APPENDIX M:

METHODOLOGIES AND DATA SOURCES FOR THE ANALYSIS OF IMPACTS OF SOLAR ENERGY DEVELOPMENT ON RESOURCES

This page intentionally left blank.

APPENDIX M:

METHODOLOGIES AND DATA SOURCES FOR THE ANALYSIS OF IMPACTS OF SOLAR ENERGY DEVELOPMENT ON RESOURCES

M.1 GENERAL ASSUMPTIONS FOR THE ANALYSIS

This appendix provides detailed information on the methodologies and data sources used to assess the potential environmental impacts of solar energy development in this programmatic environmental impact statement (PEIS), mainly focused on assessing impacts from development of the solar energy zones (SEZs). The impact assessment for the PEIS was conducted at two different levels to support decisions to be made by the U.S. Department of the Interior (DOI) Bureau of Land Management (BLM) and the U.S. Department of Energy (DOE): a programmatic assessment of impacts of solar development generally and by solar technology type (as presented in Chapter 5), and an SEZ-specific assessment of impacts (as presented in Chapters 8 through 13 of the PEIS).

The programmatic assessment of the potential impacts of utility-scale solar energy development on resources present in the six-state study area was conducted for each of the technologies included in the scope of this PEIS (i.e., parabolic trough, power tower, dish engine, and photovoltaic [PV]) and for related development of electric transmission facilities. This assessment was conducted at a relatively high and general level (i.e., not site-specific) and was intended to describe the broadest possible range of impacts for individual solar facilities, associated transmission facilities, and other off-site infrastructure related to the different phases of development. The assessment, and the assumptions it was based on, are presented in Chapter 5 along with potential mitigation measures that could be used to eliminate, avoid, or minimize impacts. As discussed in Section 2.2.2, the analyses and mitigation measures presented in Chapter 5 provided one basis for the exclusions, policies, and required design features that the BLM proposes to establish in its new Solar Energy Program.[1] The specific exclusions proposed by the BLM are presented in Table 2.2-2; the proposed policies, programmatic design features, and SEZ-specific design features are presented in Appendix A, Sections A.2.1, A.2.2, and A.2.3, respectively. This appendix, while primarily addressing the impact assessment methods for SEZs, also addresses programmatic assumptions for water resources (Section M.9), vegetation clearing (Section M.10), and socioeconomic impacts (Section M.19).

The SEZ-specific assessments considered the potential impacts of utility-scale development on resources present in the 24 SEZs being proposed by the BLM under both of its action alternatives. These analyses, presented in Chapters 8 through 13 of the PEIS, consider the potential impacts for each of the solar technologies and related transmission and infrastructure development in the context of the specific environmental settings of the SEZs, thus providing a more detailed analysis of impacts than could be presented in Chapter 5. As discussed in Section 2.2.2, the SEZ-specific analyses provided the basis for the SEZ-specific design

[1] The BLM also evaluated existing, relevant mitigation guidance (Section 3.7.3) and comments received during scoping for the Draft PEIS (summarized in Section 14.1) in developing proposed elements of its new program.

features that the BLM proposes to be a part of its Solar Energy Program. A complete list of these SEZ-specific design features is provided in Appendix A, Section A.2.3. The BLM anticipates that the SEZ-specific analyses would also be used to support future analyses of individual projects proposed within the SEZs and to maximize streamlining of project-specific reviews. This appendix provides descriptions of the assessment methodologies and data sources used, with a focus on the more detailed SEZ-specific analyses. Special applications for evaluating specific technology types or impacts in specific proposed SEZs are summarized when applicable.

M.1.1 Assumptions for Solar Facilities

Both for the programmatic-level assessments and for the SEZ assessments, assumptions on the capacities and sizes of solar facilities were needed. For both assessments, it was assumed that parabolic trough and power tower facilities permitted on BLM-administered lands would have a nameplate capacity range of 100 to 400 MW. The upper end of the range corresponds to the capacity of the proposed Ivanpah Solar Energy Generating System power tower facility, which is well into the environmental review stage. The assumed capacity range for dish engine and PV facilities was 20 to 750 MW; the upper end of this range is based on the capacity of the proposed Imperial Valley Dish Engine facility, which also is proceeding through planning and environmental review requirement stages. On the basis of these assumptions, and assuming that 9 acres/MW (0.04 km^2/MW) of land is required for power tower, dish engine, or PV technologies and 5 acres/MW (0.02 km^2/MW) is needed for solar trough technologies, the maximum area of land disturbance for single facilities would be about 2,000 acres [8.1 km^2] for a 400-MW parabolic trough facility, about 3,600 acres (15 km^2) for a 400-MW power tower facility, and about 6,750 acres (27 km^2) for a 750-MW dish engine or PV facility.

Maximum solar development (full build-out) of the proposed SEZs was assumed to involve 80% of the SEZ surface area over a period of 20 years. During construction, the maximum disturbed area for each solar development project was assumed to be 50 acres (0.20 km^2) within a 24-hour period, 250 acres (1.01 km^2) within a month, and 3,000 acres (12 km^2) within a year. If the total area of a proposed SEZ was less than 10,000 acres (40 km^2), it was assumed that only one project would be under construction at any given time; if the acreage of the SEZ was equal to or greater than 10,000 acres (40 km^2) but less than 30,000 acres (121 km^2), it was assumed that two projects could be under construction at the same time; and if the acreage of the SEZ was equal to or greater than 30,000 acres (121 km^2), it was assumed that up to three projects could be under construction at the same time.

SEZ electrical power capacity at full build-out was estimated using the 80% full build-out acreage for each SEZ, and assuming that 9 acres/MW (0.04 km^2/MW) would be required for power tower, dish engine, or PV technologies, and that 5 acres/MW (0.02 km^2/MW) would be required for parabolic trough technology.[2] For example, the assumed full-build out area for the Brenda SEZ in Arizona was assumed to be 3,102 acres (13 km^2), which is 80% of the entire area

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

of 3,878 acres (16 km^2). The capacity of the SEZ was assumed to range from 345 MW to 620 MW (3,102 acres divided by 9 acres/MW and by 5 acres/MW, respectively).

M.1.2 Assumptions for Transmission and Other Off-Site Infrastructure

Construction and operation of transmission lines to tie solar energy facilities into the main power grid would be required for most new solar energy facilities. The location of the tie-in to the transmission grid would likely be the nearest existing transmission line with sufficient uncommitted capacity to accept power from the facility (or with the ability to be upgraded to sufficient capacity). Thus, for the SEZ-specific analyses (Chapters 8 through 13), transmission construction land disturbance was analyzed for the distance from SEZs to existing transmission lines. No new transmission line construction was assumed if there was an existing transmission line within or adjacent to (up to 1 mi [1.6 km] from) the SEZ. Evaluation of the available transmission capacity of nearest existing lines was beyond the scope of the PEIS (because the required magnitude of such upgrades was unknown, the upgrades would not be controlled by the solar facility developers, and the upgrades might not be solely connected to solar facilities).

One consideration in selecting the locations for the proposed SEZs was proximity to either existing transmission lines or to designated corridors, in order to facilitate access to the regional transmission grid for these locations. Thus, many of the proposed SEZs are adjacent to (or within 1 mi [1.6 km] of) designated corridors. In these instances and where construction of a transmission line to connect to the nearest existing line was assumed to be needed (i.e., no existing line ran through or was adjacent to the SEZ), the route of the new transmission line was assumed to follow the route of the designated corridor.

It is likely that many of the existing transmission lines near SEZs would not have sufficient capacity to support solar energy development at the SEZs and thus would need to be upgraded to provide grid access for the SEZs. Upgrading of existing transmission lines would result in variable additional land disturbance, depending on the extent of the upgrades needed. As discussed in Appendix F, Section F.4.3.7, these land disturbance impacts of upgrades can be conservatively assumed to be similar to those from new transmission line construction (this could be the case if it were a large upgrade, for example, from a 69-kV line to a 230-kv or larger line). Analysis of the impacts of transmission line construction and of line upgrades is included in Chapter 5 of this PEIS.

With respect to the need for new roads to support SEZ development, a similar logic to that used for transmission line needs was used to generate assumptions about the need for new road construction. If a state, U.S., or interstate highway ran through or was within 1 mi (1.6 km) of an SEZ, no significant new road construction was assumed to be needed. In many cases, there were also existing county roads running through or adjacent to SEZs; however, use of these roads for SEZ access was not assumed. This was a conservative assumption, likely resulting in an overestimate of land disturbance associated with new road construction, because in many cases, existing county roads could be used for SEZ access (although upgrades to county roads would often be required). The assumption that a state, U.S., or interstate highway would be needed was made so that the potential for land disturbance would not be underestimated. In practice, the use and/or upgrade of existing roads for access to solar facilities would minimize land disturbance impacts; this would be a consideration in site- and project-specific planning.

If SEZ-specific data indicated that construction of either new transmission lines or access roads should be assumed, the following additional assumptions were used for the impact analysis:

- A 230-kV transmission line would be constructed to the nearest existing transmission line and delivered as alternating current (AC), and the corridor right-of-way (ROW) width would be up to 250 ft (76 m) (this width includes areas disturbed during construction, conservatively assuming that the disturbed area is doubled during construction). This would result in approximately 30 acres (0.12 km^2) of land disturbance per mile (1.6 km) of transmission line construction. If more than one project was assumed to be built within an SEZ, transmission lines were assumed to be shared between projects.

- For new access road construction from the SEZ to the nearest state, U.S., or interstate highway, the width of disturbance was assumed to be up to 60 ft (18 m), representing a two-lane highway with 12-ft (3.7-m) lanes and 3-ft (1-m) shoulders, and the area doubled during construction. This would result in approximately 7 acres (0.03 km^2) of land disturbance per mile (1.6 km) of transmission line construction.

Other off-site infrastructure that might be needed to support SEZ development could include water pipelines (if water for construction and/or operations were being obtained from an off-site source) and natural gas pipelines (if natural gas were required at the facility in large quantities). For water pipelines, the impacts of construction with respect to land disturbance were not assessed in the PEIS because: (1) based on applications received to date, most facilities would use on-site groundwater as their water source, and (2) if off-site water sources were to be used, the locations of these sources are completely unknown at this time. Similarly, the impacts of pipeline construction for natural gas were not assessed, because such pipelines are not expected to be needed for most solar facility development (solar facilities are not expected to use natural gas in significant quantities), and because locations and lengths of pipelines are not predictable at the programmatic level. Thus, if new water or gas pipelines are needed for solar facility development, the impacts of construction and operation of these pipelines will need to be assessed at the project-specific level. The amount of land disturbance associated with new pipelines would be similar to that for new transmission lines; the impacts of such construction are evaluated in the Corridors PEIS (DOE and DOI 2008).

M.2 LANDS AND REALTY

This section describes the methodology and data sources used to evaluate potential direct and indirect impacts on present and future authorized uses of public lands within the SEZs as related to the BLM's lands and realty program. This program provides authorization for a wide variety of activities, including authorization of solar energy ROWs.

M.2.1 Affected Area

The area of analysis focused on about 677,400 acres (2,741 km^2) of BLM-administered public lands proposed as SEZs. Potential impacts on private and state lands within 5 mi (8 km) of the borders of the SEZs that might be affected by development of the SEZs were also considered. Existing ROW authorizations and designations under the BLM lands and realty program within the SEZs were identified, as were existing transmission facilities and transmission corridors. The major sources of information for this analysis included the project-specific geographic information system (GIS), Google Earth™, the BLM GeoCommunicator Web site (BLM and USFS 2010), and the BLM LR 2000 system (BLM 2010b).

M.2.2 Analysis Approach and Information Sources

Both direct and indirect impacts are considered, depending on the specific situation, including the land ownership pattern, the need for new transmission facilities, the effects of topography combined with proposed SEZ boundaries, existing access routes, and the general character of the land in and around the SEZs. Indirect effects are those that would occur outside of the areas directly developed for solar energy production, including the possibility that development of solar energy facilities within an SEZ might induce the development of solar energy or related projects on adjacent and nearby state or private lands.

The analysis for the SEZs was based largely on SEZ-specific information available from public sources, which were used to identify existing authorizations for use of the public lands. Spatial analysis included the use of the project-specific GIS system, as well as paper maps, especially the BLM's 1:100,000 scale Surface Management Status Maps. Google Earth was used to provide context to the analysis and to cross-reference information sources. Existing BLM land use plans were also consulted. Each of the SEZs was visited by assessment team members to provide site familiarity. The local BLM office staff was consulted on specific issues. While the analysis of impacts was made as specific as possible, there are still technology-specific and location-specific impacts that would need to be further analyzed once details for specific projects were known.

No attempt was made to quantify direct or indirect impacts to lands and realty in SEZs other than to identify the acreage of land that could be affected.

M.3 SPECIALLY DESIGNATED AREAS AND LANDS WITH WILDERNESS CHARACTERISTICS

This section describes the methodology and data sources used to evaluate potential direct and indirect impacts on specially designated areas. The specially designated areas included in the analysis are those excluded from potential solar energy development as specified in Table 2.2-2 in Section 2.2.2 describing the Solar Energy Program, plus areas that have been determined by BLM to possess wilderness characteristics. These areas are considered because they could potentially be affected, even though they are excluded from solar facility development. In some instances, potential impacts on areas that have been designated by state and local authorities are also assessed.

M.3.1 Affected Area

The area of analysis focused on approximately 677,400 acres (2,741 km^2) of land proposed as SEZs. Potential impacts on specially designated areas located within 25 mi (40 km) of the borders of the SEZs were considered. The major sources of information for this analysis included the project-specific GIS, Google Earth, and a variety of BLM and other publicly available paper maps.

