.

MCL: *See* Maximum Containment Level.

Mean: Average.

Mean Sea Level (MSL): The arithmetic mean of hourly water elevations observed over a specific 19-year tidal epoch.

Median household income: Divides households into two equal segments, with one-half of households earning less than the median household income and the other half earning more. Median income is a better indicator of typical income levels in an area than average household income as median income is not dramatically affected by unusually high or low values.

Median housing value: Divides housing units into two equal segments, one-half of housing units less than median housing value and the other half valued more. Median housing value is a better indicator of typical housing values in an area than average housing values as median housing value is less likely to be affected by a small number of very highly priced homes.

Megafauna: A number of species of presently extinct mammals including mammoths and mastodons.

Megawatt: A unit of power equal to one million watts (equivalent to one joule per second). One megawatt serves about 300 homes in the western United States based on national data.

Megawatt electrical (MWe): One million watts of electrical energy; a measure of electrical power capacity, use in PEIS is synonymous with MW.

Mesa: A broad, flat-topped elevation with one or more steeply-sloping to vertical sides.

Mesic habitat: A habitat type characterized by the presence of a moderate amount of moisture or water. *Compare:* hydric; *opposite:* xeric.

Mesozoic: An era of geologic time between the Paleozoic and the Cenozoic, spanning the time between 251 and 65 million years ago. The word Mesozoic is from Greek and means "middle life."

Metamorphic rock: A sedimentary or igneous rock that has been changed by pressure, heat, or chemical action. For example, marble is the metamorphosed version of limestone, a sedimentary rock.

Metate: A portable stone slab upon which seeds and other grains are milled with a mano using a push-pull, back-and-forth motion. *See also* Mano.

Microbiotic soil crust: *See* Biological soil crusts.

Microphytic soil crust: *See* Biological soil crusts.

Microsite: A small area within an environment with unique features, conditions, or characteristics relative to the surrounding area. Differentiating features may be temperature, humidity, sunlight, nutrient availability, vegetation cover, or physical characteristics.

Migration corridor: A route followed by animals such as big game, birds, or fish when traveling between winter and summer habitats**.**

Migratory Bird Treaty Act (MBTA): The MBTA implements various treaties and conventions between the United States, and Canada, Japan, Mexico, and the former Soviet Union for the protection of migratory birds. The MBTA made it illegal for people to "take" migratory birds, their eggs, feathers, or nests. *See also* Take.

Military Training Routes (MTRs): A designated corridor of airspace with defined vertical and lateral dimensions established for conducting military flight training at airspeeds in excess of 250 nautical miles per hour.

Milligauss (mG): A unit of measure for magnetic fields.

Millsite mining claim: Claim on non-mineral land for processing ore from a mining claim.

Mineral: A naturally occurring inorganic element or compound having an orderly internal structure and characteristic chemical composition, crystal morphology, and physical properties such as density and hardness. Minerals are the fundamental units from which most rocks are made.

Mineral Leasing Act of 1920 (MLA): Authorizes the agency to issue rights-of-way 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.

Mineral materials: Widespread deposits of common clay, sand, gravel, or stone which are not subject to disposal under the 1872 Mining Law, as amended.

Mining claim: That portion of the public mineral lands which a miner, for mining purposes, takes and holds in accordance with the mining laws. A mining claim may be validly located and held only after the discovery of a valuable mineral deposit.

Mining water use: Water use during quarrying rocks and extracting minerals from the land.

Minority population: Includes Hispanic, American Indian, or Alaskan Native; Asian; Native Hawaiian or Other Pacific Islander; Black (not of Hispanic origin) or African American. "Other" races and multi-racial individuals may be considered as separate minorities.

Miocene: An epoch of the upper Tertiary period, 23 to 5.3 million years ago.

Mirror: A reflecting surface of various physical shapes (parabolic, nearly flat, or flat) used to reflect and/or concentrate the sun's energy to specific locations within solar energy facilities.

Mitigation: A method or process by which impacts from actions can be made less injurious to the environment through appropriate protective measures.

Mitigation measures: Methods or actions that will reduce adverse impacts from solar facility development. Mitigation measures can include best management practices, stipulations in BLM ROW agreements, siting criteria, and technology controls.

Module: *See* Photovoltaic (PV) module.

Molten salts: Mixtures of sodium nitrate and potassium nitrate in various proportions that are used as a heat transfer or heat storage medium in CSP Solar Energy facilities. Mixtures are chosen because of their long-term thermal stability at temperatures as high as 1200°F (649°C).

Montane: The highland area located below the subalpine zone. Montane regions generally have cooler temperatures, and often have higher rainfall than the adjacent lowland regions, and they are frequently home to distinct communities of plants and animals.

Mosses: Low-growing, non-vascular plants that are common to moist habitats.

Mortar: A stone bowl or bowl-shaped depression (such as in a rock) in which seeds, berries, nuts, meats, and other items are ground or pulverized with a pestle, or other handstone or milling stone, using an up-and-down motion. Mortars occur in bedrock outcrops and as portable items. *See also* Pestle.

Multijunction solar cell: A photovoltaic device comprised of two or more semiconductor materials or cell junctions, each capable of producing electricity with the photovoltaic effect by absorbing solar energy from different wavelengths of the solar spectrum. Multijunction solar cells can convert sunlight to electricity at greater overall efficiencies than single-junction cells.

Multiple Use: A combination of balanced and diverse resource uses that takes into account the long-term needs of future generations for renewable and nonrenewable resources, including, but not limited to, recreation, range, timber, minerals, watershed, wildlife, and fish, along with natural scenic, scientific, and historical values.

Multiple Use Classes: 7.2.3.1 **Class C** is for lands designated either as wilderness or for wilderness study areas. These lands are managed to protect their wilderness values. **Class L** (Limited Use) protects sensitive, natural, scenic, ecological, and cultural resource values. Public lands designated as Class L are managed to provide for generally lower intensity, carefully controlled multiple use of resources, while ensuring that sensitive values are not significantly diminished. **Class M** (Moderate Use) is based upon a controlled balance between higher intensity use and protection of public lands. This class provides for a wide variety of present and future uses such as mining, livestock grazing, recreation, energy, and utility development. Class M management is also designed to conserve desert resources and to mitigate damage to those resources which permitted uses may cause. **Class I** (Intensive Use) is to provide for the concentrated use of lands and resources to meet human needs. Reasonable protection will be provided for sensitive natural and cultural values. Mitigation of impacts on resources and rehabilitation of affected areas will occur insofar as possible.

Multiple Use Management: Coordinated management of the various surface and subsurface resources, without permanent impairment of the productivity of the land, that will best meet the present and future needs of the people.

NAAQS: *See* National Ambient Air Quality Standards.

Nameplate rating: The maximum power-generating capacity of a generator or power-generating facility.

National Ambient Air Quality Standards (NAAQS): Air quality standards established by the Clean Air Act, as amended. The primary NAAQS are intended to protect the public health with an adequate margin of safety; and the secondary NAAQS are intended to protect the public welfare from any known or anticipated adverse effects of a pollutant.

National Environmental Policy Act of 1969 (NEPA): Requires federal agencies to prepare a detailed statement on the environmental impacts of their proposed major actions that are significantly affecting the quality of the human environment.

National Historic Preservation Act (NHPA): A federal law providing that property resources with significant national historic value be placed on the *National Register of Historic Places*. It does not require permits; rather, it mandates consultation with the proper agencies whenever it is determined that a proposed action might impact an historic property.

National Historic Trails: These trails are designated by Congress under the National Trails System Act of 1968 and follow, as closely as possible, on federal land, the original trails or routes of travel that have national historical significance.

National Landscape Conservation System (NLCS): Created by the BLM in June 2000 to increase public awareness of BLM lands with scientific, cultural, educational, ecological, and other values. It consists of National Conservation Areas, National Monuments, Wilderness Areas, Wilderness Study Areas, Wild and Scenic Rivers, and National Historic and Scenic Trails.

National Pollutant Discharge Elimination System (NPDES): A federal permitting system controlling the discharge of effluents to surface water and regulated through the Clean Water Act, as Amended.

National Recreation Area: An area designated by Congress to assure the conservation and protection of natural, scenic, historic, pastoral, fish, and wildlife values, and to provide for the enhancement of recreational values.

National Register of Historic Places (NRHP): A comprehensive list of districts, sites, buildings, structures, and objects that are significant in American history, architecture, archaeology, engineering, and culture. The NRHP is administered by the National Park Service, which is part of the Department of the Interior.

National Scenic Byway: *See* All American Roads.

Native American: Of, or relating to, a tribe, people, or culture that is indigenous to the United States. (*See* Native American Graves Protection and Repatriation Act).

Native American Graves Protection and Repatriation Act (NAGPRA): This act established the priority for ownership or control of Native American cultural items excavated or discovered on federal or tribal land after 1990 and the procedures for repatriation of items in federal possession. The act allows for the intentional removal or excavation of Native American cultural items from federal or tribal lands only with a permit or upon consultation with the appropriate tribe.

Natural drainages: Natural systems that convey water (such as a stream channel) that may be perennial, intermittent, or ephemeral.

NatureServe: A non-profit organization that provides the scientific information and tools needed to guide effective conservation action. NatureServe and its network of natural heritage programs are a leading source of information about the species and ecosystems of the United States, Canada, and Latin America.

NatureServe Explorer: A website from NatureServe that provides authoritative conservation information in a searchable database for more than 70,000 plants, animals, and ecological communities in the United States, Canada, and Latin America.

Neotropical migrants: Birds (especially songbirds) that summer in North America but migrate to the tropics for the winter.

NEPA: *See* National Environmental Policy Act of 1969.

Net emissions: Applied to greenhouse gas emissions inventory in this report. "Net emissions" means gross emissions (including all industrial activities, mostly fossil fuel combustion) minus carbon sinks from forestry activities and agricultural soils.

