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.

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[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 Excavation and backfilling Stockpiling soils Constructing road beds Crossing drainages and wetlands Heavy truck and equipment traffic (especially on unpaved roads and surfaces)	Vegetation Wildlife Water resources (changes in natural flow systems and surface water quality) Cultural
Sedimentation	Vegetation clearing and grubbing Excavation and backfilling Stockpiling soils Constructing road beds Crossing drainages and wetlands Heavy truck and equipment traffic (especially on unpaved roads and surfaces)	Vegetation Wildlife Water resources (surface water quality)
Soil contamination	Fluid releases related to truck and mechanical equipment use (fuels, lubricating oils, hydraulic fluids, coolants, and battery acid) Accidental releases (spills, leaks, and fires) of hazardous materials (see Section 5.20.1) Herbicide applications for weed control Chemical stabilizer applications for erosion (fugitive dust) control Toxic metal releases if solar cells were to break during dismantling	Vegetation Wildlife Water resources (surface water and groundwater quality)

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	Wet cooling and washing 100-MW facility	500	1,500
(including CLFR[c])	Wet cooling and washing 400-MW facility	2,000	6,000
or power tower	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]: None	Small	Moderate	Large	Ability to Mitigate Impacts[c]
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] None	Small	Moderate	Large	Ability to Mitigate Impacts[c]
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] None	Small	Moderate	Large	Ability to Mitigate Impacts[c]
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] None	Small	Moderate	Large	Ability to Mitigate Impacts[c]
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] None	Small	Moderate	Large	Ability to Mitigate Impacts[c]
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

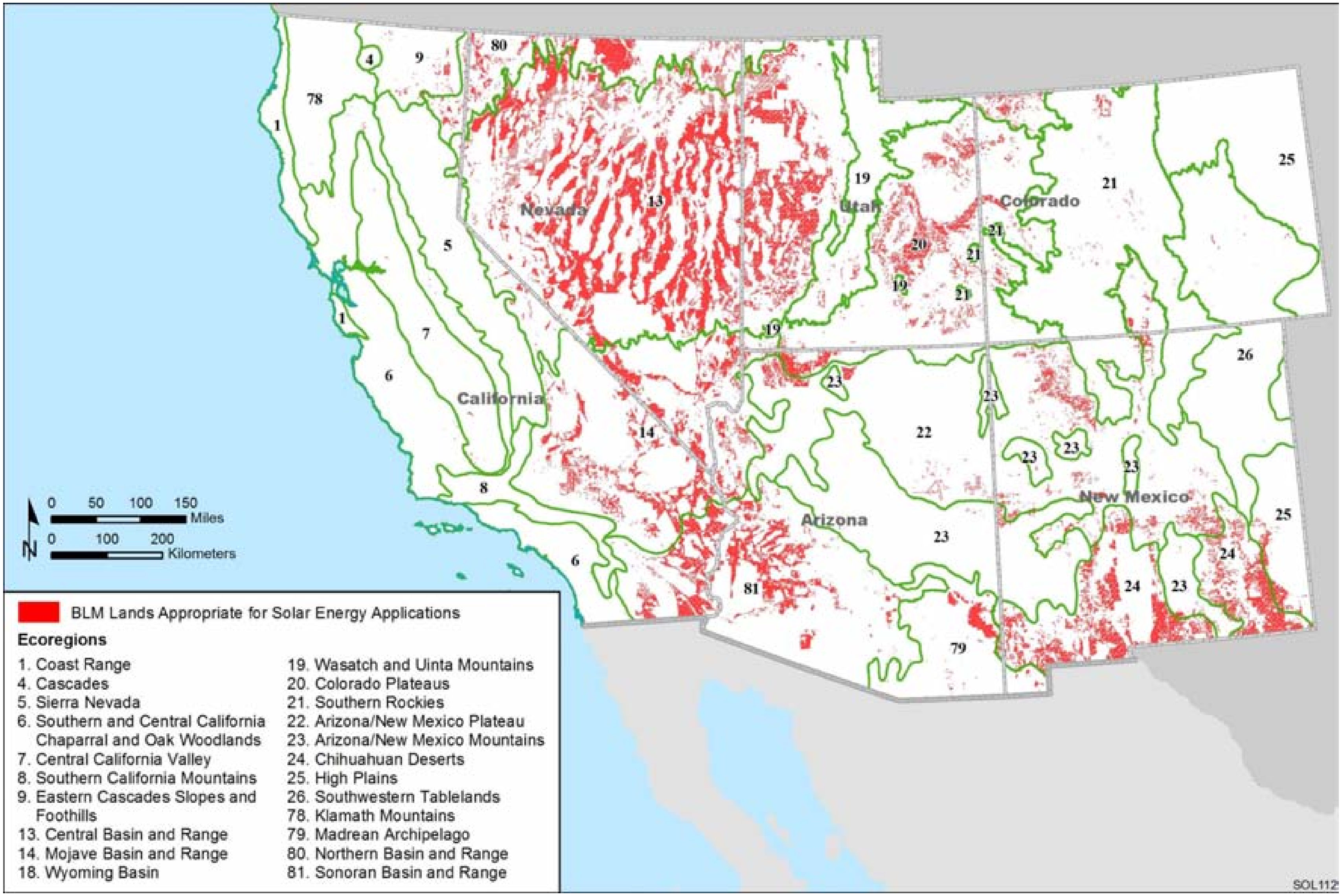

FIGURE 5.10-1 BLM-Administered Lands with Potential for Solar Energy Development and Associated Level III Ecoregions (Source: EPA 2007)

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] None	Small	Moderate	Large	Ability to Mitigate Impacts[c]
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.

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TABLE 5.10-2 (Cont.)

Impacting Factor	Project Phase	Consequence	Expected Relative Impact[a] for Different Plant Communities[b] None	Small	Moderate	Large	Ability to Mitigate Impacts[c]
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] – None	Small	Moderate	Large	Ability to Mitigate Impacts[c]
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]: None	Small	Moderate	Large	Ability to Mitigate Impacts[c]
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] None	Small	Moderate	Large	Ability to Mitigate Impacts[c]
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

			Expected Relative Impact[a] for Different Species Groups[b]				
Impacting Factor	Project Phase	Consequence	None	Small	Moderate	Large	Ability to Mitigate Impacts[c]
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]: None	Small	Moderate	Large	Ability to Mitigate Impacts[c]
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] None	Small	Moderate	Large	Ability to Mitigate Impacts[c]
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] None	Small	Moderate	Large	Ability to Mitigate Impacts[c]
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]: None	Small	Moderate	Large	Ability to Mitigate Impacts[c]
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]: None	Small	Moderate	Large	Ability to Mitigate Impacts[c]
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.

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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]

Parameter	Arizona		California		Colorado		Nevada		New Mexico		Utah	
	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.)

	Arizona		California		Colorado		Nevada		New Mexico		Utah	
Parameter	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.)

	Arizona		California		Colorado		Nevada		New Mexico		Utah	
Parameter	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]

	Arizona		California		Colorado		Nevada		New Mexico		Utah	
Parameter	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	1,33 1	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

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[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

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[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

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[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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