M.3.2 Analysis Approach and Information Sources

Although the impact analysis for specially designated areas focused on areas within a 25-mi (40-km) radius of the individual SEZs, in a few instances, more distant areas were considered if there was some unique reason to do so (on the basis of professional judgment). Several factors were considered in identifying areas that could be affected by solar development within the SEZs. These included the proximity of the SEZs to the specially designated areas, the view from the areas of potential development within an SEZ, and the nature of the resources and resource uses that were identified as the reason(s) for the special designations. In general, depending on the resources and resource values present, the closer a SEZ is to a specially designated area, the more likely the area and its resource values would be adversely affected by solar development. While there is an inherent subjectivity in this type of analysis, impact assessments of these special areas draw heavily on the visual analysis completed and recorded in the Visual Resource sections in this PEIS and on the professional judgment of the analysis team with respect to the potential sensitivity of the area to the presence of solar energy development.

Key sources of information supporting this analysis were the project-specific GIS system, SEZ-specific visual resource analysis, and Google Earth visualizations. In many cases it was not possible to make a determination of potential effects, but generally, where solar development would be within 5 mi (8 km) of a specially designated area, the impacts of development on areas with high visual sensitivity were considered to be "large." There were also instances in which specially designated areas might be farther than 5 mi (8 km) from an SEZ, but because of the potential for extensive and continuous solar energy development over a large percentage of the viewshed of a specially designated area, this would also be classified as a large level of impact. For areas located farther than 5 mi (8 km) from the SEZ and/or where the viewshed would be dominated to a lesser degree by development in the SEZ, impacts could range from negligible to moderate.

M.4 RANGELAND RESOURCES

M.4.1 Livestock Grazing

M.4.1.1 Affected Area

For this topic, the analysis of the 677,400 acres (2,741 km^2) of public lands proposed as SEZs is focused only on those grazing allotments with all or portions of their acreage located within an SEZ.

M.4.1.2 Analysis Approach and Information Sources

The SEZ-specific analysis of potential grazing impacts was based on a GIS analysis of the number of grazing allotments within the SEZ, the acreage and annual grazing authorization of each allotment, and an assumption that the reduction in the animal unit months (AUMs)[3] of a particular allotment would be the same as the percentage of the public land that would be committed to solar development. Within individual SEZ sections, there is discussion of more specific factors that would be considered in any grazing allotment modification. Sources of information for this analysis included the project-specific GIS system; the BLM GeoCommunicator Web site; the BLM Rangeland Administration System Web site, which provides detailed allotment-specific information; and communication with BLM range management staff. The identification of potential impacts is somewhat subjective—it was assumed that allotments that lose greater than 50% of their land area would suffer a large impact; losses of 25% to 50% would be considered a moderate impact; and losses of less than 25% would be considered a small or negligible impact. While the potential to mitigate some of the grazing losses through provision of range improvements on remaining portions of an allotment was discussed within individual SEZ sections, it was not possible to assign an estimate of AUMs that might be recovered.

M.4.2 Wild Horses and Burros

M.4.2.1 Affected Area

Wild horse and burro areas considered in the assessment included herd management areas (HMAs) managed by BLM (BLM 2010a) and territories managed by the U.S. Forest Service (USFS 2007). The affected areas considered in the assessment included areas of direct and indirect effects. The area of direct effects was defined as the area that would be physically modified during project development (i.e., where ground-disturbing activities would occur). For some SEZs, the area of direct effects was limited to the SEZ itself, because no new transmission

---

[3] One AUM is a unit of forage required to support one cow and her calf for one month.

corridors or access roads were expected to be needed. Additionally, maximum development was assumed to be 80% of the SEZ. Therefore, direct effects were considered to be present on 80% of the SEZ area. For other SEZs, the area of direct effects also included an assumed area of development for a transmission corridor and/or access road needed to connect projects on the SEZ to the grid or road network, respectively. If a new transmission line was assumed to be needed (see Section M.1.2), it was assumed to occur as a 250-ft (76-m) wide developed ROW within a 1-mi (1.6-km) wide corridor to the nearest existing transmission line. If needed, a new access road was assumed to occur as a 60-ft (18-m) wide developed road within a 1-mi (1.6-km) wide straight-line corridor to the nearest highway.

The area of indirect effects was defined as the area where ground-disturbing activities would not occur, but that could be indirectly affected by activities in the area of direct effects. This indirect effects area was defined as the 20% portion of the SEZ that would not be developed, the area outside of the SEZ but within 5 mi [8 km] of the SEZ boundary, and the area within the 1-mi (1.6-km) wide access road and transmission corridors but outside of the area of direct effects. The area of indirect effects could be affected by project activities in the area of direct effects related to groundwater withdrawals, surface runoff, dust, noise, lighting, and accidental spills. The distance from the SEZ boundary used to define this area of indirect effects was based on professional judgment and was considered sufficiently large to bound the area that would potentially be subject to indirect effects. The potential magnitude of indirect effects would decrease with increasing distance from the SEZ.

Wild horse and burro HMAs and territories located within a 50-mi (80-km) radius around the center of each SEZ were considered for the analysis. The area encompassed by this circle was considered the SEZ region. The 50-mi (80-km) SEZ region was conservatively chosen on the basis of professional judgment to ensure that impacts on wild horse and burro HMAs and territories potentially affected by development within the SEZ could be evaluated.

M.4.2.2 Analysis Approach and Information Sources

Mapped HMAs and territories were used to determine whether these management areas occurred in the areas of direct and indirect effects. The acreage within the areas of direct or indirect effects was determined by using the Environmental Systems Research Institute (ESRI) ArcGIS Version 9 software. If HMAs or territories were not located in these areas, distances to the closest HMAs or territories within the SEZ region were determined by using the GIS software.

A landscape-level analysis was used to determine impacts by quantifying the total acreage of HMAs or territories within the areas of direct and indirect effects relative to the total acreage of those areas within the SEZ region. The relative impact magnitude categories were based on Council on Environmental Quality (CEQ) regulations for implementing the National Environmental Policy Act of 1969 (NEPA) (Title 40, Part 1508.27 of the *Code of Federal Regulations* [40 CFR 1508.27]) in which significance of impacts is based on context and intensity. Similar impact magnitude categories and definitions were used in two recent environmental impact statements (EISs) published by the BLM and by DOE and the DOI (BLM

2008a; DOE and DOI 2008) and are widely applied by other agencies (e.g., the U.S. Nuclear Regulatory Commission) in the evaluation of environmental impacts. Impact magnitude categories used for the wild horse and burro analyses were as follows:

- None—No impacts are expected.

- Small—Effects would not be detectable or would be so minor that they would neither destabilize nor noticeably alter any important attribute of an HMA or territory (for this analysis, impacts were considered small if less than 1% of the HMAs or territories in the region would be lost).

- Moderate—Effects would be sufficient to alter noticeably but not destabilize important attributes of an HMA or territory (for this analysis, impacts were considered moderate if equal to or more than 1% but less than10% of the HMAs or territories in the region would be lost).

- Large—Effects would be clearly noticeable and sufficient to destabilize important attributes of an HMA or territory (for this analysis, impacts were considered large if 10% or more of the HMAs or territories in the region would be lost).

Actual impact magnitudes on wild horse and burros would depend on the location of the HMA or territory, project-specific design, application of mitigation measures (including avoidance, minimization, and compensation), and the status of the herd and its habitats in the project area. In defining impact magnitude, the application of design features was assumed. In most cases, it was assumed that design features would reduce most indirect effects to negligible levels.

Once impact magnitude was determined for an HMA or territory, specific mitigation measures were considered. Avoidance of HMAs or territories to the extent practicable was recommended for HMAs or territories within the direct effects area for an SEZ. For HMAs or territories outside the indirect effects area, no mitigation measures were deemed to be necessary. A final mitigation plan would have to be determined at the project level through consultation with the BLM or the USFS for any HMA or territory within the direct or indirect effects areas for an SEZ.

M.5 RECREATION

M.5.1 Affected Area

The area of analysis focused on about 677,400 acres (2,741 km^2) of public lands within the proposed SEZs. In many instances, recreational use of adjacent or nearby areas also was considered.

M.5.2 Analysis Approach and Information Sources

The analysis of impacts on recreation was complicated by the fact that site-specific recreational use or visitor data were lacking for most of the areas. The most basic assumption was that recreational use would be precluded on all areas developed for solar energy production. Discussions with local BLM staff, field observations, and professional judgment were the basis for characterizations of existing recreational use of the SEZs. Other sources of information included the project-specific GIS, Google Earth, local recreation publications, BLM recreation and surface management maps, county recreation maps, and official state maps. If areas were designated for off-highway vehicle (OHV) use or supported commercial recreation activities, or if nearby areas supported recreational use, these were noted. Where specially designated areas were located adjacent to or near the SEZs, potential adverse effects on recreational use of these areas was discussed, but it was not possible to assess the potential impacts of that use. Specific attempts were made to analyze the road access patterns in and around the SEZs and to determine whether development of the area would adversely affect access to areas around the SEZs. Because of the lack of site-specific data, no quantitative determinations of impact on recreational use were made. Possible methodologies for quantifying the value of recreation on public land are discussed in Section M.19.1.5.

M.6 MILITARY AND CIVILIAN AVIATION

M.6.1 Affected Area

All military and civilian airfields were identified and considered in the analysis. The area of analysis for military aviation focused on military airspace immediately above the SEZs or within 5 mi (8 km) of the boundaries of the SEZs.

M.6.2 Analysis Approach and Information Sources

The analysis specifically identified where military airspace overlaps the SEZs and noted any military and civilian aviation facilities near the SEZs. The sources of information for this analysis were the BLM GeoCommunicator Web site (BLM and USFS 2010), the project-specific GIS, and Google Earth. The military also provided information that has been used to identify potential area-wide impacts. In many instances, the military identified specific potential issues and concerns with SEZs that have been incorporated into the analysis. Because of the potential for differential impacts caused by different solar technologies and the various types of military uses, specific impact analysis and definition of impacts were not possible. Where military or civilian airfields are within 25 mi (40 km) of an SEZ, this was noted as a potential conflict. However, since Federal Aviation Administration regulations would control activities near these facilities, no additional analysis was performed. Because of the site-specific nature of the potential impact on military airspace, no assessments of the potential level of impact could be made.

M.7 GEOLOGIC SETTING AND SOIL RESOURCES

M.7.1 Geologic Setting

The geologic setting was established for each of the proposed SEZs based on a review of aerial maps, topographic maps, geologic maps, and the scientific literature. The descriptions provided in the affected environment section for each of the proposed SEZs focus mainly on surface features (e.g., terrain, water bodies, land forms, and geologic materials), with some attention to the underlying structural aspects of intermontane alluvial valleys (horsts and grabens). Detailed geologic history and descriptions of stratigraphic units with depth were purposely omitted to limit the discussion to the geologic context most relevant to the development of a solar project on the ground surface. References to the geologic time scale (eras, periods, and epochs) were based on the age ranges compiled by Walker and Geissman (2009) (Figure M.7-1).

Geologic map data (shapefiles) were obtained from the U.S. Geological Survey (USGS) (Ludington et al. 2007; Stoeser et al. 2007). Because the data are considered preliminary, maps generated were checked against published state geologic maps (at scales of 1:500,000 and 1:1,000,000) for accuracy and for detailed map unit descriptions.

M.7.2 Geologic Hazards Assessment

The geologic hazards assessment used several online database and interactive map sources and considered the findings published in numerous academic and professional articles and reports. The types of geologic hazards relevant to the six-state area are listed in Section 5.7.3, and a site-specific hazard assessment is provided in the affected environment section for each of the proposed SEZs. The assessment provided is preliminary, and developers may find that, depending on site conditions and local concerns, geotechnical studies are needed to fully characterize the geologic hazards associated with the locale of a particular SEZ (including those related to the engineering properties of soils). Such studies would be useful in defining facility design criteria and developing site-specific construction guidelines and mitigation measures to minimize risks.