Night-sky impact: An interference with enjoyment of dark night skies resulting from light pollution.

Nighttime mean rural background level: Nighttime (10 p.m. to 7 a.m.) average sound level in the rural environment, from all sources, rather than a particular noise that is of interest.

Nitrogen dioxide: (NO_2): A toxic, reddish-brown gas that is a strong oxidizing agent, produced by combustion (as of fossil fuels). It is the most abundant of the oxides of nitrogen in the atmosphere and plays a major role in the formation of ozone. NO_2 is one of the six criteria air pollutants specified under Title I of the Clean Air Act.

Nitrogen oxides (NO_x): Nitrogen oxides include various nitrogen compounds, primarily nitrogen dioxide and nitric oxide. They form when fossil fuels are burned at high temperatures and react with volatile organic compounds to form ozone, the main component of urban smog. They are also a precursor pollutant that contributes to the formation of acid rain.

NO_2: *See* Nitrogen dioxide.

Noise: Any unwanted sound that interferes with speech and hearing, causes damage to hearing, or annoys a person.

Noise criteria: Quantitative noise limits, below which it is acceptable for people to hear. Typically, noise criteria are specified in ordinances, regulations, or guidances.

Nonattainment area: The EPA's designation for an air quality control region (or portion thereof) in which ambient air concentrations of one or more criteria pollutants exceed National Ambient Air Quality Standards.

Nongame species: Those species not commonly harvested either for sport or profit.

Non-market value: Most environmental goods and services, such as clean air and water, and healthy fish and wildlife populations, are not traded in markets, meaning that their economic value, or how much people would be willing to pay for them, is not revealed in market prices. To incorporate them into economic analyses, monetary values are assigned to them using non-market valuation methods.

Nonpoint light source: A light source that is sufficiently large in size and close enough to the viewer to appear as an illuminated surface rather than a star-like point of light.

Nonpoint sources: Diffuse pollution sources (i.e., without a single point of origin or not introduced into a receiving stream from a specific outlet). The pollutants are generally carried off the land by storm water. Common non-point sources are agriculture, forestry, urban, mining, construction, dams, channels, land disposal, saltwater intrusion, and city streets.

Non-point source pollution: Pollution whose source is not specific in location; the sources of the pollutant discharge are dispersed, not well defined or constant. Examples include sediments from logging activities and runoff from agricultural chemicals.

Nonroad mobile sources (emissions): Sources such as farm and construction equipment, gasoline-powered lawn and garden equipment, and power boats and outdoor motors that emit pollutants.

NO_X: *See* Nitrogen oxides.

Noxious weeds: Those plants regulated by law or those that are so difficult to control that early detection is important.

Nurse plants: Mature plants that create favorable conditions for seeds to germinate and for seedlings to survive and grow.

Oasis: An isolated, fertile tract or green locality in a desert region, made so by the presence of water. *See also* Palm oasis.

Obligate species: Restricted to a particular condition of life; for example, dependent on a particular habitat to be able to breed. *See also* riparian obligate; sand-dune obligate.

O_3: *See* ozone.

Obsidian: A black or dark-colored volcanic glass.

Occupational Safety and Health Administration (OSHA): Congress created the OSHA under the Occupational Safety and Health Act on December 29, 1970. Its mission is to prevent work-related injuries, illnesses, and deaths.

Off-Highway Vehicles (OHV) or **Off-Road Vehicles**. Any motorized vehicle designed for or capable of cross-country travel on or immediately over land, water, sand, snow, ice, marsh, swampland, or other natural terrain; except that such term excludes (A) any registered motorboat, (B) any military, fire, emergency, or law enforcement vehicle when used for emergency purposes, and (C) any vehicle whose use is expressly authorized by the respective agency head under a permit, lease, license, or contract. *See also* Off-Road Vehicle Designations.

Off-Road Vehicle: *See also* Off-Highway Vehicle.

Off-Road Vehicle (OHV) Designations: OPEN: Vehicles are allowed without restrictions. **LIMITED:** Vehicle travel off existing roads and trails would be allowed only for authorized or permitted uses. **CLOSED**: Vehicle travel is closed in the area including existing roads and trails, except for authorized uses.

Off-site facility: A hazardous waste treatment, storage, or disposal area that is located away from the generating site.

Oil and gas leasing (on BLM land): The BLM leases oil and gas rights to explore for and produce oil and gas resources from federal lands or mineral rights owned by the federal government. Federal oil and gas leases may be obtained and held by any adult citizen of the United States.

Onroad mobile source (emissions): Any mobile source of air pollution such as cars, trucks, motorcycles, and buses that travels on roads and highways.

OSHA: *See* Occupational Safety and Health Administration.

Ostracods: Group of small crustaceans with a bivalved carapace which can be closed to completely cover the body; important planktonic fish food.

Outflow: The amount of surface water or groundwater passing a given point downstream, expressed as a volume per time. Water flowing out of a body of water.

Overbank deposits: Fine-grained sediment (silt and clay) deposited from suspension on a floodplain by floodwaters from a stream channel.

Overdraft: The pumping of water from a groundwater basin or aquifer in excess of the supply flowing into the basin; resulting in a depletion or mining of the groundwater in the basin.

Ozone O_3: A strong-smelling, reactive, toxic, chemical gas consisting of three oxygen atoms chemically attached to each other. Ozone is formed in the atmosphere by chemical reactions involving NO_X and volatile organic compounds in the presence of sunlight. Ozone is a criteria air pollutant under the Clean Air Act and is a major constituent of smog.

Paleontological Resources: Fossilized remains, imprints, and traces of plants and animals preserved in rocks and sediments since some past geologic time.

Paleozoic: An era of geologic time, from the end of the Precambrian to the beginning of the Mesozoic, spanning the time between 542 and 251 million years ago. The word Paleozoic is from Greek and means "old life."

Palm oasis: (1) A desert habitat with permanent water or a water table near the surface that supports a canopy of palm trees. Oasis habitats generally occupy sites with moist alkaline soils near seeps, springs, and streams. (2) An isolated palm-dominated area of vegetation in a desert, typically surrounding a spring or a similar water source. Palm oasis habitats are found adjacent to a number of other desert habitats including desert riparian, desert cactus shrub, and desert wash. In many cases, characteristic plant species from these habitats comprise the understory of palm oases.

Palustrine wetland: Shallow freshwater wetlands that often support plant communities of trees, shrubs, emergent plants, mosses, or lichens. Palustrine wetlands without such plant communities are small (less than 20 acres [0.08 km^2]) and lack an active wave-formed or bedrock shoreline.

Pan evaporation: A measurement that combines or integrates the effects of several climate elements: temperature, humidity, solar radiation, and wind. Evaporation is greatest on hot, windy, dry days; and is greatly reduced when air is cool, calm, and humid. *See also* Evaporation rate.

Parabolic solar collector trough: *See* Parabolic trough**.**

Parabolic trough: A type of CSP Solar Energy technology that uses parabolic-shaped mirrors to concentrate sunlight on a receiver filled with a heat transfer fluid that subsequently transfers the heat it absorbs to water to produce steam to drive a steam turbine-generator (STG) to produce electricity. Parabolic Trough systems typically mount the mirrors on a support that can track the sun's movement across the sky over the course of the day, ensuring maximum solar energy capture.

Parabolic trough system: *See* Parabolic trough.

Particulate matter: Fine solid or liquid particles such as dust, smoke, mist, fumes, or smog, found in air or emissions. The size of the particulates is measured in micrometers (μm). One micrometer is 1 millionth of a meter or 0.000039 inch. Particle size is important because the EPA has set standards for $PM_{2.5}$ and PM_{10} particulates.

Passerine: Birds of the order Passeriformes, which includes perching birds and songbirds such as the jays, blackbirds, finches, warblers, and sparrows.

Patterned-body anthropomorphs: Object or drawing having a human shape with a pattern or design. *See also*: Anthropomorphic; Anthropomorphism.

Peak horizontal acceleration: *See* Acceleration.

Peanut-body anthropomorphs: Object or drawing having a human-like shape resembling that of a peanut. *See also*: Anthropomorphic; Anthropomorphism.

Pediment: A broad, gently-sloping erosion surface developed at the base of a mountain range in a dry region. It is usually covered with a thin layer of gravel.

Per capita income: The average income per person in a given group.

Perennial allotment: A BLM grazing allotment that consistently produces enough perennial forage to support a year round livestock operation.

Perennial streams: Streams that flow continuously, because they lie at or below the groundwater table which constantly replenishes them.

Perennial surface water features: Surface water features that contain water at all times throughout the year.

Perennial yield (groundwater): The amount of groundwater that can be withdrawn from a groundwater basin over a period of time, without exceeding the long-term recharge of the basin or unreasonably affecting the basin's physical and chemical integrity.

Perennial/Safe/Sustainable yield: A specified rate of groundwater pumping that can be sustained for an indefinite period of time without impairing hydrogeologic and ecologic processes, characteristics, or functions existing within a groundwater basin. Examples of impacts to hydrogeologic and ecologic processes, characteristics, and functions include (but are not limited to) alterations to basin-scale flow paths (direction and magnitude); significant drawdown of groundwater surface elevations; decreases in hydrostatic pressures; and decreased connectivity with surface features such as springs, wetlands, and phreatic vegetation. Quantifying perennial/safe/sustainable yields is a non-trivial task that is often done by examining basin-scale information on groundwater recharge, discharge, and storage processes that is obtained through the combination of extensive field-data collection and numerical modeling.

Perfluorocarbons (PFCs): Compounds consisting of carbon and fluorine. They do not deplete the stratospheric ozone but are very strong greenhouse gases with long lifetimes in the atmosphere.

Permeability: The rate at which liquids pass through soil or other materials in a specified direction.

Permissible Exposure Limit (PPL): The maximum amount or concentration of a chemical that a worker may be exposed to under OSHA regulations.

Permit: An authorization, license, or equivalent control document issued by the EPA or an approved state agency to implement the requirements of an environmental regulation. Permit includes information on which pollutants are being released, how much the source is allowed to release, and the program that will be used to meet pollutant release requirements. Permits are required both for the operation of plants (operating permits) and for the construction of new plants. The 1990 Clean Air Act introduced a nationwide permit system for air pollution control.

Permittee: An individual who holds either a BLM grazing permit or grazing lease that authorizes grazing use of the public lands issued under authority of Section 3 or 15 of the Taylor Grazing Act of June 28, 1934, as amended (TGA). While technically, an individual holding an authorization under Section 3 of the TGA is a permittee, an individual holding an authorization under Section 15 of the TGA holds a lease and is a lessee. For the purpose of the PEIS both permittees and lessees are referred to as permittees.

Permitted use: The forage allocated by, or under the guidance of, an applicable land use plan for livestock grazing in an allotment under a permit or lease; expressed in Animal Unit Months (AUMs) (43 CFR 4100.0-5).

Personal Protective Equipment (PPE): Clothing and equipment that are worn to reduce exposure to potentially hazardous chemicals and other pollutants.

Pesticide: Substances or mixtures thereof, intended for preventing, destroying, repelling, or mitigating any pest. Also, any substance or mixture intended for use as a plant regulator, defoliant, or desiccant.

Pestle: An elongated, often cylindrical stone used to pulverize food products and other cultural products in a mortar. *See also* Mortar.

Petrocalcic: Soil horizon formed when secondary calcium carbonate accumulates in the subsoil and hardens into a hardpan.

Petroglyph: A figure or design carved, abraded, or pecked on rock.

PFYC: *See* Potential Fossil Yield Classification.

Phosphorous: A chemical element used as a dopant in making n-type semiconductor layers. An essential chemical food element that can contribute to the eutrophication of lakes and other water bodies. Increased phosphorus levels result from discharge of phosphorus-containing materials into surface waters.

Photon: A particle of light that acts as an individual unit of energy.

Photosynthesis: The process in green plants and certain other organisms by which carbohydrates are synthesized from carbon dioxide and water using sunlight as an energy source. Most forms of photosynthesis release oxygen as a byproduct. Chlorophyll typically acts as the catalyst in this process.

Photovoltaic (PV) array: An interconnected system of PV modules that function as a single electricity-producing unit. The modules are assembled as a discrete structure, with common support or mounting. In smaller capacity systems, an array can consist of a single module.

Photovoltaic (PV) cell: The smallest semiconductor element within a PV module that converts incident sunlight into electrical energy (direct current voltage and current). Also called a solar cell.

Photovoltaic (PV) facility: A solar energy facility that uses photovoltaic cells to produce electricity and that includes all components, such as the PV system, power conditioning equipment, monitoring and control capabilities, and other features required for safe connection of the facility to the bulk electricity transmission grid, as well as buildings, access roads, perimeter fence, and other equipment needed for operation and maintenance of the facility.

Photovoltaic (PV) module: An assembly of solar cells (flat-plate type) or receiver(s) and optics (concentrator type) and ancillary parts, such as interconnects and terminals, enclosed in a weatherproof container, intended to generate DC power under unconcentrated sunlight. (Note: A CPV module is a concentrator type PV module.) The structural (load carrying) member of a module can either be the top layer (superstrate) or the back layer (substrate).

Photovoltaic (PV) panel: A collection of modules, either flat-plate or concentrator type, mechanically fastened, electrically interconnected, and designed to provide a field-installable unit. (Note: Not all PV systems will use panelized units during installation. Sometimes the modules are individually attached to a support structure.)

Photovoltaic (PV) power plant: *See* Photovoltaic (PV) facility.

Photovoltaic (PV) receiver: An assembly of one or more PV cells that accepts concentrated sunlight and incorporates means for thermal and electric energy removal.

Photovoltaic (PV) system: *See* Photovoltaic (PV) facility.

Photovoltaics (PV): Technologies that utilize semiconducting materials that convert sunlight directly into electricity.

Phreatic vegetation: Vegetation supported by groundwater below the land surface.

Phreatophytes: Any plant, typically living in the desert, that obtains its water from long taproots that reach the water table.

Physiography: The physical geography of an area or the description of its physical features.

Phytoplankton: Small, often single-celled plants that live suspended in bodies of water.

Pictograph: A design drawn in pigment upon an unprepared or ground rock surface.

Piezometer: A nonpumping well, generally of small diameter, for measuring the elevation of a water table.

Pithouse: A semi-subterranean dwelling with an excavated floor and earthen superstructure supported by posts and beams.

Placer: An alluvial deposit of sand and gravel containing valuable minerals. (nps geo)

Placer Mining: That form of mining in which the surficial detritus is washed for gold or other valuable minerals. When water under pressure is employed to break down the gravel, the term hydraulic mining is generally employed.

Placer mining claim: Minerals are loose on the ground or in a streambed.

Plains: An extensive area that ranges from level to gently sloping or undulating.

Planetary boundary layer turbulence structure: In the Earth's atmosphere, the planetary boundary layer is the air layer near the ground that is affected by diurnal heat, moisture, or momentum transfer, to or from the surface.

Plankton (planktonic): The aggregate of small plant and animal organisms that float or drift in fresh or salt water.

Playa: Flat areas that contain seasonal or year-to-year shallow lakes that often evaporate, leaving minerals behind. Playas form in arid basins where rivers merge, but do not drain.

Playa lake: Ephemeral lakes formed in the lowest part of a closed (internally drained) basin in an arid region. High rates of evaporation in these areas often leave behind mineral deposits. Also referred to as dry lakes or alkali flats.

Pleistocene: The oldest epoch of the Quaternary period, ranging from 2.6 million to 10,000 years ago. Together the Pleistocene and the Holocene make up the Quaternary period.

Plume: A visible or measurable discharge of a contaminant from a given point of origin. Can be visible or thermal in water, or visible in the air as, for example, a plume of smoke.

Plume downwash: Downward movement of plumes immediately to the lee of flow obstacles such as buildings, bluffs, or smokestacks, caused by wake turbulence or lee cavity circulations generated by the obstacles. It brings higher-concentration pollutants down toward the ground.

Plume model: A computer model used to calculate air pollutant concentrations at receptor locations. The model assumes that a pollutant plume is carried downwind from its emission source by a mean wind and dispersed horizontally and vertically by atmospheric stability characteristics.

Pluton: A body of igneous rock that solidified below the Earth's surface.

Plutonic: Pertaining to a class of igneous rocks that have solidified far below the Earth's surface.

Pluvial lake: A lake formed during episodes of heavy precipitation or glacial melting, such as during the Pleistocene, and may either be extinct or remain as a remnant or dry lake with periodic water.

$PM_{2.5}$: Particulate matter with a mean aerodynamic diameter of 2.5 micrometers (0.0001 in.) or less. Particles less than this diameter can lodge deeply in the lungs. $PM_{2.5}$ is one of the six criteria pollutants specified under Title I of the Clean Air Act.

PM_{10}: Particulate matter with a mean aerodynamic diameter of 10 micrometers (0.0004 in.) or less. Particles less than this diameter can be inhaled and accumulate in the respiratory system. PM_{10} is one of the six criteria pollutants specified under Title I of the Clean Air Act.

Point light source: A light source that has no visible surface area, and appears as a point, such as a star.

Point of diversion: A specifically named place where water is removed from a body of water. The location of a surface water or groundwater extraction associated with a water right.

Point source (emissions): A stationary location or fixed facility from which pollutants are discharged; any single identifiable source of pollution; e.g., a pipe, ditch, ship, ore pit, or a factory smokestack.

Potable water: Water of a sufficient quality that it can be consumed by humans without the risk of immediate or long-term affects. Also referred to as drinking water.

Potential Fossil Yield Classification (PFYC): Initially developed by the U.S. Forest Service and the Region 2 Paleo Initiative in May 1996, the PFYC system provides baseline guidance for assessing the relative occurrence of important paleontological resources and the need for mitigation. Specifically, it is used to classify geologic units, at the formation or member level, according to the probability that they could yield paleontological resources of concern to land managers.

Potentially Active Fault: *See* Fault, potentially active.

Power block: Portion of the facility at which electrical power is generated.

Power Conditioning System (PCS): In solar energy facilities, the collection of electrical equipment that converts direct current (DC) from a photovoltaic array to alternating current (AC) or that conditions AC current produced at CSP facilities to match the voltage and phase conditions of the bulk electricity grid to which the solar energy facility is connected; power conditioning systems also include system monitoring devices and isolation switches that can isolate the solar energy facility from the bulk electricity grid during off-normal conditions that could jeopardize or damage either the facility or the grid.

Power, electrical: A unit of electrical energy, usually expressed in watts (W), kilowatts (kW), or megawatts (MW). One watt equals 3.14 Btu/hr.

Power production capacity: The amount of power that a facility can produce under ideal operating conditions. *See also* Battery capacity.

Power tower: A type of CSP technology comprised of many large, sun-tracking mirrors (heliostats) that focus sunlight on a receiver at the top of a centrally located tower. The sunlight heats up a heat transfer fluid in the receiver, which then is used to generate steam (or directly heats water to produce steam) that powers a steam turbine-generator (STG) to produce electricity. Power tower systems can also be equipped with molten salt in which the heat generated at the receiver can be stored for delayed production of electricity.

Power tower system: *See* Power tower.

Precambrian: The oldest and largest division of geologic time, between the consolidation of the Earth's crust and the beginning of the Cambrian period. It includes all time from the origins of the Earth to about 542 million years ago; about 3.3 billion years in duration.

Prehistoric: The time period before the appearance of written records. In the New World this generally refers to indigenous, precontact societies.

Prehistoric resources: Refers to any material remains, structures, and items used or modified by people before Euro-Americans established a presence in the region.