The seismic-related hazards assessment was based on information compiled primarily from the USGS, the State of California, and literature reviews, including several earthquake- and fault-related sources, as follows:

- Quaternary Fault and Fold Database of the United States—Class A fault search (USGS 2010a);

- National Earthquake Information Center Database—Circular search within a 100-km radius of the center of each proposed SEZ (USGS 2010b);

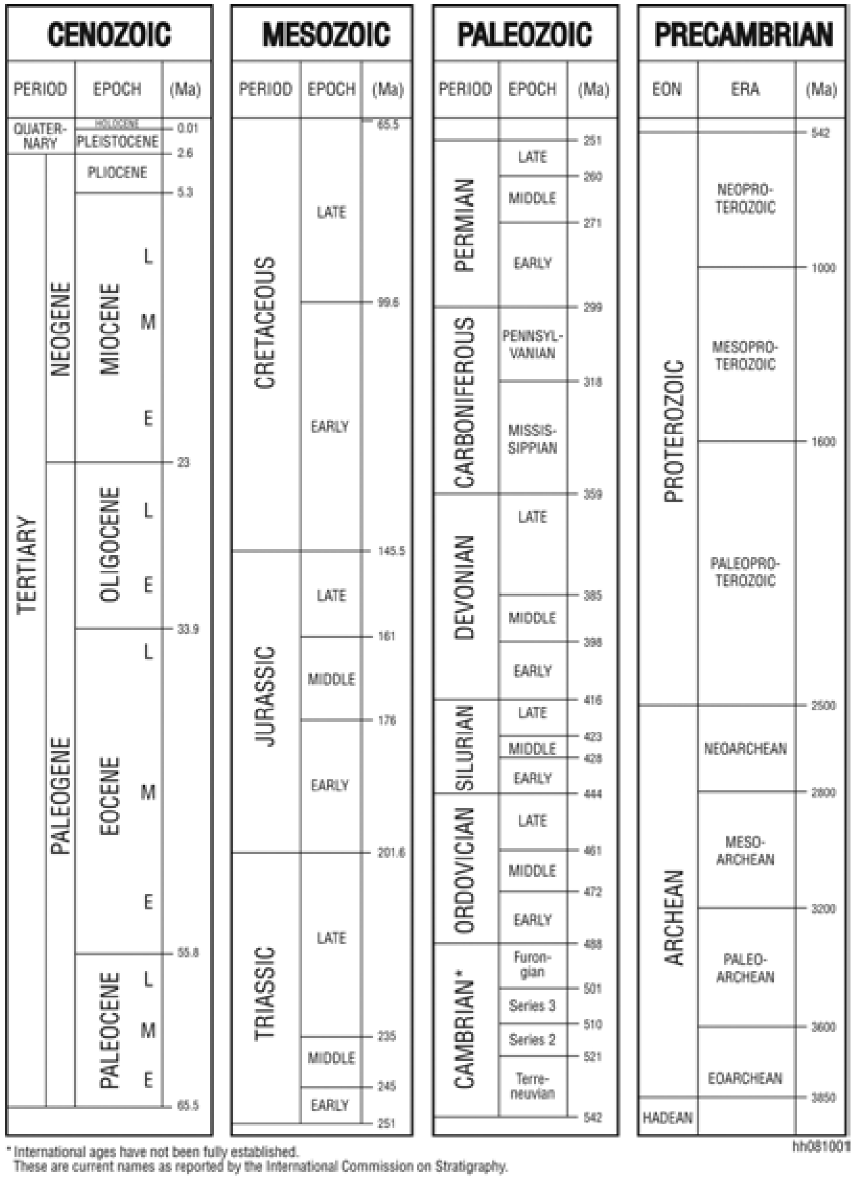

FIGURE M.7-1 Geologic Time Scale (Source: modified from Walker and Geissman 2009)

- Geologic Hazards Team Interactive Map Server (Seismic Hazard Map)—Peak horizontal acceleration (as a percentage of "g") with a probability of exceedance in 50 years (USGS 2010c); and

- Alquist-Priolo Earthquake Fault Zones—Detailed surface trace maps for active faults in California (CGS 2010).

The evaluation of liquefaction potential was based on the findings of published studies (if available) or a general consideration of the liquefaction susceptibility of sediments at the proposed SEZs (based on sediment texture and depth to groundwater) in combination with the opportunity for liquefaction to occur based on the projected strength of ground shaking caused by a probable earthquake as shown on USGS shake maps (USGS 2010c).

Volcanic hazards were assessed by consulting the maps and publications on the USGS's Volcano Hazards Program Web site (USGS 2010d), state geological surveys, and various published studies.

Other geologic hazards, including soil settlement and subsidence, slope instability, and flooding, were preliminarily assessed by considering site-specific conditions (e.g., soil texture, topography, and land forms) in combination with findings published in academic and professional articles and reports. State and local sources (e.g., ground fissures) were also considered, as available.

M.7.3 Soil Resources Impacts Assessment

The impacts assessment for soil resources relied on field observations, reviews by and consultations with BLM field office personnel, and academic and professional literature reviews to characterize site-specific soil conditions. No soil boring samples were collected, and no field or laboratory tests for soil properties were conducted at any of the proposed SEZs as part of this assessment. At this time, only general project locations (as delineated by the site boundaries for each proposed SEZ) are known; footprints of specific solar projects to be developed within the proposed SEZs are not yet available. As a result, impacts on soil resources are discussed in this PEIS only in relative terms by project phase and technology type and size (these are presented in Sections 5.7.1 and 5.7.2). Site-specific impacts are identified in the impacts section for each of the proposed SEZs.

The main elements in assessing relative impacts on soil resources at the proposed SEZs are the geographic location and temporal/spatial extent of ground-disturbing activities during all project phases. Activities resulting in ground disturbance include vegetation clearing and grubbing, excavation and backfilling, construction of project structures (met towers, solar collectors, cooling systems) and ancillary facilities, trenching, drilling, stockpiling of soils, construction of road beds, drainage and wetland crossings, heavy truck and equipment traffic, and increased foot traffic (Section 5.7.1). Because the footprints of specific solar projects to be developed within the proposed SEZs are not currently known, the temporal/spatial extent of these ground-disturbing activities and soil-related impacts cannot be quantified in this PEIS.

Soil conditions within each of the proposed SEZs were characterized by using customized map data from the U.S. Department of Agriculture (USDA's) National Resources Conservation Service (NRCS) Web soil survey (USDA 2010a) as a starting point and supplemented with information provided by state and local agencies, as available. Information such as soil texture and composition, parent material, land forms on which the soils developed, drainage class, soil permeability, surface runoff potential, soil hydric rating, compaction, fugitive dust, rutting potential, soil erosion factors (e.g., whole soil erodibility factor [K factor] and wind erodibility group/index), land classification (e.g., prime or unique farmland), and primary land use data was gathered to gain a general understanding of a soil's susceptibility to impacts as a result of ground-disturbing activities. Information on special soil features, such as biological crusts and desert pavement, was also obtained. General soil maps and map unit descriptions are provided in the affected environment section for each of the proposed SEZs. These maps are based on the soil series delineated on county soil surveys at scales of 1:12,000 to 1:100,000 (USDA 1999). The types of potential soil impacts are described in detail in Section 5.7.1, and site-specific concerns are identified in the impacts section for each of the proposed SEZs.

Mitigation measures identified in Section 5.7.4 were based on a combination of best engineering practices published as general industry standards and guidelines developed by various government agencies, including the BLM (erosion control and road construction), the Western Area Power Administration (transmission line construction), and the State of California (erosion and sediment control).

M.8 MINERALS (FLUIDS, SOLIDS, AND GEOTHERMAL RESOURCES)

M.8.1 Affected Area

The area of analysis focused within the SEZs for direct impacts and also considered the presence of mining claims and leases near the SEZs. The distance evaluated outside the SEZs for mining claims or leases varied by location and was based on professional judgment.

M.8.2 Analysis Approach and Information Sources

The analysis specifically identified whether there are closed or active mining claims or mineral or geothermal leases within the SEZ or within the immediate vicinity of the SEZ. This information was obtained from the BLM GeoCommunicator Web site (BLM and USFS 2010). If there were either no active leases or mining claims and there had been no previous mineral development, it was assumed there would be no impact on mineral resources. Where there were existing valid claims or leases, these represented prior existing rights. There would be no impact on valid claims or leases because solar energy development would have to be conducted in such a way as to not adversely affect those prior rights. In the case of potential future development of oil and gas resources (should any be found) under SEZs, it was assumed that those resources would usually be accessible by directional drilling from outside of the SEZs.

M.9 WATER RESOURCES

M.9.1 General Considerations

The analysis of water resources considered impacts on surface water features and groundwater within the SEZ, the surrounding valley, the entire groundwater basin, as well as upstream/upgradient and downstream/downgradient valleys and groundwater basins (if it was determined that there was connectivity and the potential for indirect impacts). Surface water features that were considered were streams, lakes, wetlands, surface springs and seeps, ephemeral washes/drainages, playas, dry lakes, and floodplains. Groundwater features considered for potential impacts were drawdown of groundwater elevations, surface water-groundwater connectivity, recharge and discharge areas, land subsidence, phreatic vegetation, and groundwater flow systems in local and regional aquifers.

Impacts on surface water and groundwater features are primarily related to the alteration of natural hydrologic conditions, degradation of water quality, and the consumptive use of water for solar facilities. The assessment of impacts relating to hydrologic alterations and water quality was performed by using a variety of data sources to characterize water features and professional judgment to identify potential direct and indirect impacts from solar energy developments. Impacts related to water use were determined by assessing the available amount of surface water and groundwater resources in the region of the SEZ (explained above) and estimating water requirements for solar energy developments during construction and operation phases.

M.9.2 Methods for Determining Water Use at Solar Facilities

This section explains the methods and assumptions used to estimate water use requirements by solar energy facilities. The analysis is relevant to construction and operations phases of utility-scale parabolic trough, power tower, dish engine, and PV facilities.

M.9.2.1 Construction

During construction, water is needed primarily for fugitive dust control and the workforce potable supply. Water potentially needed for concrete preparation was assumed to come from an off-site source and was not included in the calculations. Workforce potable water supply was calculated by using scaled estimates of full-time-equivalent (FTE) workforce (see Section M.19) and water consumption rates from various solar energy development applications (CEC 2009a,b; CEC and BLM 2009; Topaz Solar Farms, LLC 2008).

Fugitive dust was assumed to be controlled by spraying the land surface with water. Dust can be problematic in a desert climate where the surface is composed of fine-grained aeolian or lacustrine deposits easily transported by wind. Less water would be required if a chemical immobilizer was mixed with the water; however, the potential use of chemicals would have to be investigated during site characterization. Fugitive dust control using only water was estimated according to the empirical equation presented by Cowherd et al. (1988):

$$I = \frac{0.8\,P\,d\,t}{(100 - C)}, \qquad \text{(M.1)}$$

where

I = rate of water application (L/m^2),

P = potential average daytime evaporation rate (mm/h),

C = removal efficiency of the process for PM_{10} (i.e., particles <10 μm),

d = number of vehicles passing a point (h^{-1}), and

t = time between applications (h).

The rate of water application (I) was estimated by assuming that C was equal to 80% (CASLC 2006), d was equal to 5, and t was equal to 6 hours. Potential evaporation (P) values were estimated by using average pan evaporation data relevant to the particular region considered (Cowherd et al. 1988; WRCC 2010a). The total water needed for dust suppression for a single day was calculated by multiplying the rate of application, I, by the number of applications per day, assumed to be two, and the disturbed area for the project. The factors used to estimate water use during the peak construction year are presented in Table M.9-1. The estimated value of sanitary wastewater generated during the peak construction year was assumed to equal to the required workforce potable water supply.

M.9.2.2 Normal Operations

Water needs for normal operation of a solar project were calculated for mirror washing, the potable workforce water supply, and cooling for parabolic trough and power tower technologies (dish engine and PV technologies do not use cooling systems). During operations, the water use estimates are a function of the full build-out capacity of the facility. The factors used to estimate water use during operations are presented in Table M.9-2. The estimated value of sanitary wastewater generated during operations was assumed to equal the required workforce potable water supply.

M.10 VEGETATION

This section describes the methodology used to evaluate potential impacts on vegetation within the potentially affected area of the proposed SEZs.

M.10.1 Vegetation Included in the Assessment

Vegetation considered in the assessment included plant communities that were associated with the ecoregions and land cover types mapped for the potentially affected area (see data sources below) or that were known to occur based on field observations in 2009. Communities associated with wetland types, or other water-dependent habitats, known to occur in the potentially affected area were also included.

TABLE M.9-1 Assumptions and Multipliers for Estimating Water Use Requirements during the Peak Construction Year

	Factor	Parabolic Trough	Power Tower	Dish Engine	PV	Reference
Facility Details						
(A)	Number of facilities	If the total area of the proposed development is <10,000 acres (40 km^2), one annual project was assumed; if the acreage of the site is ≥10,000 acres (40 km^2) and <30,000 acres (121 km^2), two annual projects were assumed; if the acreage of the site is ≥30,000 acres (121 km^2), three annual projects were assumed.				Section M.1
(B)	Land use for a solar facility (acres/MW)	5	9	9	9	Section M.1
(C)	Maximum power produced by individual solar facility (MW)	400	400	750	750	Section M.1
(D)	Maximum allowed annual build-out for individual solar facility (acres)	3,000	3,000	3,000	3,000	Section M.1
(E)	Land disturbance during peak construction year (acres)	If A × B × C < D, the area of land disturbance per project during peak construction is A × B × C. If A × B × C > D, the area of land disturbance per project during peak construction is D.				
Water Use Requirements						
(F)	Full-time equivalent (FTE/MW)	3.30	2.40	1.00	0.50	Section M.19
(G)	FTE water consumption (gal/day/FTE)	50	50	50	50	[a]
(H)	Workforce water supply (ac-ft)	0.00112 × F × G × E ÷ B[b]				
(I)	Fugitive dust control (ac-ft)	Estimated using Equation M.1 with local rates of pan evaporation; see Section M.9.1.1 for explanation of conversion of application rate, *I* , to water volume.				

[a] Calculated using potable water consumption values given in utility-scale solar energy development applications representing parabolic trough (CEC 2009a), power tower (CEC 2009b), dish engine (CEC and BLM 2009), and PV (Topaz Solar Farms, LLC 2008) technologies.

[b] Where 0.00112 is the conversion factor from gal/day to ac-ft/yr.