Prescribed fires: Application of fire (by planned or unplanned ignitions) to fuels in either their natural or modified states, under specified conditions, to allow the fire to burn in a predetermined area while producing the fire behavior required to achieve certain management objectives.

Prevention of Significant Deterioration (PSD) Program: A Federal air pollution permitting program intended to ensure that air quality does not diminish in attainment areas which meet national ambient air quality standards.

Prey base: The assemblage of prey (food) animals available in a given area or habitat to support a predator such as a hawk or cougar.

Prior Appropriation Doctrine: A system for allocating water rights used in the western United States under which the first person (or entity) to divert water from a source has a priority to that water right, and so on. Under the system of prior appropriation, water rights that are junior are not allowed to prevent senior water rights holders from obtaining their allocation of water. Thus, in times of drought, a junior water rights holder may not be entitled to its share of the resource. However, even senior water rights holders are not allowed to change the time of use, place of use, purpose of use, or point of diversion of the right, if it would injure other water rights holders within a basin.

Projectile point: Any sharp tip of an arrow, spear, or dart.

PSD increments: The maximum increases in ambient pollution concentrations allowed over baseline concentrations for a pollutant while ensuring that an area continues to meet national ambient air quality standards. See 40 CFR §51.166 (c) for increments for specific pollutants.

Public Land: Any land and interest in land (outside of Alaska) owned by the United States and administered by the Secretary of the Interior through the Bureau of Land Management.

Public Land Order (PLO): An order affecting, modifying, or cancelling a withdrawal or reservation that has been issued by the Secretary of the Interior pursuant to powers of the President delegated to the Secretary by Executive Order 9146 of April 24, 1942, or 9337 of April 24, 1943.

Public Land Survey System (PLSS): The survey carried out by the Bureau of Land Management and its predecessors for establishing boundaries and subdivisions of public lands of the United States, using the rules embodied in the U.S. Public Land System. The system is frequently used for designating the locations of a parcel of land based on township, range, section, and quarter delineations.

Pueblo: The Spanish word for town. A community dwelling with numerous households within, up to five stories high, built of stone or adobe by Indian tribes in the southwestern United States.

Pueblo rights: A water right possessed by a municipality which, as a successor of a Spanish or Mexican pueblo, entitled to the beneficial use of all needed, naturally-occurring surface and groundwater of the original pueblo watershed. Pueblo rights are paramount to all other claims.

Pyroclastic flow: High-speed avalanches of hot ash, rock fragments, and gas that move down the sides of a volcano during explosive eruptions or when the steep edge of a dome breaks apart and collapses. These pyroclastic flows, which can reach 1500ºF (815.55°C) and move at 100 to 150 miles per hour, are capable of knocking down and burning everything in their paths.

Pyroclastic surge: Similar to a pyroclastic flow, but contains a higher proportion of gas to rock and is more turbulent and faster moving.

Quad-level occurrence: The recorded occurrence of a species in the area represented by a specific, named U.S. Geological Survey 7.5-minute topographic quadrangle map (quad map). Some State Natural Heritage Programs record the locations of rare species as the name of the quad map on which a species location occurred.

Quaternary: The most recent period of the Cenozoic era, spanning the time between 2.6 million years ago and the present. It contains two epochs: the Pleistocene and the Holocene.

Quartzite: A hard, metamorphic rock that was originally sandstone.

Rain shadow effect: The region on the lee (sheltered) side of a mountain or mountain range where the precipitation is noticeably less than on the windward side, because the moisture-bearing air mass loses most of its moisture on the windward side before reaching the lee side.

Rangeland: Land on which the native vegetation, climax, or natural potential consists predominately of grasses, grasslike plants, forbs, or shrubs. Rangeland includes lands that are revegetated naturally or artificially to provide a plant cover that is managed similar to native vegetation. Rangelands may consist of natural grasslands, savannas, shrub lands, most deserts, tundra, alpine communities, coastal marshes, and wet meadows. (blm4)

Rankine steam cycle: The thermodynamic cycle of temperature and pressure changes of water as it is converted from a liquid to a gaseous state by heating, and returns back to liquid as it performs work, typically by driving a steam turbine. Modern steam turbines operating in a Rankine cycle have a maximum steam temperature of about 1,963°F (1,073°C) with thermal efficiencies of about 40%.

Raptor: A bird of prey such as a falcon, hawk, or eagle.

Rare species: *See* Special Status Species.

Rated battery capacity: The term used by battery manufacturers to indicate the maximum amount of energy that can be withdrawn from a battery under specified discharge rate and temperature. *See* Battery capacity.

Rebound (of water levels): The recovery/rise of the water level in a groundwater aquifer after groundwater pumping has ceased.

Receiver: A component of a solar energy facility that receives solar energy and converts it to useful energy forms, typically heat.

Receptor: A location where environmental resources such as air concentration or noise level are evaluated, e.g., property boundaries, residences, schools, hospitals, libraries, etc.

Recharge: The addition of water to an aquifer by natural infiltration (e.g., rainfall that seeps into the ground) or by artificial injection through wells.

Reclamation: The process of restoring surface environment to acceptable pre-existing conditions.

Reclamation Withdrawal: Withholding an area of public land from the operation of the public land laws for the purpose of reserving the land for the use of the Bureau of Reclamation (BOR). In general, this means that the BOR has first priority for use of the land for BOR projects. Other uses of the land may sometimes be approved with the concurrence of the BOR.

Record of Decision (ROD): A document separate from but associated with an environmental impact statement (EIS) that publicly and officially discloses the responsible agency's decision on the EIS alternative to be implemented.

Reflector: A component of a solar energy facility that reflects incident sunlight to a desired location or component within the facility, allowing it to be converted to other useful forms of energy, typically heat.

Region of Influence (ROI): Area occupied by affected resources and the distances at which impacts associated with license renewal may occur.

Regular-track proposals: Proposals on public land with pending applications considered as potential future projects, but not necessarily foreseeable projects, since not all applications would be expected to be carried to completion.

Relict: A land surface that was once a basin (valley) floor.

Renewable Resource Generation Development Areas (GDAs): Regions within Colorado with a concentration of renewable resources that provide a minimum of 1,000 MW of developable electric generating capacity.

Reptile: Cold-blooded vertebrate of the class Reptilia whose skin is usually covered in scales or scutes. Reptiles include snakes, lizards, turtles, crocodiles, and alligators.

Reserved Water Right: A special water right accompanying federal lands (military reservations, national parks, forests, or monuments) or Indian reservations. Federal reserved water rights have a priority date originating with the creation of the federal land or reservation and may be used in the future in the amount necessary to fulfill the purpose of the federal land or reservation.

Reservoir: A natural or artificial place to store water. Water storage created by building a dam. A pond, lake, or basin used for the storage, regulation, and control of water.

Residuum: Unconsolidated, weathered, or partly weathered mineral material that accumulates by disintegration of bedrock in place.

Resource Conservation and Recovery Act (RCRA): An amendment to the Solid Waste Disposal Act, RCRA (42 U.S.C. 6901 et seq.) authorized the development of federal regulations for the definition, storage, treatment, and disposal of solid wastes and hazardous wastes, as well as the process by which states may obtain primacy for implementation of the federal program.

Resource Management Plan (RMP): A land use plan that establishes land use allocations, multiple use guidelines, and management objectives for a given planning area. The RMP planning system has been used by the Bureau of Land Management since about 1980.

Retinal damage: Damage to photoreceptor cells of the retina. One mechanism for such damage is exposure to bright light that triggers chemical reactions in the tissues (this may also be called retinal burn).

Reuse: The reclamation of water diverted from a municipal or industrial wastewater conveyance system. To use again; to intercept for subsequent beneficial use, either directly or by exchange. Water that would otherwise return to the steam system.

Rhyolite: Volcanic rock (or lava), characteristically light in color and containing 69% silica or more and generally rich in potassium and sodium (felsic composition).

Rhyolitic domes: *See also* Dome, volcanic; Rhyolite.

Richter Magnitude Scale: Developed in 1935 by Charles Richter to measure and compare the size of earthquakes. The magnitude is determined from the logarithm of the amplitude of waves recorded by seismographs.

Rift: An area where the Earth's crust and lithosphere is being pulled apart by extensional tectonic forces.

Rift zone: A tectonic feature characterized by a central linear downfaulted segment (graben) with parallel normal faulting and flanking uplifts (horsts). The rift axis commonly contains volcanic rocks and volcanic and/or hydrothermal activity.

Right-of-Way (ROW): The legal right to cross the lands of another. Also used to indicate the strip of land for a road, railroad, or power line. In BLM, a permit or an easement which authorizes the use of public lands for certain specified purposes. Also, the lands covered by such an easement or permit. The authorization to use a particular parcel of public land for specific facilities for a definite time period. Authorizes the use of a ROW over, upon, under, or through public lands for construction, operation, maintenance, and termination of a project.

Right-lateral fault: *See* Fault, right-lateral.

Rill: A small and shallow incision into topsoil layers resulting from erosion by overland flow or surface runoff that is common on slopes of unvegetated ground and agricultural land.

Riparian: Relating to, living in, or located on the bank of a river, lake, or tidewater.

Rinsate: Water that is used to rinse or clean equipment or reaction vessels and that may, as a result, become contaminated and require special handling and disposal.

Riparian obligate species: Plants or animal species found only in riparian habitats.

Risk: The likelihood of suffering a detrimental effect as a result of exposure to a hazard.

River basin: The land area surrounding one river from its headwaters to its mouth. The area drained by a river and its tributaries.

Riverine wetland: Wetlands within river and stream channels, generally characterized by flowing water. Ocean-derived salinity is less than 0.5 part per thousand.

Rock art: Images on rock surfaces. There are two types of rock art: pictographs, which are drawn or painted *onto* the surface, and petroglyphs, which are pecked, incised, or abraded *into* the surface.

Rock outcrop: The part of a rock formation that appears above the surface of the surrounding land.

Roost: An area where birds or bats rest or sleep. Birds often use branches or tree cavities for roosts while bats use tree bark, tree hollows, caves, mines, buildings, bridges, or rock crevices.

Sacred landscapes: Natural places recognized by a cultural group as having spiritual or religious significance.

Sacred sites: Any specific, discrete, narrowly delineated location on federal land that is identified by an Indian tribe, or Indian individual determined to be an appropriately authoritative representative of an Indian religion, as sacred by virtue of its established religious significance to, or ceremonial use by, an Indian religion; provided that the tribe or appropriate authoritative representative of an Indian religion has informed the agency of the existence of such a site.

Safe Drinking Water Act (SWDA): Act authorizing development of maximum contaminant levels for drinking water applicable to public water systems (i.e., systems that serve at least 25 people or have at least 15 connections).

Safe yield: The amount of groundwater that can be withdrawn from a groundwater basin over a period of time without exceeding the long-term recharge of the basin or unreasonably affecting the basin's physical and chemical integrity.

Safe yield: *See* Perennial/Safe/Sustainable yield.

Salinity: A measure of the amount of salt and other mineral substances dissolved in water.

Salt flat: Low-lying ground where salts collect in the soil because of the evaporation of standing water.

Sand: A rock or mineral fragment of any composition that has a diameter ranging from 0.5 to 2.0 mm. Sand has a gritty feel.

Sand boil: A sand boil is sand and water that come out onto the ground surface during an earthquake as a result of liquefaction at shallow depth.

Sand dune: An elongated mound (hill or ridge) of sand accumulated and sorted by the action of wind or water.

Sand dune obligate species: Plant or animal species found only in sand dune habitats.

Sanitary waste: Nonhazardous, nonradioactive liquid and solid waste generated by normal housekeeping activities.

Sanitary wastewater: Wastewater (includes toilet, sink, shower, and kitchen flows) generated by normal housekeeping activities.

Savanna: A flat grassland of tropical and subtropical regions usually having distinct periods of dry and wet weather.

Scarify: Loosening topsoil or breaking up the forest floor to improve conditions for seed germination or tree planting. Also refers to nicking or abrading the hard seed coat of some species to aid germination.

Scarp: *See* Escarpment.

Scenic integrity: The degree of "intactness" of a landscape, which is related to the existing amount of visual disturbance present. Landscapes with higher scenic integrity are generally regarded as more sensitive to visual disturbances.

Scenic quality: A measure of the intrinsic beauty of landform, water form, or vegetation in the landscape, as well as any visible human additions or alterations to the landscape.

Scenic resources: The visible physical features on a landscape (e.g., land, water, vegetation, animals, structures, and other features). Also referred to as visual resources.

Scenic value: The importance of a landscape based on human perception of the intrinsic beauty of landform, water form, and vegetation in the landscape, as well as any visible human additions or alterations to the landscape.

Schist: A metamorphic rock formed from many types of rocks. Minerals in the rocks include micas, chlorite, talc, hornblende, and garnets. The minerals are characteristically platey and foliated (layered), indicating they were subjected to intense compression.

Scoping: The process of inviting public comment on what should be considered prior to preparation of an environmental impact statement (EIS). Scoping assists the preparers of an EIS in defining the proposed action, identifying alternatives, and developing preliminary issues to be addressed in an EIS.

Scraper: A stone tool that is modified for the specific task of scraping; for example, to scrape the meat from hides, to remove fat from the underside of a skin, to smooth wood, to scrape leather, and so forth. Different types are described in terms of the shape and/or position of the cutting edge: side scraper, end scraper, snub-nosed scraper, thumbnail scraper, and scoop scraper.

Scoria: Congealed lava, usually of mafic composition and red or black in color, with a large number of vesicles formed by gases coming out of solution.

Scree: Small, loose, rock debris covering a slope; a slope of loose rock debris at the base of a steep incline or cliff.

Scrubland: An area of land that is uncultivated and covered with sparse stunted vegetation.

Secondary containment: A safeguarding method for the prevention of unauthorized releases of toxic or hazardous gases into uncontrolled work areas. Secondary containment is a method in addition to the primary containment system**.**

Sedge: A grasslike plant with a triangular stem often growing in wet areas.

Sedimentary rock: Rock formed at or near the Earth's surface from the consolidation of loose sediment that has accumulated in layers through deposition by water, wind, or ice, or living organisms. Examples are sandstone and limestone.

Sedimentation: The removal, transport, and deposition of sediment particles by wind or water.

Sedentism: A term used to describe the process of settling down to live in groups for periods of time.

Seepage: The act or process involving the slow movement of water or other fluid through a porous material such as soil or rock.

Seeps: Wet areas, normally not flowing, arising from an underground water source. Any place where liquid has oozed from the ground to the surface.

Seismic: Pertaining to any earth vibration, especially that of an earthquake.

Seismic swarm: *See* Swarm.

Seismicity: Refers to the geographic and historical distribution of earthquakes.

Semi-arid: Moderately dry region or climate where moisture is normally greater than under arid conditions but still definitely limits the production of vegetation.

Semiconductor: Any material that has a limited capacity for conducting an electric current. Certain semiconductors, including silicon, gallium arsenide, copper indium diselenide, and cadmium telluride, are uniquely suited to the photovoltaic conversion process.

Senior water rights: Water rights that have been established first (measured by the date of appropriation) to the limit of their respective right, frequently to the exclusion of other more junior (in time) water right holders. *See also* Junior water right.

Sensitive Species: A plant or animal species listed by the state or federal government as threatened, endangered, or as a species of special concern. The list of BLM sensitive species varies from state to state, and the same species can be considered sensitive in one state but not in another. Also, a species that is adversely affected by disturbance or altered environmental conditions, such as sedimentation. *See also* Special Status Species.

Sensitivity level (analysis): Measures (e.g., high, medium, and low) of public concern for the maintenance of scenic quality.

Shadow zone: The region where direct sound does not penetrate because of upward diffraction due to vertical temperature and/or wind gradients.

Shale (outcrop): A fine-grained sedimentary rock characterized by parallel layering.

Shear strength: Internal resistance to stress (or movement) that comes from friction and cohesion of the sediment.

Sherds: Broken pieces of earthenware/pottery.

Shrink-swell potential: The extent to which soil shrinks or swells with changes in soil moisture content. The shrink-swell potential is influenced by the amount and type of clay in the soil. Shrinking and swelling of soils cause damage to building foundations, roads, and other structures.

Shrub: A plant with persistent woody stems and relatively low growth form; usually produces several basal shoots as opposed to a single bole; differs from a tree by its low stature and nonarborescent form.

Shrub-steppe: Habitat primarily composed of various shrubs and grasses.

Shrubsteppe obligate: A species that is dependent on shrubsteppe habitats to provide food and/or habitat necessary for its survival. Examples include the sage grouse, sage sparrow, and pygmy rabbit.

Silencer: A device used for reducing noise within air and gas flow systems.

Silicic volcanism: Volcanism characterized by the eruption of magma that is rich in lighter elements such as silicon, oxygen, aluminum, sodium, and potassium. Silicic volcanoes are associated with the melting of continental crust and often have explosive eruptions.

Silicon: A semi-metallic chemical element that makes an excellent semiconductor material for photovoltaic devices. It crystallizes in face-centered cubic lattice similar to a diamond. It is commonly found in sand and quartz (as the oxide).

Silt: A rock or mineral fragment of any composition that has a diameter ranging from 0.002 to 0.05 mm. Moist silt has a floury feel and is gritty when placed between the teeth.

Siltation: The process by which a river, lake, or other water body becomes clogged with sediment. The process of covering or obstructing with silt.

Siltstone: A sedimentary rock made mostly of silt-sized grains.

Sink: Any process, activity, or mechanism which removes a greenhouse gas, an aerosol, or a precursor of a greenhouse gas or aerosol from the atmosphere.

Skirt (fan, dune): A sloping alluvial fan surface made of sediment deposited by a stream at the mouth of a canyon between a mountain and the adjacent alluvial valley floor. *See* fan apron.

Sky glow: Brightening of the sky caused by outdoor lighting and natural atmospheric and celestial factors.

Skylining: Siting of a structure on or near a ridge line so that it is silhouetted against the sky.

Slash: Any tree-tops, limbs, bark, abandoned forest products, windfalls, or other debris left on the land after timber or other forest products have been cut.

Slip: Motion occurring along a fault plane.

Slip rate: The rate of motion obtained when the amount of offset is divided by a time interval. The common units of measure are mm/yr or m/k.y. (equivalent units). The average slip rate at a point along a fault is commonly determined from geodetic measurements, displacement of manmade features, or from offset geologic features whose age can be estimated or measured. Offset is measured parallel to the predominant slip direction or estimated from the vertical or horizontal separation of geologic features. In special cases, interval slip rates may be calculated if the times and amounts of slip of prehistoric earthquake events have been determined. This type of high-quality data is rather sparse.

Slope failure: The downward and outward movement of a mass of rock or unconsolidated materials as a unit. Landslides and slumps are examples.

Slope stability: The resistance of an inclined surface to failure by sliding or collapsing.

Snag: Dead, drying, or defective trees that remain standing or leaning against other trees. Snags provide habitats for a variety of wildlife species.

SO_2: *See* Sulfur Dioxide.

Social disruption: Social and psychological dislocation associated with the alteration or breakdown of social life in small rural communities that may occur as a result of rapid economic and demographic change with rapid industrial and natural resource development.

Socioeconomics: The social and economic conditions in the study area.

Soil compaction: Compression of the soil which results in reduced soil pore space (the spaces between soil particles), decreased movement of water and air into and within the soil, decreased soil water storage, and increased surface runoff and erosion.

Soil deposition: A general term for the accumulation of sediments by either physical or chemical sedimentation.