TABLE M.9-2 Assumptions and Multipliers for Estimating Water Use Requirements during Operations

Factor		Parabolic Trough	Power Tower	Dish Engine	PV	Reference
Facility Details						
(A)	Full build-out land use (acres)	Equals 80% of the total area of the proposed development.				Section M.1
(B)	Land use for a solar facility (acres/MW)	5	9	9	9	Section M.1
(C)	Full build-out capacity (MW)	Equals A ÷ B.				
Water Use Requirements						
(D)	Mirror washing (ac-ft/yr/MW)	0.5	0.5	0.5[a]	0.05[a]	DOE 2009
(E)	Full-time equivalent (FTE/MW)	0.25	0.20	0.20	0.02	Section M.19
(F)	FTE water consumption (gal/day/FTE)	50	50	50	50	[b]
(G)	Annual mirror washing and workforce supply (ac-ft/yr)	Mirror washing = D × C. Workforce supply = 0.00112 × E × F × C.[c]				
	Cooling technology estimates	Range in dry- and wet-cooling estimates reflect the assumed 30% to 60% operating times of the facilities.				
(H)	Dry cooling (ac-ft/yr/MW)	0.2–1	0.2–1	NA[d]	NA	DOE 2009
(I)	Wet cooling (ac-ft/yr/MW)	4.5–14.5	4.5–14.5	NA	NA	DOE 2009
(J)	Annual cooling water needs (ac-ft/yr)	Dry cooling = H × C, wet cooling = I × C.				

[a] Water needs for PV panel washing were estimated as one-tenth of the requirements for concentrating solar power (CSP) mirror-washing values.

[b] Calculated using potable water consumption values given in utility-scale solar energy development applications representing parabolic trough (CEC 2009a), power tower (CEC 2009b), dish engine (CEC and BLM 2009), and PV (Topaz Solar Farms, LLC 2008) technologies.

[c] Where 0.00112 is the conversion factor from gal/day to ac-ft/yr.

[d] NA = not applicable.

M.10.2 Affected Area

The affected area considered in this assessment included the areas of direct and indirect effects. The area of direct effects was defined as the area that would be physically modified during project development (i.e., where ground-disturbing activities would occur). For some SEZs, the area of direct effects was limited to the SEZ itself, because no new transmission corridors or access roads were expected to be needed (see Section M.1). For others, the area of direct effects included an assumed area of development for a transmission corridor and/or access road needed to connect projects on the SEZ to the grid or road network, respectively. If needed, a new transmission line was assumed to occur as a 250-ft (76-m) wide developed ROW within a 1-mi (1.6-km) wide corridor from the SEZ to the nearest existing transmission line, and a new access road was assumed to occur as a 60-ft (18-m) wide developed road within a 1-mi (1.6-km) wide straight-line corridor to the nearest highway.

The area of indirect effects was defined as the area where ground-disturbing activities would not occur, but that could be indirectly affected by activities in the area of direct effect. This indirect effects area was defined as the area outside of the SEZ but within 5 mi (8 km) of the SEZ boundary and the area within the 1-mi (1.6-km) wide access road and transmission corridors. The area of indirect effects could be affected by project activities in the area of direct effects related to groundwater withdrawals, surface runoff, dust, noise, lighting, and accidental spills. The distance from the SEZ boundary used to define this area of indirect effects was based on professional judgment and was considered sufficiently large to bound the area that would potentially be subject to indirect effects. The potential magnitude of indirect effects would decrease with increasing distance from the SEZ.

For some SEZs, the area of indirect effects included areas dependent on groundwater that did not meet the distance criteria defined above. An example is the proposed Amargosa Valley SEZ in Nevada, where groundwater withdrawals have the potential to deplete regional groundwater supplies needed to maintain seeps, springs, wetlands, and surface water bodies in the Amargosa River, Oasis Valley, and Ash Meadows, which are up to 25 mi (40 km) from the SEZ boundary. The size of the affected area for these SEZs was considered on a case-by-case basis.

A circular area with a 50-mi (80-km) radius around the center of each SEZ was identified. The area encompassed by this circle was considered the SEZ region. The SEZ region was conservatively chosen based upon professional judgment to account for uncertainty in species distributions and to ensure that impacts on vegetation potentially affected by development on the SEZ could be comprehensively evaluated.

M.10.3 Data Sources

The types of data used to determine the known or potential presence of plant communities in the vicinity of the proposed SEZs were collected from various sources and at different geographical and organizational levels. Sources of information included, but were not limited to, the following:

- Level III and Level IV ecoregions (EPA 2007; Bryce et al. 2003; Woods et al. 2001; Chapman et al. 2006; Griffith et al. 2006);

- Gap analysis programs (the California Gap Analysis Program [Davis et al. 1998; USGS 2008]; Sanborn Mapping (2008); the Southwest Regional Gap Analysis Project (SWReGAP) (USGS 2004, 2005, 2007);

- State noxious weed lists;

- Regional weed management area lists;

- USDA Plants Database (USDA 2010b);

- National Wetlands Inventory (USFWS 2009); and

- National Hydrography Dataset.

M.10.4 Analysis Approach

Plant communities that were known to occur or could potentially occur within the affected area were included in the impact analysis. A landscape-level analysis was used to determine impacts by quantifying the total number of acres of each land cover type, encompassing a range of similar plant communities, within the areas of direct and indirect effects relative to the total acreage of each cover type within the SEZ region. The impact magnitude was based on what percentage that the area of each cover type within the direct impact area represented out of the total of all occurrences of that cover type within the SEZ region. The percentage that area represented out of a total of all occurrences of that cover type on BLM lands within the SEZ region was also calculated. In addition, the area of each cover type within the indirect impact area relative to the total acreage of each cover type within the SEZ region was calculated.

Relative impact magnitude categories were based on CEQ regulations for implementing NEPA (40 CFR 1508.27), in which significance of impacts is based on context and intensity. Similar impact magnitude categories and definitions were used in two recent EISs published by the BLM (2008a) and by DOE and the DOI (2008) and are widely applied by other agencies (e.g., the U.S. Nuclear Regulatory Commission) when evaluating environmental impacts. Impact magnitude categories were as follows:

- *None*—No impacts are expected.

- *Small*—Effects would not be detectable or would be so minor that they would neither destabilize nor noticeably alter any important attribute of the resource (for this analysis, impacts were considered small if less than 1% of the cover type would be lost in the region).

- *Moderate*—Effects would be sufficient to alter noticeably, but not destabilize important attributes of the resource (for this analysis, impacts were considered moderate if equal to or more than 1% but less than 10% of the cover type would be lost in the region).

- *Large—E*ffects would be clearly noticeable and would be sufficient to destabilize important attributes of the resource (for this analysis, impacts were considered large if 10% or more of a cover type would be lost in the region).

Actual magnitudes of impacts 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 plant communities in project areas. In defining impact magnitude, the application of design features was assumed. In most cases, it was assumed that design features would reduce most indirect effects to negligible levels.

The analysis of impacts on environmental resources from the construction of utility-scale solar energy projects was based, in part, on a set of assumptions regarding site preparation and restoration activities. These assumptions were based on management practices at existing and planned large-scale solar facilities and current BLM guidance (BLM 1992, 2007a,b, 2008b,c), and were used for the evaluation of impacts at the programmatic level and at the SEZ-specific level.

Areas granted ROWs for solar project development would typically be located in shrubland, shrub steppe, or grassland habitat types. The actual extent of land clearing within the ROW footprint of any solar facility would be specified in a detailed facility development plan that would likely avoid development in difficult areas (severe slopes, natural drainage courses, environmentally sensitive areas, rocky outcroppings, unstable areas, and the like) and that would reflect the tolerance of the solar technology for proximate vegetation. However, to ensure an upper-bound assumption for the impact analyses, the entire project area was assumed to be cleared of all vegetation during site preparation for facility construction. For most solar facilities it can be assumed that the project area would cover most of the ROW area. Because of variations in ROW configurations, 80% of the total SEZ area was assumed to be cleared of vegetation. Design features recommending that project-specific vegetation management plans investigate possibilities of revegetating parts of the solar array area were included, but such revegetation was not assumed in the impact analysis because its applicability is technology-specific and its success has not yet been demonstrated. Additionally, where revegetation was accomplished, a design feature was included to require firebreaks such that vegetated areas would not result in increased fire hazard.

It was assumed that Joshua trees (*Yucca brevifolia*), other *Yucca* species, and most cactus species would be salvaged prior to clearing and transplanted (as directed by the local BLM field office), held for use in revegetating temporarily disturbed areas, or otherwise protected as prescribed by state or local BLM requirements. It was further assumed that facility operators would maintain all ground surfaces within and adjacent to the solar array, the power block, and any electrical substations or switchyards or other support structures (buildings, roads, and so on) free of all vegetation throughout the operating period of the facility. An invasive species plan would be implemented to prevent the establishment and spread of invasive plant species within any portion of the solar ROW area and within access road and transmission line ROWs. In the case of the transmission line ROW, the invasive species plan would be consistent with the existing vegetation management plan for that ROW. Principles of integrated pest management, including biological controls, would be used to prevent the spread of invasive species. Design features would require the plan to include periodic monitoring, reporting, and immediate eradication of noxious weed or invasive species occurring within these managed areas.

A small proportion of the solar ROW project area was assumed to be temporarily disturbed during the construction period for short-term uses, such as component assembly, equipment storage and laydown, or underground utility line installation. These areas would not be included in the footprint of the solar array or support structures. Design features would include the reestablishment of vegetation within temporarily disturbed areas immediately following the completion of construction activities, provided such revegetation would not compromise the function of the buried utilities. Yucca species salvaged during construction could be transplanted into these areas at a density similar to preconstruction conditions.

Immediately following the decommissioning of a solar energy facility, it was assumed land surfaces would be returned to predevelopment contours to the greatest extent feasible. The operator would subsequently reestablish vegetation on the ROW area, including those areas previously replanted and subsequently disturbed during decommissioning. As identified in the design features, revegetation efforts would be guided by the implementation of a restoration plan that would focus on the establishment of native plant communities similar to those present in the vicinity of the project site. The plan would be designed to expedite the reestablishment of vegetation and require restoration to be completed as soon as practicable. To ensure rapid and successful reestablishment efforts, the plan would specify success criteria, including target dates, that would be developed in coordination with the BLM and that would be required to be met by the operator. Vegetation reestablishment efforts would continue until all success criteria were met. Bonding to cover the full cost of vegetation reestablishment would be required as a design feature. Species used for vegetation reestablishment would consist of native species dominant within the plant communities existing in adjacent areas having similar soil conditions. The plan would require the use of weed-free seed mixes of native shrubs, grasses, and forbs. In areas where suitable native species were unavailable, other plant species approved by the BLM would be used. The cover, species composition, and diversity of the reestablished plant community would be similar to those in the vicinity of the site.

On the basis of current Federal Energy Regulatory Commission (FERC) recommendations, it was assumed that only low-growing vegetation would be allowed in solar facility-associated transmission line ROWs. Revegetation and control of invasive species within the transmission line ROWs was assumed to be required as described above for the solar facility project areas.

The following text, extracted from BLM documents, represents current policy regarding habitat restoration and the use of native species on BLM lands:

- Native species should always be given first consideration and shall be used except under limited circumstances. If local sources of native plants and seeds are unavailable, commercial sources may be used. The BLM should determine if the use of released germplasm, which may include cultivars, is appropriate for a particular project. If non-natives are necessary, for example, for site stabilization, they should be non-invasive, and ideally be short-lived, have low reproductive capabilities, or be self-pollinating to prevent gene flow into the native community. Non-natives used should not exchange genetic material with common native plant species (BLM 2008c).

- In certain circumstances to prevent further site degradation and improve functionality, non-native plants may be used to achieve land management objectives (BLM 2008b).

- The use of non-native seeds as part of a seeding mixture is appropriate only if (1) suitable native species are not available, (2) the natural biological diversity of the proposed management area will not be diminished, (3) exotic and naturalized species can be confined within the proposed management area, (4) analysis of ecological site inventory information indicates that a site will not support reestablishment of a species that historically was part of the natural environment, and (5) resource management objectives cannot be met with native species (BLM 1992).

- The use of local seed sources for native plants is recommended; the use of local native genotypes is encouraged. If cultivars of native species are used, the use of certified seed (i.e., blue tag) is recommended. The use of "source identified" seed (i.e., yellow tag) is recommended when native seed is collected from wildland sites. The use of native species is preferred to non-natives. However, a mixture of native and non-native species is preferable to using only non-natives if the desired natives are not available and if the use of non-natives is consistent with approved land use plans. Competitive non-native seed or plants should not be used in a seed mixture to facilitate the establishment and persistence of the native (BLM 2007a).

- When available, use seed of known origin as labeled by state seed certification programs; use seed of non-native cultivars and species only when locally adapted native seed is not available or when it is unlikely to establish quickly enough to prevent soil erosion or weed establishment; use seed that is free of noxious and invasive weeds, as determined and documented by a seed inspection test by a certified seed laboratory; where important pollinator resources exist, include native nectar and pollen producing plants, include non-forage plant species for their pollinator/host relationships as foraging, nesting, or shelter species, choose native plant species over manipulated cultivars, especially of forbs and shrubs, for their more valuable pollen and nectar resources, and choose species with bloom times that match the activity times for pollinators (BLM 2007b).

M.11 WILDLIFE AND AQUATIC BIOTA

M.11.1 Wildlife

This section describes the methodology used to evaluate impacts on wildlife known to occur, or for which suitable habitat could occur, within the potentially affected area of the proposed SEZs.

M.11.1.1 Wildlife Species Included in the Assessment

Wildlife species considered in the assessment included representative amphibian, reptile, bird, and mammal species. Representative species were selected among those species known to occur, or for which potentially suitable habitat occurs, within the potentially affected areas of an SEZ. To a large extent, selection of representative species was based on whether a species (1) has key habitats within or near the SEZ, (2) is important to humans (e.g., big game, small game, and furbearer species), (3) is representative of other species that share important habitats (e.g., desert focal bird species), or (4) has some type of regulatory protection (e.g., Migratory Bird Treaty Act or Bald and Golden Eagle Protection Act). To the extent practicable, representative species included wildlife species whose range included the six-state study area or at least extended throughout the region for all or most of the SEZs within a state.

M.11.1.2 Affected Area

For the wildlife impact assessment, the affected area, the area of direct effects, and the SEZ region were the same as assumed for the vegetation assessment (see Section M.10.2).

M.11.1.3 Data Sources

The types of data used to determine the known or potential presence of wildlife species in the vicinity of the proposed SEZs, and life history information for the species, were collected from various sources and at different geographical and organizational levels. The most current, location-specific data at the highest resolution were used whenever available. Sources of information included, but were not limited to, the following:

- State game or natural resource agencies—Arizona Game and Fish Department (AZGFD 2010a,b), Biota Information System of New Mexico (BISON-M) (NMDGF 2010), California Department of Fish and Game (CDFG 2010a,b), Colorado National Heritage Program (CNHP 2009), Colorado Division of Wildlife (CDOW 2009), Natural Heritage New Mexico (NHNM 2010), Nevada Department of Wildlife (NDOW 2010), Nevada Natural Heritage Program (NNHP 2010a), and Utah Division of Wildlife Resources (UDWR 2009);

- Gap analysis programs—the California Gap Analysis Program (Davis et al. 1998; USGS 2008) and the Southwest Regional Gap Analysis Project (SWReGAP) (USGS 2004, 2005, 2007); and

- NatureServe (2010).

M.11.1.4 Analysis Approach

Because of the uncertainty in species distributions and the inherent challenges involved with tracking wildlife species in all solar energy study areas, a conservative approach was used to determine the potential for species to occur on or in the vicinity of the proposed SEZs. For the purpose of identifying potential wildlife species in the general area of the SEZ, a 50-mi (80-km) radius circle around the center of each SEZ was used to identify species based on (1) county-level occurrences, (2) locations of species observations as determined by state wildlife and/or natural heritage agencies, and (3) occurrence of identified land cover for the species listed by the SWReGAP (USGS 2005). The area encompassed by this circle was considered the SEZ region. The 50-mi (80-km) SEZ region was conservatively chosen on the basis of professional judgment to account for uncertainty in species distributions and to ensure that impacts on representative wildlife species potentially affected by development within the SEZ could be evaluated.

Wildlife species that were known to occur within the SEZ region were screened to determine their potential to occur within the direct or indirect effects areas. Spatial data provided by state natural heritage and regional Gap Analysis Programs were used to determine whether potentially suitable habitat occurred in the affected area. Gap Analysis Program data consisted of vertebrate animal land cover models. When mapped key habitats for a big game or game bird species (e.g., crucial winter range) were available from state agencies, the acreage of that habitat within the area of direct effects, the area of indirect effects, and the SEZ region was determined using the ESRI ArcGIS Version 9 software.

Wildlife species that were known to occur or for which potentially suitable habitat occurred within the area of direct effects were included as representative species in the impact analysis. A landscape-level analysis was used to determine impacts by quantifying the total acreage of potentially suitable habitat within the areas of direct and indirect effects relative to the total acreage of potentially suitable habitat within the SEZ region.

As for the assessment of vegetation (Section M.10.2), relative impact magnitude categories were based on CEQ regulations for implementing NEPA (40 CFR 1508.27), and were as follows:

- *None*—No impacts are expected.

- *Small*—Effects would not be detectable or would be so minor that they would neither destabilize nor noticeably alter any important attribute of the resource (for this analysis, impacts were considered small if less than 1% of identified habitat for a representative species would be lost in the region).

- *Moderate*—Effects would be sufficient to alter noticeably but not destabilize important attributes of the resource (for this analysis, impacts were considered moderate if equal to or more than 1% but less than 10% of identified habitat for a representative species would be lost in the region).

- *Large*—Effects would be clearly noticeable and sufficient to destabilize important attributes of the resource (for this analysis, impacts were considered large if 10% or more of identified habitat for a representative species 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 the species and their habitats in project areas. In defining impact magnitude, the application of design features was assumed. In most cases, it was assumed that design features would reduce most indirect effects to negligible levels.

Once impact magnitude was determined for each species, species-specific mitigation measures were considered. For all SEZs, pre-disturbance surveys to identify occupied and potentially suitable habitats were recommended. Avoidance of potentially suitable habitat was recommended (1) for those species that inhabited sensitive or unique habitats (e.g., desert dunes, washes, playas, wetlands, and riparian areas), (2) where minimization or avoidance measures could be readily implemented, and (3) for habitats such as nesting or roosting habitats that served a critical life history function. For species that used habitats common or widespread in the SEZ region (such as habitat generalists that may forage in a wide variety of habitats), avoidance of potentially suitable habitats was not considered feasible mitigation unless pre-disturbance surveys were conducted to determine the location of occupied habitats. A final mitigation plan would have to be determined at the project level through consultation with the U.S. Fish and Wildlife Service (USFWS) and appropriate state agencies (particularly for mitigation to species protected by the Migratory Bird Treaty Act or Bald and Golden Eagle Protection Act).

M.11.2 Aquatic Biota

This section describes the methodology used to evaluate direct and indirect impacts on aquatic habitat and biota known to occur on or within the potentially affected area of the proposed SEZs.

M.11.2.1 Affected Area

For the aquatic biota impact assessment, the affected area, the area of direct effects, and the SEZ region were the same as assumed for the vegetation assessment (see Section M.10.2).

M.11.2.2 Analysis Approach

Aquatic habitat and communities were assessed by determining first the perennial and intermittent/ephemeral surface water features (streams and water bodies) and wetlands present within the SEZ region. Maps of surface water features were based on data from the USGS National Atlas (http://www.nationalatlas.gov/natlas/Natlasstart.asp), and the length and acreage within each zone were calculated for streams and water bodies, respectively, using the ESRI ArcGIS Version 9 software. Small ephemeral washes are scattered throughout the desert southwest landscape. Only larger washes were inventoried by the National Atlas; therefore, many washes present in SEZs could not be quantified. Wetlands within each zone were identified by using National Wetland Inventory maps when available. Also quantified was the percentage of each surface water type (intermittent stream, perennial stream, intermittent lake, perennial lake) located within the area of direct and indirect effects as a percentage of the total amount of that surface water type within the SEZ region.

Many of the wetland and surface water features in the Southwest are washes and dry lakes that have no connection to perennial surface waters and contain water for only short periods following rainfall. Therefore, although map data indicated the presence of an intermittent surface water or wetland feature within the SEZ region, it was not considered to be aquatic habitat if hydrologic data indicated water was rarely, if ever, present. The hydrologic status of wetlands and surface waters was evaluated on the basis of information from site visits and existing hydrology data for the region as described in the water resources section for each SEZ.

Descriptions of aquatic communities within wetlands and surface water features were derived from state and federal resource agency reports and existing EISs when available. For many of the ephemeral/intermittent washes and rivers, no data were available. Many of the surface water features in the SEZ regions, particularly in California, Utah, and Nevada, are ephemeral and are not expected to contain aquatic habitat or biota. However, with sufficient frequency and flow, ephemeral or intermittent surface water may contain a diverse seasonal community of opportunistic species or habitat specialists adapted to living in temporary aquatic environments. Such specialists may be present in a dormant state even in dry periods. Therefore, for larger washes and frequently flooded ephemeral washes, aquatic biota could be present at least temporarily. To better resolve whether aquatic habitat and biota are present within an SEZ, site-specific surveys of aquatic communities were presumed to be required prior to site development.

Impacts on aquatic habitat and communities were considered to potentially result from direct disturbance, surface and ground water withdrawal, and changes in water, sediment, and contaminant inputs to surface water features. Based on best professional judgment, much greater weight was given to the magnitude of direct effects, because those effects would be difficult to mitigate. The potential for indirect impacts on surface water outside of the SEZs was evaluated based on their proximity and connectivity to surface water inside the SEZs. In most cases, it was assumed that design features would reduce most indirect effects to negligible levels. Actual impacts on aquatic habitat and biota would depend on the location of projects relative to surface water, project-specific design, and application of mitigation measures (including avoidance, minimization, and compensation). Mitigation was considered if there was a potential for impacts on aquatic habitat and biota. Mitigation methods for aquatic habitats are described in detail in Section 5.9.3 and Section 5.10.4, and SEZ-specific measures are described in the individual SEZ sections.

M.12 SPECIAL STATUS SPECIES

This section describes the methodology used to evaluate impacts on special status species that are known to occur, or for which suitable habitat could occur, within the potentially affected area of the proposed SEZs.

M.12.1 Special Status Species Included in the Assessment

Special status species considered in the assessment included the following groups:

- Species listed as threatened or endangered under the Endangered Species Act (ESA);

- Species that are proposed for listing, are under review, or are candidates for listing under the ESA;

- Species that are designated by the BLM as sensitive;

- Species that are listed as threatened or endangered by the state or states in the affected area[4]; and

- Species that are considered rare in the affected area. These included species that have been ranked by state natural heritage programs as S1 or S2, species listed by the state(s) as species of concern, or species listed by the USFWS as species of concern. The inclusion of species with high state ranks also accounted for species with high global ranks (i.e., G1 or G2), because these species invariably have high state ranks as well.

M.12.2 Affected Area

For the special status species impact assessment, the affected area, the area of direct effects, and the SEZ region were the same as assumed for the vegetation assessment (see Section M.10.2). As for the vegetation assessment, for some SEZs, the area of indirect effects included areas dependent on groundwater that did not meet the distance criteria defined above (e.g., Amargosa Valley, where groundwater withdrawals have the potential to deplete regional

[4] State-listed species are considered to be those species that are protected by individual state regulatory statutes (e.g., in California, the California Endangered Species Act; in Nevada, *Nevada Revised Statutes* (NRS) 501 or NRS 527).

groundwater supplies). The size of the affected area for these SEZs was considered on a case-by-case basis.

M.12.3 Data Sources

The types of data used to determine the known or potential presence of special status species in the vicinity of the proposed SEZs were collected from various sources and at different geographical and organizational levels, as presented in Table M.12-1. The most current, location-specific data at the highest resolution were used whenever available.

M.12.4 Analysis Approach

Because of the uncertainty in species distributions and the inherent challenges involved with tracking special status species in all solar energy study areas, a conservative approach was used to determine the potential for species to occur on or in the vicinity of the proposed SEZs. This approach is diagrammed in Figure M.12-1. Special status species in the area of the SEZs were determined by using the ESRI ArcGIS Version 9 software and spatial and nonspatial data of species occurrences. For the purpose of identifying potential special status species in the area, a circular area with a 50-mi (80-km) radius around the center of each SEZ was used to identify species based on (1) county-level occurrences, (2) locations of species observations as determined by state natural heritage programs, and (3) designated critical habitat for species listed under the ESA (Table M.12-1). The full list of special status species in the region surrounding each of the SEZs is presented in Appendix J.

Special status species that were known to occur within the SEZ region were screened to determine their potential to occur within the direct or indirect effects areas (Figure M.12-1). Spatial data provided by state natural heritage and regional Gap Analysis Programs were used to determine whether potentially suitable habitat occurred in the affected area. Gap Analysis Program data consisted of vertebrate animal habitat suitability models and land cover models. For plants and animals that did not have published habitat suitability models, professional judgment was used to determine the land cover types that could serve as potentially suitable habitat based on species ecology and natural history information. For many of the species evaluated, therefore, their predicted potential occurrence in the affected area was conservatively based on a general correspondence between mapped land cover types and descriptions of species habitat preferences. This overall approach to identifying species in the affected area likely overestimated the number of species that actually occurred in the affected area.

Special status species that were known to occur or for which potentially suitable habitat occurred within the affected area were included in the impact analysis (Figure M.12-1). A landscape-level analysis was used to determine impacts by quantifying the total area of potentially suitable habitat (and designated critical habitat for ESA-listed species) within the areas of direct and indirect effects relative to the total area of potentially suitable habitat within the SEZ region.

TABLE M.12-1 Information Reviewed and the Types of Data for Special Status Species Analyzed in this PEIS

States	Data Element	Data Type[a]	Source
All	Ecology, habitat, and natural history information; county-level occurrences; state rank information	Nonspatial; descriptive only	NatureServe Explorer (NatureServe 2010)
All	Current ESA and USFWS status, *Federal Register* documents describing ESA listing decisions for special status species, and species recovery information	Nonspatial; descriptive only	USFWS Environmental Conservation Online System (USFWS 2010a)
All	USFWS-designated critical habitat for ESA-listed species[b]	GIS spatial data—lines and polygons representing designated critical habitat	USFWS Critical Habitat Portal (USFWS 2010b)
All	Regional land cover data	GIS spatial data—raster grid	Gap Analysis Program, National Landcover (USGS 2004, 2008)
Arizona, Colorado, Nevada, New Mexico, Utah	Predicted potentially suitable habitat for special status terrestrial wildlife species (amphibians, reptiles, birds, and mammals) in the five-state region, excluding California	GIS spatial data—raster grid	Gap Analysis Program (Davis et al. 1998; USGS 2007)
Arizona, California, Nevada, Utah	USGS desert tortoise habitat suitability model[c]	GIS spatial data—raster grid	Nussear et al. (2009)
Arizona	Ecology and distribution of special status plant and animal species in Arizona; statewide distribution maps included	Nonspatial; descriptive only[d]	Arizona Game and Fish Department, Plant and Animal Abstracts, Distribution Maps, and Illustrations (AZGFD 2010a)
Arizona	Occurrences of special status species in Arizona	GIS spatial data—polygons of USGS quad-level occurrences	Arizona Game and Fish Department Heritage Data Management System (AZGFD 2010b)
California	Ecology and distribution of special status plant species in California; statewide distribution maps included	Nonspatial; descriptive only[d]	California Native Plant Society (CNPS 2010)

TABLE M.12-1 (Cont.)