Soil horizon: A layer of soil developed in response to localized chemical and physical processes resulting from the activities of soil organisms, the addition of organic matter, precipitation, and water percolation through the layer.

Soil horizon mixing: Soil horizon mixing occurs when soil is disturbed by activities such as excavation.

Solar array: *See* Photovoltaic (PV) array.

Solar cell: *See* Photovoltaic (PV) cell.

Solar collector: A component of a solar energy facility that receives solar energy and converts it to useful energy forms, typically heat. Major components include the mirrors or reflectors, additional features designed to further concentrate the incident sunlight (in some facilities), and a receiver containing a heat transfer fluid.

Solar collector arrays: That portion of the solar energy facility containing components that track and capture sunlight and convert it to other useful forms of energy, typically heat. All such solar collector arrays are typically comprised of mirrors, receivers containing some form of heat transfer fluid, and support structures and controls that allow the mirrors to track the sun over the course of the day to maximize solar energy capture. Together, all components of the solar array make up what is known as the solar field of a solar energy facility.

Solar energy: Electromagnetic energy emitted from the sun (solar radiation). The amount that reaches the Earth is equal to one billionth of total solar energy generated, or the equivalent of about 420 trillion kilowatt-hours.

Solar energy technology: Any engineered method for harnessing, storing, and using the Sun's energy.

Solar Energy Zone (SEZ): Lands identified by the BLM as best-suited for large-scale production of solar energy.

Solar module: *See* Photovoltaic (PV) module.

Solar panel: *See* Photovoltaic (PV) panel.

Solar power tower: *See* Power tower.

Solar tracking impacts: The solar panels can be swiveled using the electric motors to follow the path of the sun exactly in the course of the day to maximize the yields.

Sole source aquifer: An aquifer that supplies 50 percent or more of the drinking water of an area.

Solid waste: All unwanted, abandoned, or discarded solid or semisolid material whether or not subject to decomposition, originating from any source.

Source: Any place or object from which air pollutants are released. Sources that are fixed in space are stationary sources and sources that move are mobile sources.

Southwest Regional Gap Analysis Project (SWReGAP): The Southwest Regional Gap Analysis Project is an update of the Gap Analysis Program's mapping and assessment of biodiversity for the five-state region encompassing Arizona, Colorado, Nevada, New Mexico, and Utah. It is a multi-institutional cooperative effort coordinated by the USGS Gap Analysis Program. The primary objective is to use a coordinated mapping approach to create detailed, seamless GIS maps of land cover, all native terrestrial vertebrate species, land stewardship, and management status, and to analyze this information to identify those biotic elements that are underrepresented on lands managed for their long term conservation or are gaps.

Special areas: Areas of high public interest and containing outstanding natural features or values. Bureau of Land Management special areas include National Wild and Scenic Rivers, National Wildernesses, National Conservation Areas, National Scenic Areas, National Recreation Areas, National Monuments, National Outstanding Natural Areas, National Historic Landmarks, National Register of Historic Places, National Natural Landmarks, National Recreational Trails, National Scenic Trails, National Historic Trails, National Backcountry Byways, Areas of Critical Environmental Concern, Research Natural Areas, Important Bird Areas, United Nations Biosphere Reserves, and World Heritage Sites. *See also* Specially Designated Areas.

Special Status Species (Threatened, Endangered, Sensitive, Rare): Includes both plant and animal species that are proposed for listing, officially listed as threatened or endangered, or are candidates for listing as threatened or endangered under the provisions of the Endangered Species Act; those listed by a state in a category such as threatened or endangered, implying potential endangerment or extinction; and those designated by each BLM State Director as sensitive.

Special Use Airspace (SUA): Airspace of defined dimensions identified by an area on the surface of the Earth wherein activities must be confined because of their nature and/or wherein limitations may be imposed upon aircraft operations that are not a part of those activities.

Specially Designated Areas: Includes a variety of areas that have received recognition or designation because they possess unique or important resource values. While these areas would not be available for development of solar energy resources, they could be located near solar development areas and could be affected by solar development. Examples of BLM-administered specially designated areas include components of the BLM National Landscape Conservation System (NLCS), areas of critical environmental concern (ACECs), special recreation management areas, and areas with wilderness values. These areas may have been designated by Congress or by the BLM. The majority of specially designated areas discussed in this PEIS are located on BLM-administered public lands; however, some specially designated areas managed by the U.S. Forest Service (USFS), U.S. Fish and Wildlife Service (USFWS), National Park Service, and states also are included in the analysis when they could be affected by solar development on public lands.

Species of Special Concern: A species that may have a declining population, limited occurrence, or low numbers for any of a variety of reasons.

Specular reflection: Also known as direct reflection, regular reflection, or mirror reflection. The reflection of electromagnetic rays without scattering or diffusion. In specular reflection, the angle at which the wave is incident on the reflecting surface is equal to the angle at which it is reflected from that surface. *See also* Glint; Glare.

Spill light: Light that falls outside of the area intended to be lighted.

Spring: The point at which the water table meets Earth's surface, causing water to flow from the ground.

Sprinkler system: Consists of pipelines which carry water under pressure from a pump or elevated source to lateral lines along which sprinkler heads are spaced at appropriate intervals.

Staging area: A designated area where construction equipment is temporarily stored (usually only during the construction phase).

State Historic Preservation Officers (SHPOs): The State officer charged with the identification and protection of prehistoric and historic resources in accordance with the National Historic Preservation Act.

Steam amendment chemicals: Chemicals used to treat raw water to remove certain chemical species, thus amending its hardness or pH, making it suitable for use in a steam cycle.

Steam Turbine-Generator (STG): A device that uses high-pressure steam, produced in a boiler, to drive the blades of a turbine to produce mechanical energy that can then be used to produce electricity by causing rotation of the central shaft of a mechanically connected generator.

Steep slopes: Ground surface that rises precipitously above the horizon.

STG: *See* Steam Turbine Generator.

Steppe: Habitat dominated by shrubs and grasses.

Stirling Engine: Named after its inventor, a reciprocating engine that converts heat into useable mechanical energy (shaftwork) by the heating (expanding) and cooling (contracting) of a captive gas (a working fluid) such as helium or hydrogen. As a solar energy technology, the Stirling Engine uses sunlight reflected off a parabolic surface to heat hydrogen to drive the engine that in turn drives a mechanically connected generator to produce electricity.

Stolon: An elongated stem growing along the ground surface and giving rise to leaves and adventitious roots at the nodes. (Nodes are bud containing areas along a stem.)

Strain: A change in the volume or shape of a rock mass, in response to stress.

Strata: Single, distinct layers of sediment or sedimentary rock.

Stratigraphy (stratigraphic): Layers of sediments and rocks that reflect the geologic history of an area. With respect to cultural resources and archaeological sites, the relative stratigraphic locations of human artifacts help determine the sequence in which past human activities took place.

Stream terrace: A remnant of a floodplain surface formed by streams as they carve downward into their floodplains.

Stressors: Physical, chemical, or biological entities that can induce adverse effects on ecosystems or human health.

Strike-slip fault: Vertical (or nearly vertical) fractures where the blocks have mostly moved horizontally. If the block opposite an observer looking across the fault moves to the right, the slip style is termed right lateral; if the block moves to the left, the motion is termed left lateral.

Structure: Any apparatus constructed to divert or impound water, such as a berm, head gate, pipe, or well.

Structural fires: Fire originating in and burning any part or all of any building, shelter, or other structure.

Subalpine: The upper mountain vegetation immediately below the cold limits of tree and tall shrub growth.

Sub-canopies: Woody vegetation that grows beneath the canopy or tree tops of a forest or woodland.

Subsidence: Sinking or settlement of the land surface, due to any of several processes. As commonly used, the term relates to the vertical downward movement of natural surfaces although small-scale horizontal components may be present. The term does not include landslides, which have large-scale horizontal displacements, or settlements of artificial fills.

Subsistence: The practices by which a group or individual acquires food, such as through hunting and gathering, fishing, and agriculture.

Substation: A substation consists of one or more transformers and their associated switchgear. It is used to switch generators, equipment, and circuits or lines in and out of a system. It is also used to change AC voltages from one level to another.

Substrate: The composition of a streambed, including either mineral or organic material. Materials that form an attachment medium for organisms.

Sulfur dioxide (SO_2): A gas formed from burning fossil fuels, notably from coal-fired power plants. Sulfur dioxide is one of the six criteria air pollutants specified under Title I of the Clean Air Act.

Sulfur oxides (SO_x): Compounds containing sulfur and oxygen, such as sulfur dioxide (SO_2) and sulfur trioxide (SO_3). Pungent, colorless gases that are formed primarily by fossil fuel combustion, notably from coal-fired power plants. Sulfur oxides may damage the respiratory tract, as well as plants and trees.

Surface expression: Refers to the physical expression of seismic activity at the ground exterior in the form of a fault rupture or fissure.

Surface rupture: The breakage of ground along the surface trace of a fault caused by the intersection of the fault surface area ruptured in an earthquake with the Earth's surface.

Surface texture: The visual manifestations of the interplay of light and shadow created by the variations in the top of an object or landscape.

Surface water: Water on the Earth's surface that is directly exposed to the atmosphere, as distinguished from water in the ground (groundwater).

Sustainable yield: *See* Perennial/Safe/Sustainable yield.

Swale: A low place in a tract of land, usually moister, and often having denser vegetation than the adjacent higher land.

Swarm (seismic swarm): A localized surge of earthquakes, with no one shock being conspicuously larger than all other shocks of the swarm. Seismic swarms typically last longer than more typical earthquake sequences that consist of a main shock followed by significantly smaller aftershocks. Seismic swarms occur in a variety of geologic environments. They are not known to be indicative of any change in the long-term seismic risk of the region in which they occur.

Take: Under the Bald and Golden Eagle Protection Act, it means to pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, destroy, molest, or disturb. Disturb means to agitate or bother a bald eagle or a golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, (1) injury to an eagle, (2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or (3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior.