States	Data Element	Data Type[a]	Source
California	Ecology, natural history, and range of special status terrestrial wildlife (amphibians, reptiles, birds, and mammals) in California; statewide range maps included	Nonspatial; descriptive only	California Department of Fish and Game, California Wildlife Habitat Relationship System (CDFG 2010a)
California	Predicted potentially suitable habitat for special status terrestrial wildlife species (amphibians, reptiles, birds, and mammals) in California	GIS spatial data—raster grid	Gap Analysis Program (Davis et al. 1998)
California	Occurrences of special status species in California	GIS spatial data—point and polygon element occurrences	California Department of Fish and Game, California Natural Diversity Database (CDFG 2010b)
Colorado	Ecology and distribution of special status plant species in Colorado; statewide distribution maps included	Nonspatial; descriptive only[d]	*Colorado Rare Plant Field Guide* (Colorado Rare Plant Technical Committee 2010)
Colorado	Occurrences of special status species in Colorado	GIS spatial data—polygons of USGS quad-level occurrences	Colorado Natural Heritage Program (CNHP 2009)
Nevada	Occurrences of special status species in Nevada	GIS spatial data—polygon element occurrences	Nevada Natural Heritage Program (NDCNR 2010)
Nevada	Ecology and distribution of special status plant species in Nevada; statewide distribution maps included	Nonspatial; descriptive only[d]	*Nevada Rare Plant Atlas* (NNHP 2010b)
New Mexico	Federal and state listing status, county-level occurrence information, and species documentation	Nonspatial; descriptive only	Biota Information System of New Mexico (BISON-M) (NMDGF 2010)
New Mexico	Occurrences of special status species in the state of New Mexico	GIS spatial data—polygons of USGS quad-level occurrences	Natural Heritage New Mexico (NHNM 2010)
New Mexico	Occurrences of special status plant species in the BLM Las Cruces Field Office	GIS spatial data—point element occurrences	BLM Las Cruces Field Office

TABLE M.12-1 (Cont.)

States	Data Element	Data Type[a]	Source
Nevada, New Mexico	Locations of Aplomado falcons in the BLM Las Cruces Field Office	GIS spatial data—point element occurrences	BLM Las Cruces Field Office
New Mexico	Model of potentially suitable habitat for the Aplomado falcon in New Mexico	GIS spatial data—polygons of habitat ranked not suitable to highly suitable	BLM Las Cruces Field Office (as verified from Young et al. 2002)
Utah	Ecology and range of special status plant species in Utah; statewide range maps included	Nonspatial; descriptive only[d]	Utah Native Plant Society, *Utah Rare Plants Guide* (UNPS 2009)
Utah	Ecology and distribution of special status plant species in Utah; statewide distribution maps included	Nonspatial; descriptive only[d]	*Revised Atlas of Utah Plants* (Shultz et al. 2006)
Utah	Occurrences of special status species in Utah	GIS spatial data—polygons of USGS quad-level occurrences	Utah Division of Wildlife Resources, Utah Conservation Data Center (UDWR 2009)
Utah	Occurrences of Utah prairie dog colonies through the UDWR Utah prairie dog colony tracking database	GIS spatial data—polygon element occurrences	Utah Division of Wildlife Resources, GRAMA Request (UDWR 2010)

[a] Spatial data were evaluated in a GIS and used to identify species that occurred in the SEZ region, determine the occurrence of species or the presence of potentially suitable habitat in the affected area, and facilitate the impact analysis. Nonspatial data included species reports of natural history information and county-level occurrences, which were used to determine the presence of species within the SEZ region and habitat associations for the impact analysis.

[b] Designated critical habitat is a specific geographic region that is essential for the conservation of a threatened or endangered species and that may require special management and protection. Critical habitat may include an area that is not currently occupied by the species but that will be needed for its recovery. An area is designated as "critical habitat" after the USFWS publishes a proposed federal regulation in the *Federal Register* and receives and considers public comments on the proposal. The final boundary of the critical habitat area is also published in the *Federal Register*. Federal agencies are required to consult with the USFWS on actions they carry out, fund, or authorize to ensure that their actions do not destroy or adversely modify critical habitat. In this way, a critical habitat designation protects areas that are necessary for the conservation of the species. A critical habitat designation does not necessarily restrict further development. It is a reminder to federal agencies that they must consult with the USFWS and make special efforts to protect the important characteristics of these areas (USFWS 2002). Not all species listed as threatened or endangered have designated critical habitat spatially available through the USFWS critical habitat portal.

Footnotes continued on next page

TABLE M.12-1 (Cont.)

---

[c] The desert tortoise habitat suitability model provides output of the statistical probability of habitat potential that can be used to map potential areas of desert tortoise habitat. This type of analysis, while robust in its predictions of habitat, does not account for anthropogenic changes that may have altered habitat with relatively high potential into areas with lower potential.

[d] In some cases, species distribution maps were digitized in a GIS to facilitate spatial analyses in the impact assessment.

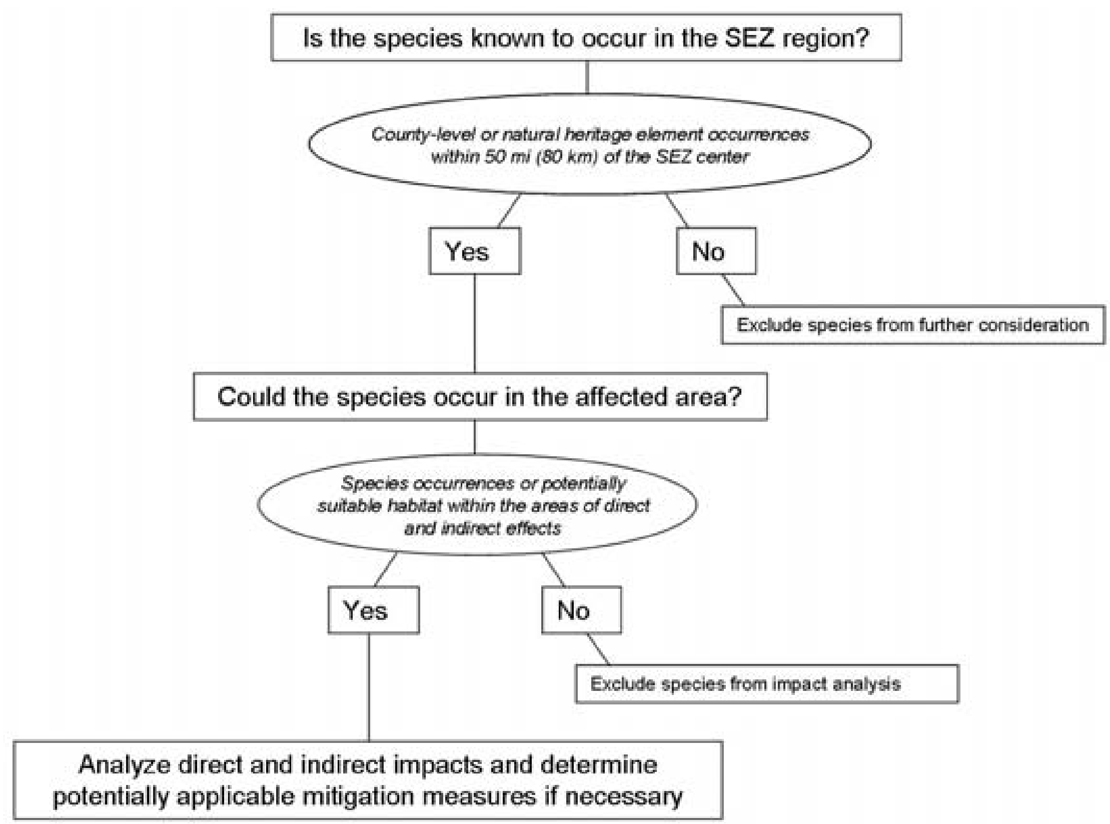

FIGURE M.12-1 Approach for Identifying and Analyzing Impacts on Special Status Species (see text for description of steps)

As for the assessment of vegetation (Section M.10.2), relative impact magnitude categories were based on CEQ regulations for implementing NEPA (40 CFR 1508.27), and were as follows:

- *None*—No impacts are expected.

- *Small*—Effects would not be detectable or would be so minor that they would neither destabilize nor noticeably alter any important attribute of the resource (for this analysis, impacts were considered small if less than 1% of the population or its habitat would be lost in the region).

- *Moderate*—Effects would be sufficient to alter noticeably but not destabilize important attributes of the resource (for this analysis, impacts were considered moderate if equal to or greater than 1% but less than 10% of the population or its habitat would be lost in the region).

- *Large*—Effects would be clearly noticeable and would be sufficient to destabilize important attributes of the resource (for our analysis, impacts were considered large if 10% or more of a population or its habitat would be lost in the region).

Actual impact magnitudes 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 special status species and their habitats in project areas. In defining impact magnitude, the application of design features was assumed. In most cases, it was assumed that design features would reduce most indirect effects to negligible levels.

Once impact magnitude was determined for each species, species-specific mitigation measures were considered. Mitigation measures were not considered warranted for species that occur only in the project vicinity as occasional migrants or transients. For all SEZs with the potential to support special status species, pre-disturbance surveys to identify occupied and potentially suitable habitats were recommended. Avoidance of potentially suitable habitat was recommended for those species that inhabit sensitive or unique habitats (e.g., desert dunes, washes, playas, wetlands, and riparian areas), where minimization or avoidance measures could be readily implemented, and for habitats such as nesting or roosting habitats that serve a critical life history function. For species that use habitats common or widespread in the SEZ region (such as habitat generalists that may forage in a wide variety of habitats), avoidance of potentially suitable habitats was not considered feasible mitigation unless pre-disturbance surveys were conducted to first determine the location of occupied habitats. If avoidance of occupied habitats was not possible, translocation and compensatory mitigation were recommended for consideration and, where possible, followed established mitigation protocols (e.g., *Guidelines for Handling Desert Tortoises during Construction Projects* [Desert Tortoise Council 1994]). A final mitigation plan would have to be determined at the project level through consultation with the USFWS and appropriate state agencies (particularly for mitigation to ESA-listed species).

M.13 AIR QUALITY AND CLIMATE

M.13.1 Affected Area

The area considered in this analysis included the areas at the SEZ boundaries and beyond the boundaries up to 31 mi (50 km). The affected area was defined as the area in which air emissions from the proposed SEZ could have some impacts and for which the Gaussian air dispersion model is typically applicable. However, if other air pollution problems, such as air quality-related values (AQRVs) like visibility or acid deposition or ground-level ozone are issues in the areas surrounding the SEZs or nearby federal Class I areas, the affected area could be extended to several hundred miles (kilometers) from the SEZ boundaries.

M.13.2 Estimation of Emissions Associated with Construction of Solar Facilities at the Proposed SEZs

Most of SEZs have a flat terrain; thus only a minimum number of site preparation activities, perhaps with no large-scale earthmoving operations, would be required. However, fugitive dust emissions from soil disturbances during the construction phase would be a major concern because of the large areas that would be disturbed in regions that experience windblown dust problems. In addition, fugitive dusts, which are released near ground level, typically have higher impacts than similar emissions from an elevated stack. For screening purposes, only potential impacts for particulate matter with a mean aerodynamic diameter of 10 µm or less (PM_{10}) and of 2.5 µm or less ($PM_{2.5}$), which compose fugitive dust, are presented in this analysis.

In the absence of details on the time schedule, heavy equipment usage, and activity level, affected area-wide uncontrolled PM_{10} emission factors of 0.11 and 0.42 ton/acre-month (0.025 and 0.094 kg/m^2-month) were considered for use for average and worst-case construction conditions, respectively (MRI 1996). For construction sites that include cut-and-fill areas, large-scale earthmoving activities, and/or heavy traffic volumes, an emission factor of 0.42 ton/acre-month (0.094 kg/m^2-month) was applied. During the site preparation and general construction phase, no large-scale earthmoving activities at the solar construction site are anticipated; thus, an uncontrolled emission factor of 0.11 ton/acre-month (0.025 kg/m^2-month) was applied. The $PM_{2.5}$ emission factor assumed for construction activities was 10% of the PM_{10} emission factor (MRI 2006). It was assumed that the conventional dust control measure of water spraying, with a control efficiency of 50%, would be applied over the disturbed area and on unpaved roads. While construction emissions for PV or dish engine facilities without power blocks might be less than for those for other solar technologies, for modeling it was assumed that construction emissions would be uniform regardless of solar technology.

As stated in Section M.1, depending on SEZ size, one to three simultaneous construction projects were assumed for each SEZ. Each project could disturb up to 3,000 acres (12 km^2) annually. It was also conservatively assumed that the projects being constructed simultaneously could be located in the area within the SEZ that is closest to off-site residences.

The emissions estimated in this analysis could be highly conservative in terms of emission factors and acreage of disturbed areas. In the permitting phase, when more detailed information on construction activities might be available, more realistic emission inventories based on actual activity levels are warranted.

M.13.3 Air Quality Modeling Analysis for Construction

For screening purposes, air quality modeling for PM_{10} and $PM_{2.5}$ emissions associated with construction activities was performed; the estimated air concentrations were compared with the applicable National Ambient Air Quality Standards (NAAQS) and State Ambient Air Quality Standards (SAAQS) levels at the site boundaries and nearby residences/communities and Prevention of Significant Deterioration (PSD) increment levels at nearby Class I areas.[5] However, air dispersion modeling for other criteria air pollutants might be needed in the permitting process. In particular, if AQRVs, such as visibility or acid deposition, are a concern in the nearby federal Class I areas, or the area surrounding the SEZ has an ozone problem, more refined air dispersion modeling would be needed.

The following sections briefly describe the air dispersion model used for the analysis, meteorological and terrain data processing, receptor data, and underlying modeling assumptions.

M.13.3.1 Selection of Air Dispersion Model

For this modeling analysis, the latest version of the AMS/EPA Regulatory Model (AERMOD) modeling system (version 09292) (EPA 2009b) was used. AERMOD is the U.S. Environmental Protection Agency's (EPA's) preferred or recommended model for a wide range of regulatory applications and uses hourly sequential meteorological data to estimate pollutant concentrations for averaging times ranging from 1 hour to annual to multiple years.

AERMOD contains three major components, as follows:

- AERMET—a meteorological data preprocessor that incorporates air dispersion based on planetary boundary layer turbulence structure and scaling concepts;

- AERMAP—a terrain data preprocessor that incorporates complex terrain using digital elevation data; and

---

[5] To provide a quantitative assessment, the modeled air impacts of construction were compared to the NAAQS/SAAQS levels and the PSD Class I increment levels. Although the Clean Air Act exempts construction activities from PSD requirements, a comparison with the Class I increment levels was used to quantify potential impacts. Only monitored data can be used to determine the attainment status. Modeled data are used to assess potential problems and as a consideration in the permitting process.

- AERMOD—an air dispersion model that estimates airborne concentrations and dry/wet deposition fluxes.

In addition, supporting programs for the AERMOD modeling system include the following:

- AERSURFACE—a surface characteristics preprocessor that estimates surface characteristics, including surface roughness length, albedo, and Bowen ratio for input to the AERMET;

- BPIPPRIME—a tool that calculates building parameters to account for building downwash effects of point source(s) for input to the AERMOD; and

- AERSCREEN—a screening model for AERMOD that produces estimates of regulatory design concentrations without the need for meteorological data and is designed to produce more conservative results than AERMOD. The EPA is currently working on a beta version of the code.

All these components, except BPIPRIME and AERSCREEN, were used for air dispersion modeling.

M.13.3.2 Determination of Surface Characteristics

For the computation of the fluxes and stability of the atmosphere, AERMET needs surface characteristics parameters, including surface roughness length, albedo, and the Bowen ratio. The surface roughness length is a measure of irregularities at the surface of the earth, including vegetation, topography, and structures, which influence the near-surface wind stress. Surface roughness length plays the most crucial role in determining the magnitude of mechanical turbulence and the stability of the boundary layer. Typical values range from 0.003 ft (0.001 m) over calm water surfaces to 3 ft (1 m) or more over a forest or urban area. Albedo is the fraction of the amount of radiation reflected from the surface to the amount of radiation incident on the surface. Typical values range from 0.1 for thick deciduous forests to 0.9 for fresh snow. The Bowen ratio, an indicator of surface moisture, is the ratio of sensible heat flux to the latent heat flux. The Bowen ratio is used to determine the planetary boundary layer parameters for convective conditions. Typical values range from 0.1 over water to 10 over the desert at mid-day.

Surface characteristics should represent the meteorological data at the application site. However, such data may not be available at the proposed SEZ site, and data from a nearby representative measurement site (typically the nearest airport) can be used. Sometimes, the nearest meteorological station is not representative of the proposed SEZ; for example, there may be a dissimilar orientation of nearby mountain ranges between the proposed SEZ and the nearest meteorological station. In this case, the AERMOD Implementation Guide (EPA 2009b) recommends finding another nearby measurement site representative of both meteorological parameters and surface characteristics of the site of interest. Failing that, it is likely that site-specific meteorological data will be required.

The AERSURFACE tool has been developed to aid users in obtaining realistic and reproducible surface characteristic values, which is, in turn, entered into the meteorological data preprocessor AERMET. AERSURFACE requires land cover data from the USGS National Land Cover Data 1992 archives (USGS 2010e). These data are used to determine the land cover types around the user-defined location.

Seasonal surface characteristics were determined for each of twelve 30-degree sectors. A default domain defined by 10 km × 10 km (6 mi × 6 mi) centered on the measurement site is used for determination of albedo and Bowen ratio. A radius of 0.6 mi (1 km) from the measurement site was used to determine the surface roughness values per recommendation in the EPA's AERMOD Implementation Guide (EPA 2009b). To determine the Bowen ratio, surface moisture conditions around the site are needed to characterize the area relative to climate normals. Surface moisture conditions for the Bowen ratio were determined by year, based on the 30-year (1971 to 2000) annual precipitation record at the nearby airport or meteorological station (NCDC 2010a; WRCC 2010b). If annual precipitation for the year of interest is within the lower 30th percentile or the upper 30th percentile of the 30-year record, dry or wet conditions, respectively, are assigned. Otherwise, average conditions were assigned. Additional user inputs affecting surface characteristic values include whether the site is an airport or an arid region and the amount of continuous snow cover through most of the winter.

M.13.3.3 Meteorological Data Processing

The meteorological data preprocessor (AERMET) requires three types of data: National Weather Service (NWS) hourly surface observations; NWS twice-daily upper air soundings; and data collected from an on-site measurement tool such as an instrumented tower, if available. However, no on-site meteorological data are available for the proposed SEZs, so hourly surface and twice-daily upper sounding data from the nearby NWS stations were used for the analysis (NCDC 2010b; NOAA 2010). Based on proximity, topographic features, climate regime, and longer-time history of complete records (up to 5 years), the meteorological stations for surface and twice-daily upper air meteorological data were selected as being representative of the SEZ site. Using the AERMET preprocessor, the most recent 5 years of meteorological data (2005 to 2009)[6] were processed for input to the AERMOD model.

M.13.3.4 Receptor Location Data

For the analysis, a modeling domain centered on the proposed SEZ was developed. Two sets of receptor networks were developed for the assessment: (1) SEZ boundary receptors and (2) regularly spaced receptor grids. For the analysis, discrete receptors, ranging from 100 to 200, depending on the size of the SEZ, were set along the SEZ boundary, where maximum

6 In accordance with the EPA's Modeling Guidance (40 CFR Part 51 Appendix W), the most recent consecutive 5 years of meteorological data representative of the site of interest should be used when estimating concentrations with an air quality model. However, meteorological stations representative of some SEZs have less than 5 years of data or not the most recent consecutive 5 years of meteorological data.

concentrations would be anticipated to occur. The modeling domain was determined based on a maximum modeling distance of 31 mi (50 km) for the AERMOD. Accordingly, regularly spaced receptor grids over a modeling domain of 62 mi × 62 mi (100 km × 100 km) centered on the proposed SEZ were developed. Three intervals of these receptors (with intervals of innermost, 0.6 mi [1 km]; intermediate, 1.2 mi [2 km]; and outermost, 6.2 mi [10 km]) were placed over the modeling domain. For PSD analysis, additional receptors were placed at site boundaries and regular-interval inner locations at the nearby federal Class I areas, if they were located within the modeling domain. If not, no receptors were modeled for PSD analysis at the nearest Class I area. Instead, several regularly spaced receptors in the direction of the nearest federal Class I area were selected as surrogates for the PSD analysis. To predict concentrations at the Class I area, concentrations at these surrogate receptors were estimated by considering the same decay ratio with distance. For the analysis, a proportional ratio was applied; for example, concentration was reduced to a half for a distance ratio of two to the emission source.

M.13.3.5 Terrain Data Processing

The AERMAP terrain data preprocessor was used to account for the effects of terrain features. The terrain elevations for source and receptor locations were estimated based on the Digital Elevation Model (DEM) elevation data in the USGS DEM format (USGS 2010e). One vertex of each area source for the construction site and receptors was entered into the AERMAP. For area sources, the AERMAP determines the elevation of the area source. For receptors, the AERMAP determines the elevations of receptors along with hill height scale, which is the elevation of the terrain feature that dominates the flow at a receptor of interest.

M.13.3.6 Modeling Assumptions

The following assumptions were used for air quality modeling and modeling result interpretations:

- Construction sites are divided into one to three area sources depending on topographic features of the SEZ. The AREAPOLY source option in the AERMOD is used to specify an area source as an irregularly shaped polygon of a construction site, and one elevation representative of the construction site is needed for input to the AERMOD.

- Construction activities are assumed to occur every day of the year from 7 a.m. to 4 p.m.

- Dry and wet deposition mechanisms are uncertain and are not included in EPA's regulatory option, and thus, it is not recommended that they be used for typical applications, except in special cases (e.g., deposition impacts on vegetation). Accordingly, no dry and wet depositions for construction-related PM modeling are assumed (i.e., all PMs are conservatively assumed to be airborne).

- During site preparation and construction phases, fugitive dust emissions resulting from soil disturbances by heavy construction equipment or vehicles are typically released at the top of the wheel/tire, with initial dispersion corresponding to the volume size of the equipment or truck. However, for this analysis, it is conservatively assumed that emissions are released at the ground level without vertical initial volume.

- For PM_{10}, the highest concentration of the sixth highest[7] over 5 years was calculated; for $PM_{2.5}$, the highest concentration of the highest-eighth[8] at each receptor was calculated. The highest of 5-year averaged annual means across the receptors for PM_{10} and $PM_{2.5}$ were calculated.

To obtain total concentrations for comparison with applicable air quality standards, these modeled concentration increments were added to measured background concentrations representative of the SEZ, which can be obtained from state agency or from the EPA's *AirData* Web site (EPA 2010).

M.13.4 Air Quality Impacts of Operations

Because solar facilities either do not burn any fossil fuels or use only small amounts for maintaining the temperature of the heat transfer fluids for more efficient daily start-up during operation, only a few sources of air emissions exist, and their emissions would typically be relatively small. In particular, since design features would require on-site roads and parking lots to be paved and/or treated, their fugitive dust emissions would be significantly lower than during the construction phase. Therefore, potential impacts on ambient air quality during the operation of a solar facility would be small.

Overall, the operation of a solar facility would likely have positive air quality impacts, because it would offset air emissions of criteria pollutants, volatile organic compounds (VOCs), toxic air pollutants (TAPs), and greenhouse gases (GHGs) that would otherwise be released from fossil fuel–fired power plants. However, these benefits might accrue at locations far removed from the solar facilities and over a wide geographic area. To assess these benefits, emissions avoided from fossil fuel–fired power plants (e.g., coal, natural gas, oil) were estimated on the basis of the assumption that the SEZ would eventually have development on 80% of its lands. Total offset emissions for the SEZ can be estimated by:

$$\text{Total offset emissions (tons/year)} = CAP \times (8{,}760) \times CF \times CEF \div (2{,}000), \qquad \text{(M.2)}$$

[7] Represents the highest concentration among the ranked sixth-highest concentration of 24-hour PM_{10} received by the receptors.

[8] Represents the highest concentration among the ranked eighth-highest concentration of 24-hour $PM_{2.5}$ received by the receptors.

where

CAP is a nameplate capacity in MW;

8,760 is total hours in a year;

CF is a capacity factor (unitless), the percentage of time that the plant can produce power at its nameplate capacity;

CEF is a composite emission factor (lb/MWh) (see Table M.13-1); and

2,000 is a conversion factor from pounds to tons.

To estimate the potential capacity for a SEZ, it is assumed that the SEZ would eventually have development on 80% of the lands and that a range of 5 acres (0.020 km^2) per MW (for parabolic trough technology) to 9 acres (0.036 km^2) per MW (power tower, dish engine, and PV technologies) would be required. A capacity factor of 20% is assumed, which can be attained in case of no thermal energy storage (TES). Composite emission factors for a state are estimated based on annual total emissions divided by total combustion net generation, as shown in Table M.13-1 (EPA 2009a). Emission factors for SO_2 and NO_x (representative of criteria pollutants), Hg (representative of TAPs), and CO_2 (representative of GHGs) are developed. Potential air emissions offset by the solar project development for each SEZ are compared with emissions from electric power systems and all source categories for its own state and the entire six-state study area to examine the importance of solar projects.

TABLE M.13-1 Composite Emission Factors Estimated Based on Combustion-Related Power Generation

	Composite Emission Factors (lb/MWh; lb/GWh for Hg)			
State	SO_2	NO_x	Hg	CO_2
Arizona	1.54	2.37	0.0217	1,700
California	0.26	0.42	0.0037	994
Colorado	2.64	3.05	0.0171	1,976
New Mexico	1.79	4.47	0.0657	1,990
Nevada	2.82	2.42	0.0161	1,553
Utah	1.99	3.81	0.0078	2,158
Six-state average	1.51	2.23	0.0176	1,578

Source: EPA (2009a).

M.14 VISUAL RESOURCES

The visual impact analysis identified lands within the 25-mi (40-km) viewshed of the proposed SEZs that would likely be affected by views of solar energy development within the SEZs. The SEZ analysis included two major components: viewshed analyses and analyses using Google Earth and Google SketchUp™ to create visualizations of the SEZ and models of hypothetical solar energy facility models placed within the SEZ.