Talus: Rock debris accumulated at the base of the cliff or slope from which they have broken off.

Taxonomy: The field of science that classifies life.

Tectonic: Refers to the rock-deforming processes and resulting structures that occur over large sections of the lithosphere.

Tephra: A general term for fragments of volcanic rock and lava, regardless of size, that are blasted into the air by explosions or carried upward by hot gases in eruption columns or lava fountains. Tephra includes large dense blocks and bombs, and small light rock debris such as scoria, pumice, reticulite, and ash.

Tertiary volcanics (Tv): Volcanic rocks deposited during the Tertiary period (between 2.8 and 65 million years ago). The Tertiary period was a time of extensive volcanism in the western United States.

Terrace: A step-like surface, bordering a valley floor or shoreline, that represents the former position of a floodplain, lake, or sea shore.

Terrain: Topographic layout and features of a tract of land or ground.

Terrestrial: Pertaining to plants or animals living on land rather than in the water.

Tertiary period: The earliest period of the Cenozoic era, beginning about 65 million years ago and ending 2.6 million years ago. Together the Tertiary and Quaternary periods make up the Cenozoic era.

Texture: The visual manifestations of light and shadow created by the variations in the surface of an object or landscape.

Texture contrasts: Visual contrasts between different objects or landscapes resulting from different visual manifestations of the interplay of light and shadow created by the variations in the surfaces of the objects or landscapes.

Thermal energy: The use of heat as a source of energy. Thermal energy can be used directly or can be transformed into mechanical energy (using a steam engine) which can then be transformed into electrical energy. Thermal energy is usually measured in British thermal units (Btu).

Thermal inertia: The amount of heat energy that must be present in, preserved, or added to a system (in this case, a CSP facility) before it can function as designed.

Thermal water: A water body (usually a spring or its outflow) that is produced by geothermally heated groundwater.

Thermoelectric (power) water use: Water used in generating electricity with steam-driven turbine generators. Power plants that burn coal and oil are examples of thermoelectric-power facilities. Production of electrical power results in one of the largest uses of water in the United States and worldwide.

Thin film: A layer of semiconductor material, such as copper indium diselenide or gallium arsenide, a few microns or less in thickness, used to make photovoltaic cells.

Thorn forest: A type of forest formation, mostly tropical and subtropical, intermediate between desert and steppe, dominated by small trees and shrubs. Many are armed with thorns and spines; leaves are absent, succulent, or deciduous during long dry periods.

Threatened species: Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. Requirements for declaring a species threatened are contained in the Endangered Species Act. *See also* Special Status Species.

Topography: The shape of the Earth's surface; the relative position and elevations of natural and human-made features of an area.

Total dissolved solids (TDS): The dry weight of dissolved material, organic and inorganic, contained in water. The term is used to reflect salinity.

Toxic Air Pollutants (TAPs): *See* Hazardous air pollutants.

Toxic Substances Control Act (TSCA): An act, 7 U.S.C. Section 136 et seq., authorizing the U.S. Environmental Protection Agency to secure information on all new and existing chemical substances and to control any of these substances that are determined to cause an unreasonable risk to public health or the environment.

Toxicity: Harmful effects to an organism through exposure to a hazardous substance. Environmental exposures are primarily through inhalation, ingestion, or the skin.

Tracking array: A PV panel array that follows the path of the sun to maximize the solar radiation incident on the PV surface. The two most common orientations are (1) single-axis where the array tracks the sun east to west and (2) dual-axis tracking where the array changes position seasonally as well as diurnally to allow the panels to directly face the sun at all times of the year. Tracking arrays use both the direct and diffuse sunlight. Dual-axis tracking arrays capture the maximum possible energy.

Traditional cultural property: A property that is eligible for inclusion in the National Register of Historic Places because of its association with cultural practices or beliefs of a living community that (a) are rooted in that community's history, and (b) are important in maintaining the continuing cultural identity of the community. An example would be a location associated with the traditional beliefs of a Native American group about its origins, its cultural history, or the nature of the world.

Transform fault: *See* Fault, transform.

Translocation: The intentional capture, movement, and release of individuals of a species into a different area, usually to prevent harm to the individuals or to establish populations elsewhere.

Transmission corridor: An electric or pipeline transmission corridor is a route approved on public lands, in a BLM or other federal agency land use plan, as a location that may be suitable for the siting of electric or pipeline transmission systems.

Transmission line: A set of electrical current conductors, insulators, supporting structures, and associated equipment used to move large quantities of power at high voltage, usually over long distances (e.g., between a power plant and the communities that it serves).

Transmissivity: The rate at which water of the prevailing kinematic viscosity is transmitted through a unit width of the aquifer under a unit hydraulic gradient. It is equal to an integration of the hydraulic conductivities across the saturated part of the aquifer perpendicular to the flow paths.

Travertine: A sedimentary rock formed by the precipitation of carbonate minerals from solution in ground and surface waters, and/or geothermal hot-springs.

Tribal land: In NAGPRA, tribal land is defined as: (a) all lands within the exterior boundaries of any Indian reservation; (b) all dependent Indian communities; (c) any lands administered for the benefit of Native Hawaiians pursuant to the Hawaiian Homes Commission Act, 1920, and section 4 of Public Law 86-3. In NHPA, tribal land is defined as: (a) all lands within the exterior boundaries of any Indian reservation; and (b) all dependent Indian communities.

Tribe: Term used to designate a Federally recognized group of American Indians and their governing body. Tribes may be comprised of more than one band.

Tributary: A stream that flows into another stream, river, or lake.

Troposphere: The layer of the atmosphere closest to the Earth's surface.

Tsunami: Ocean waves produced by earthquakes or underwater landslides.

Tuff: Volcanic rock made up of rock and mineral fragments in a volcanic ash matrix. Tuffs commonly are composed of much shattered volcanic rock glass—chilled magma blown into the air and then deposited. If volcanic particles fall to the ground at a very high temperature, they may fuse together, forming a welded tuff.

Tundra: *See* Arctic or Alpine tundra.

Turbidity: A measure of the cloudiness or opaqueness of water. Typically, the higher the concentration of suspended material, the greater the turbidity.

Unconfined aquifer: *See* Aquifer-unconfined.

Unconsolidated (basin fill deposits): Loose sediment; lacking cohesion or cement.

Unconsolidated shore wetlands: Includes all wetland habitats having three characteristics: (1) unconsolidated substrates with less than 75% areal cover of stones, boulders, or bedrock; (2) less than 30% areal cover of vegetation other than pioneering plants; and (3) any of the following water regimes: irregularly exposed, regularly flooded, irregularly flooded, seasonally flooded, temporarily flooded, intermittently flooded, saturated, or artificially flooded.

Underflow: The movement of groundwater through the soil or a subsurface stratum, or under a structure; specifically, the water flowing beneath the bed of a stream, in the same direction, but much more slowly, especially in a dry stream channel in an arid region.

Understory: The vegetation layer immediately beneath the canopy.

Unfaulted: An area without faults.

United States Environmental Protection Agency: The independent federal agency, established in 1970, that regulates federal environmental matters and oversees the implementation of federal environmental laws.

Unrest (episode): Usually non-eruptive volcanic activity (e.g., ground deformation, steam plumes, degassing) that may be interpreted as a precursor to an eruption.

Unstable slopes: Slopes considered unstable due to their incline (or critical angle of repose), applied to slopes made of unconsolidated material. Unstable slopes are prone to failure in the form of rockfalls, rock flows, plane shears, or rotational shears.

Upland: The portion of the landscape above the valley floor or stream.

Upper-air sounding: An upper-air observation of the vertical profile of an atmospheric variable such as temperature or wind.

Uplighting: Light directed upward at greater than 90° above nadir, generally upward into the sky. Uplighting can result from direct illumination of the sky and/or light reflected upward from illuminated objects below a light source.

Upwarp: A broad anticline with gently sloping limbs formed as a result of differential uplift.

USGS: United States Geological Survey.

Utility scale facilities: Facilities that generate large amounts of electricity that is delivered to many users through transmission and distribution systems.

Valley floor: The gently sloping to nearly level bottom surface of a valley.

Vent: *See* Volcanic vent.

Vernal pool: Seasonally-flooded depressions found on soils with an impermeable layer such as a hardpan, claypan, or volcanic basalt. California's vernal pools occur on a variety of landscape formations, but most often on alluvial formations deposited by ancient waterways and seas. The impermeable layer allows the pools to retain water much longer than the surrounding uplands; nonetheless, the pools are shallow enough to dry up each season.

Vertebrate: Any species having a backbone or spinal column including fish, amphibians, reptiles, birds, and mammals.

Vertical angle of view: Elevation of viewer relative to the elevation of the proposed action, and the resulting angle of difference. *See also* Horizontal angle of view; Angle of view.

View duration: Length of time a proposed action is in view. Impacts that are viewed for a long period of time are generally judged to be more severe than those viewed briefly.

Viewer distance: The distance from a viewpoint to a seen object or landscape element.

Viewpoint: A point from which a landscape view is analyzed and/or evaluated.

Viewshed: The total landscape seen or potentially seen from all or a logical part of a travel route, use area, or water body.

Visibility factors: Conditions or other phenomena that affect the visibility or appearance of an object or a landscape. Examples of visibility factors include distance, lighting conditions, air quality, atmospheric conditions, and viewing angle.

Visual absorption capability: The physical capacity of a landscape to accept human alterations without loss of its inherent visual character or scenic quality.

Visual attention: Noticing and focusing of vision on a particular object or landscape element.

Visual clutter: The complex visual interplay of numerous disharmonious landscape characteristics and features resulting in a displeasing view.

Visual contrast: Opposition or unlikeness of different forms, lines, colors, or textures in a landscape.

Visual disharmony: A state of disagreement, incongruity, or disproportionate arrangement of forms, lines, colors, and textures in the visual elements of a seen landscape.

Visual feature: An element, such as a land or water form, vegetation, or structure in the seen landscape.

Visual harmony: A pleasing array of visual elements in a landscape, usually as a result of a sense of visual order, compatibility, and completeness between and among the land forms, water forms, vegetation, or structures visible in the landscape.

Visual impact: Any modification in land forms, water bodies, or vegetation, or any introduction of structures, which negatively or positively affect the visual character or quality of a landscape through the introduction of visual contrasts in the basic elements of form, line, color, and texture.

Visual intrusion: Any human-caused change in the land form, water form, vegetation, or the addition of a structure which creates a visual contrast in the basic elements (form, line, color, texture) of the naturalistic character of a landscape.

Visual mitigation: Actions taken to avoid, eliminate, or reduce potential adverse impacts on scenic resources.

Visual quality: *See* Scenic quality.

Visual resources: Refers to all objects (man-made and natural, moving and stationary) and features such as landforms and water bodies that are visible on a landscape.

Visual Resource Inventory (VRI): Consists of a scenic quality evaluation, sensitivity level analysis, and a delineation of distance zones. Based on these three factors, BLM-administered lands are placed into one of four visual resource inventory classes.

Visual Resource Inventory (VRI) Classes: VRI Classes are assigned to public lands based upon the results from the Visual Resource Inventory. They do not establish management direction and should not be used as a basis for constraining or limiting surface disturbing activities. Inventory classes are informational in nature and provide the basis for considering visual values in the RMP process. There are four classes (I, II, III, and IV).

Visual Resource Management (VRM) Classes: Categories assigned to BLM lands, utilizing the Visual Resource Inventory Classes in the RMP process, with an objective which prescribes the amount of change allowed in the characteristic landscape. All actions proposed during the RMP process that would result in surface disturbances must consider the importance of the visual values and the impacts the project may have on these values. Management decisions in the RMP must reflect the value of visual resources. The value of the visual resource may be the driving force for some management decisions. There are four VRM classes: I, II, III and IV.

Visual Resource Management (VRM) Class Designations: **Class I** objective is to preserve the existing character of the landscape. The level of change to the characteristic landscape should be very low and must not attract attention. **Class II** objective is to retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen but must not attract the attention of the casual observer. Any changes must repeat the basic elements of form, line, color, and texture found in the predominant natural landscape features. **Class III** objective is to partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention but should not dominate the view of the casual observer. Changes should repeat the basic elements of form, line, color, and texture found in the predominant natural landscape features. **Class IV** objective is to provide for management activities that require major modification of the existing character of the landscape. The level of change to the characteristic landscape can be high.

Visual Resource Management (VRM) System: BLM's system for minimizing the visual impacts of surface-disturbing activities and maintaining scenic values for the future. The inventory and planning actions taken to identify visual values and to establish objectives for managing those values; and the management actions taken to achieve the visual management objectives.

Visual sensitivity: Public concern for the maintenance of scenic quality in a particular landscape setting.

Visual unity: The quality or state of appearing to be united in principles and relationships or to be logically and aesthetically connected because of the visual elements and properties of a seen object or landscape.

Visual value: *See* Scenic value.

Volatile Organic Compounds (VOCs): Any organic compound that participates in atmospheric photochemical reactions except those designated by the EPA as having negligible photochemical reactivity. Sources include certain solvents, degreasers (benzene), and fuels. Volatile organic compounds react with other substances (primarily nitrogen oxides) to form ozone, which contributes significantly to photochemical smog production and certain health problems.

Volcanic ash: Consists of rock, mineral, and volcanic glass fragments smaller than 2 mm (0.1 inch) in diameter, which is slightly larger than the size of a pinhead. Volcanic ash is not the same as the soft fluffy ash that results from burning wood, leaves, or paper. It is hard, does not dissolve in water, and can be extremely small—ash particles less than 0.025 mm (1/1,000th of an inch) in diameter are common. Volcanic ash is created during explosive eruptions by the shattering of solid rocks and violent separation of magma (molten rock) into tiny pieces.

Volcanic chain: A linear sequence of volcanoes that occurs within a tectonic plate. As the plate moves over a stationary hot spot, new volcanoes are created.

Volcanic cone: A landform built by the material ejected from a volcanic vent and piled up around the vent in the shape of a cone with a central crater. The cone type is defined by the nature of the fragments ejected from the vent (e.g., cinder cones or ash cones).

Volcanic-rock aquifer: *See* Aquifer-volcanic rock.

Volcanic vent: The opening at the Earth's surface through which volcanic materials issue forth.

Volcanism: The process by which magma and associated gases rise to the Earth's crust and are extruded, or expelled, onto the surface and into the atmosphere.

Volcano: A vent (opening) in the surface of the Earth through which magma erupts. It is also the landform that is constructed by the erupted material.

Volcanoclastic rock: Sedimentary rocks such as sandstones formed by the aggregation of rock fragments (clasts) of volcanic origin.

Voluntary relinquishment: To voluntarily relinquish possession with the intent of terminating ownership, but without vesting it in any other person. In determining whether one has abandoned his property or rights, intent is the paramount object of inquiry, for to abandon, one must intend to abandon. The intent must be clear and the act must be complete. To abandon a homestead one must leave with the intention of never returning. To abandon a mining claim held by location without patent, the holder must leave voluntarily, without any intention to retake or resume the claim and regardless of what may become of it in the future. Even in prescriptive rights, non-use is not abandonment.

Wake effect: Enhanced plume dispersion due to mechanical turbulence and zones of turbulent eddies, primarily downwind of a building, which results in increased ground-level concentrations of pollutants.

Wash: A normally dry stream bed that occasionally fills with water.

Waste Management: Procedures, physical attributes, and support services that collectively provide for the identification, containerization, storage, transport, treatment (as necessary), and disposal of wastes generated in association with an activity.

Waste minimization: Actions, policies, or procedures that collectively serve to reduce the amount of wastes generated as a result of operation of an activity or facility. Efforts can extend to identifying recycling options for wastes and for discarded materials and equipment, or by selecting the least hazardous chemicals to input into the process.

Wastewater: Water that typically contains less than 1% concentration of organic hazardous waste materials. Water originating from human sanitary water use (domestic wastewater) and from a variety of industrial processes (industrial wastewater).

Water code: A type of legislation that is specific to the management of water resources.

Water quality: A term used to describe the chemical, physical, and biological characteristics of water, usually with respect to its suitability for a particular purpose.

Water right: A legal entitlement of an individual or entity to extract water from a water source (surface water or groundwater) and to use it for a beneficial use (e.g., potable water supply, irrigation, mining, livestock). *See also* Senior water right.

Watershed: A region or area bounded peripherally by a water parting and draining ultimately to a particular water-course.

Water table: The upper level of ground water; the level below which soil and rock are saturated with water.

Watt (W): A basic unit of power; one joule of energy consumed per second. When used to describe electrical power, one watt is the product of voltage times current.

Weed: A plant considered undesirable, unattractive, or troublesome, usually introduced and growing without intentional cultivation.

Wet closed-cycle cooling system: *See* Closed-loop cooling system.

Wet cooling system: *See* Closed-cycle cooling system.

Wetlands: Areas that are soaked or flooded by surface or groundwater frequently enough or long enough to support plants, birds, animals, and aquatic life. Wetlands generally include swamps, marshes, bogs, estuaries, and other inland and coastal areas and are federally protected.

Wickiup: Temporary dwelling framed of arched poles covered by brush, bark, rushes, or mats.

Wild and Scenic Rivers (WSR) Act: Primary river conservation law enacted in 1968. The Act was specifically intended by Congress to balance the existing policy of building dams on rivers for water supply, power, and other benefits, with a new policy of protecting the free-flowing character and outstanding values of other rivers.

Wild Free-Roaming Horses and Burros Act of 1971: Act passed by Congress in 1971 giving BLM the responsibility to protect, manage, and control wild horses.

Wild horses and burros: Unbranded and unclaimed horses or burros roaming free on public lands in the western United States and protected by the Wild Free-Roaming Horse and Burro Act of 1971. They are descendants of animals turned loose by, or escaped from, ranchers, prospectors, Indian Tribes, and the U.S. cavalry from the late 1800s through the 1930s.

Wilderness: All lands included in the National Wilderness Preservation System by public law, generally defined as undeveloped federal land retaining its primeval character and influence without permanent improvements or human habitation.

Wilderness characteristics: Wilderness characteristics include (1) Naturalness: the area generally appears to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; (2) Outstanding Opportunities: the area has either outstanding opportunities for solitude, or outstanding opportunities for primitive and unconfined types of recreation; (3) Size: the area is at least 5,000 acres (20 km^2) of land or is of sufficient size as to make practicable its preservation and use in an unimpaired condition; and (4) Values: the area may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value.

Wildfires: Any non-structure fire that occurs in the wildland.

Wildlife corridor: Linear spaces that connect various areas of an animal's habitat (i.e., links between feeding, watering, resting, breeding, or seasonal habitats).

Wind rose: A circular diagram, for a given locality or area, showing the frequency and strength of the wind from various directions over a specified period of record.

Winnowing: Selective sorting or removal of fine particles by wind or water.

Withdrawal: The removal of surface water or groundwater from the natural hydrologic system for use, including: public-water supply, industry, commercial, domestic, irrigation, livestock, or thermoelectric power generation.

Xeric (habitat): Low in moisture. Dry environmental conditions. Habitats or sites characterized by their limited water availability.

Yardang: A wind-carved rock ridge feature found in desert environments.

Zoned fault: *See* Fault, zoned.

Zoomorphic: Having or representing animal forms.

Zooplankton: A generic term referring to consumers that have limited ability to move against the current. Zooplankton can be permanent (i.e., rotifers or cladocerans) or temporary, as with the early life stages (i.e., eggs, larvae, juveniles, and adults) of many fish and invertebrate species.