The selected sensitive visual resource areas included in the analysis were as follows:

- National Parks, National Monuments, National Recreation Areas, National Preserves, National Wildlife Refuges, National Reserves, National Conservation Areas, National Historic Sites;
- Congressionally authorized Wilderness Areas;
- Wilderness Study Areas;
- National Wild and Scenic Rivers; Congressionally authorized Wild and Scenic Study Rivers;
- National Scenic Trails and National Historic Trails;
- National Historic Landmarks and National Natural Landmarks;
- All-American Roads, National Scenic Byways, State Scenic Highways; and BLM- and USFS-designated scenic highways/byways;
- BLM-designated Special Recreation Management Areas; and
- Areas of Critical Environmental Concern (ACECs) designated because of outstanding scenic qualities.

M.14.1 Viewshed Analyses

Preliminary viewshed analyses were conducted to identify which lands surrounding the proposed SEZs are visible from the SEZs. Four viewshed analyses were conducted, each with a different height representative of project elements associated with potential solar energy technologies, including PV and parabolic trough arrays (24.6 ft [7.5 m]), solar dishes and power blocks for CSP technologies (38 ft [11.6 m]), transmission towers and short solar power towers (150 ft [45.7 m]), and tall solar power towers (650 ft [198.1 m]). These heights were selected based on review of available literature on utility-scale solar technologies and consultation with solar technology experts at Sandia National Laboratories.

The Spatial Analyst Extension of the ESRI ArcGIS 9.3.1 software was used to calculate viewsheds. The viewshed tool (or program) determines whether there is a line of sight between a target and the area surrounding the target. The only inputs required for the viewshed tool are targets (or points), from which to determine the line of sight and a digital elevation model (a grid of rectangular cells, each cell representing the elevation at its center). The viewshed tool examines each cell in the digital elevation model and determines whether there are one or more cells of higher elevation between it and the target point. If there is not, that cell is included in the calculated viewshed. The result of the viewshed tool is another grid of rectangular cells; in this case each cell represents how many of the targets used as input have a line of sight to that individual cell.

For all the proposed SEZs except Imperial East in California, the 32.8-ft (10-m) (the approximate vertical resolution and width of each cell) digital elevation models from the USGS National Elevation Data were used as inputs. For the proposed Imperial East SEZ, the 32.8-ft (10-m) data were not available, so the 98.4-ft (30-m) data were used instead.

The viewshed analysis did not account for the presence of vegetation or structures that might screen views of the landscape; however, in most cases, this introduced little error, because most of the land within the viewsheds of the SEZs is devoid of vegetation or structures of sufficient height to screen solar facilities from view.

Because the proposed SEZs represent large areas, rather than specifically located targets, sample points placed throughout the area of each SEZ had to be used as target inputs to the viewshed tool. The sample points were developed by dividing each proposed SEZ into rectangular zones measuring about 1 mi (1.6 km) on each side. Zonal sampling tools from the Spatial Analyst Extension were then used to calculate the location of the highest point in each zone. These sampling points were then used as target inputs for the viewshed tool. In some cases, more sampling points were added around the SEZ border based on the analyst's visual inspection of the surrounding terrain (as seen in the digital elevation model).

In addition to its geographical location on the ground, each target point can represent its own height as well as the height of a person viewing it. Heights representative of the potential solar energy technologies (see above) were used as target heights, and the viewer height remained constant at 1.75 m (5.7 ft) for each set of targets. This resulted in four separate viewsheds for each proposed SEZ, each representing a potential solar energy technology.

An additional parameter set in the viewshed tool is whether or not curvature of the earth is to be taken into consideration. The viewsheds for the proposed SEZs were calculated to include the curvature of the earth at a refractivity coefficient of 0.13.

Each viewshed was then overlaid on the 17 layers of data representing the different classes of visual resources (for example, wilderness areas). Each of the visual resource layers was another grid of rectangular cells measuring about 32.8 ft (10 m) on each side. In this case, each grid represented an individual visual resource (e.g., Big Maria Mountains Wilderness Area was represented by a grid with 1,863,808 cells). The overlap between the viewshed and the visual resource layer was measured, and acreage estimates for each individual resource were calculated by using the count of overlapping cells divided by 40.46873 to convert the 100-m^2 cells to acres.

Viewshed maps for each of the SEZs for all four solar technology heights are available in Appendix N.

M.14.2 Google Earth Visualizations

Google Earth and Google SketchUp were used extensively for preparing visualizations of virtual models of solar facilities within the SEZs. The visualizations allowed visual resource analysts to judge the apparent size and viewing angles of hypothetical solar facilities within the SEZs. The visualizations also allowed visual resource analysts to see the relationship of the hypothetical facilities to nearby land forms that would form the visual setting for potential solar facilities built within the SEZs. These visualizations helped analysts assess the potential visual contrast levels that could be expected if real solar facilities were built within the SEZs.

The following approach was used to create the Google Earth visualizations used in the visual impact analysis.

The ESRI ArcGIS software Version 9.3.1 was used to generate keyhole markup language (KML) files for use in Google Earth. KML files were created for (1) the proposed SEZ boundaries and (2) the selected sensitive visual resource areas listed above.

Google SketchUp is a three-dimensional modeling software package that allows construction of three-dimensional models that can be imported and manipulated within Google Earth. By using drawings and other information contained in available utility-scale solar energy facility applications, simplified but spatially accurate scale models of the facilities were built in Google SketchUp. The three-dimensional models of facilities were then imported into Google Earth and placed within the SEZs. Where possible, multiple models were placed into the SEZs. Most analyses utilized models of power tower facilities, because the inclusion of the power tower receiver, which is very tall, in the model facilitated "worst case" analysis of impacts.

Using the KML files of the sensitive visual resource area boundaries imported from ArcGIS, analysts chose a variety of viewpoints within the sensitive areas to create (1) views of the SEZs and (2) views of the models within the SEZs. Viewpoints were chosen to be as close to the assumed human viewpoint elevation of 5.7 ft (1.7 m) as possible, but generally Google Earth limits viewpoints to between 7 and 10 ft (2 to 3 m) above the surface elevation. Thus the Google Earth viewer height is slightly above the actual height of a person standing in a real landscape. However, because of the large distances between the sensitive visual resource areas and the SEZs, the difference between the real view and the modeled view would be minimal. When possible, viewpoints were selected based on knowledge of visitor use areas. For cases where that information was not available, the analysts chose viewpoints that represented a range of contrast levels that might be experienced by visitors to the sensitive resource areas. The lead visual analyst used the visualizations to inform the impact assessment and selected some visualizations for inclusion in this PEIS document. Google Earth's "Snapshot View" tool was used to create screen captures of the visualizations, which were then imported into Adobe Photoshop and converted to a suitable image format for inclusion in this PEIS.

M.15 ACOUSTIC ENVIRONMENT

Potential noise impacts were assessed by estimating the noise levels from noise-emitting sources associated with construction and operation and then performing simplified noise propagation modeling. Estimated noise levels at sensitive receptors, such as nearby residences, were assessed by comparison to assumed background noise levels, the EPA noise guideline (EPA 1974), and/or state and local regulations or ordinances, if any.

M.15.1 Affected Area

Noise energy is dissipated quickly with distance, and thus the noise is usually considered a local problem unless the noise levels are extremely high. The affected area considered in these noise assessments included the areas at the nearest sensitive receptors (e.g., residences), which range from one adjacent to the SEZ to one about 6 mi (10 km) from the SEZ boundary.

M.15.2 Estimation of Noise Emissions Levels

M.15.2.1 Construction

During construction, heavy equipment such as bulldozers, graders, heavy trucks, compressors, and the like would be employed. No detailed information, such as schedule, number and type of equipment, or activity levels, is available. 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) (Hanson et al. 2006). Most construction equipment has noise levels within the range of 80 to 90 dBA at 50 ft (15 m). For several pieces of heavy equipment and their separation distances, a combined noise level of 95 dBA at a distance of 50 ft (15 m) is conservatively assumed, if impact equipment such as pile drivers or rock drills is not being used.

M.15.2.2 Operation

For the parabolic trough and power tower technologies, most noise sources during operations would be in the power block area, including the turbine generator (typically in an enclosure), pumps, boilers, and dry- or wet-cooling systems. The power block is typically located in the center of the facility. On the basis of a 250-MW parabolic trough facility with a cooling tower (Beacon Solar, LLC 2008), a sound pressure level of 118 dBA at a distance of 3 ft (0.9 m) from the cooling tower was used for the analysis. This noise level dominates (by about 30 dBA) any other equipment, such as boiler, pumps, and steam turbine generators in the facility.

The solar dish engine is unique among CSP technologies, because it generates electricity directly and does not require a power block. A single, large solar dish engine has relatively low noise levels, but a solar facility might employ tens of thousands of dish engines, which would cause high noise levels around such a facility. For example, the proposed 750-MW SES Solar Two dish engine facility in California would employ as many as 30,000 dish engines (SES Solar Two, LLC 2008). A sound power level of 99 dBA from a Stirling solar dish engine, which is equivalent to a sound pressure level of about 89 dBA at a distance of 3 ft (0.9 m),[9] was used for this analysis. The noise level from a solar dish engine is about 17 dBA higher than that from a transformer and about 32 dBA higher than that from a step-up transformer embedded in the solar field.

M.15.3 Estimation of Noise Levels at the Receptors

Several important factors affect the propagation of sound in the outdoor environment (Anderson and Kurze 1992):

- *Source characteristics,* such as sound power, directivity, and configuration;
- *Geometric spreading* (independent of frequency), as the sound moves away from the source, resulting in 6- and 3-dB reductions per doubling of distance from point (e.g., fixed equipment) and line (e.g., road traffic) sources, respectively;
- *Air absorption,* which depends strongly on frequency and relative humidity;
- *Ground effects,* which result from interferences of reflected sound by reflecting surfaces (e.g., ground surfaces) with direct sound;
- *Meteorological effects* due to turbulence and variations in vertical wind speed and temperature; and
- *Screening effects,* by topography, structures, dense vegetation, and other natural or man-made barriers.

A refined noise analysis would employ a sound propagation model that integrates most of the sound attenuation mechanisms noted above along with detailed source-, receptor-, and site-specific data. However, such detailed information is unavailable at this time. Thus, only geometric spreading or geometric spreading combined with ground effects was considered when predicting noise levels.

---

9 Many SEZs are located at a higher elevation, and thus this level was corrected based on average temperature and atmospheric pressure. For example, all SEZs in Utah have an elevation of 5,000 ft (1,524 m), where the sound pressure level would be about 0.7 dBA lower than that at mean sea level.

The sound pressure level at the receptor locations from point source(s) was estimated by using the following simple noise propagation formula, which considers geometric spreading and ground effects only (Hanson et al. 2006):

$$L_p = L_{p,ref} - (20 + 10\ G)\ \log_{10}\ (D \div D_{ref}), \quad \text{(M.3)}$$

where

L_p is A-weighted sound pressure level at a given distance (dBA),

$L_{p,\ ref}$ is A-weighted sound pressure level at a reference distance (dBA),

G is a constant that accounts for ground effects (unitless),

D is the distance from the receiver to the noise source (ft), and

D_{ref} is the reference distance (ft).

Large ground factor, G, means large amounts of ground attenuation with increasing distance from the source. Ground factor can be calculated as follows:

For soft ground,

$$G = 0.66 \text{ for } H_{eff} \leq 5,$$

$$G = 0.75\ (1 - H_{eff} \div 42) \text{ for } 5 \leq H_{eff} \leq 42, \quad \text{(M.4)}$$

$$G = 0 \text{ for } H_{eff} \geq 42.$$

For hard ground,

$$G = 0. \quad \text{(M.5)}$$

Effective height (H_{eff}) is the average height of source height and receptor height. To minimize noise attenuation from ground effects (i.e., maximize noise impacts at the receptors), the highest point among many source heights is selected as source height. Source height for construction equipment is assumed to be 10 ft (3.0 m) (approximate exhaust stack height), while that for cooling tower is assumed to be 50 ft (15.2 m) (approximate fan stack height). Source height of the Stirling solar dish engine is assumed to be 38 ft (11.6 m) (SES Solar Two, LLC 2008). The receptor height is set at 5 ft (1.5 m), which is the approximate height of human ears from the ground.

Day-night average noise level (L_{dn} or DNL in dBA), which represents a receiver's cumulative noise exposure from all events over a full 24 hours, is given by:

$$L_{dn} = 10 \times \log_{10} [(T_d \times 10^{(Lp,d/10)} + T_n \times 10^{[(Lp,n+10)/10]} + 15 \times 10^{(Lpb,d/10)}$$

$$+ 9 \times 10^{[(Lpb,n+10)/10]}) \div 24], \quad \text{(M.6)}$$

where

T_d and T_n are daytime and nighttime operation hours of the project noise sources, respectively,

$L_{p,d}$ and $L_{p,n}$ are sound pressure levels from the project noise sources for daytime and nighttime hours, respectively, and

$L_{pb,d}$ and $L_{pb,n}$ are background levels for daytime and nighttime hours, respectively.

Because most SEZs are located in remote areas with rural environments, background levels of 40 and 30 dBA for daytime and nighttime hours, respectively, are assumed (Eldred 1982), which result in a day-night average noise level (L_{dn}) of 40 dBA considering only background levels alone.

On a calm, clear night typical of the sites of most of the proposed SEZs, the air temperature would likely increase with height (temperature inversion) because of strong radiative cooling. Such a temperature profile tends to focus noise downward toward the ground. There would be little, if any, shadow zone[10] within 1 or 2 mi (2 or 3 km) of the noise source in the presence of a strong temperature inversion (Beranek 1988). In particular, such conditions add to the effect of noise being more discernable during nighttime hours, when the background noise levels are the lowest. The noise propagation formula used in the analysis assumes a simplified uniform (isothermal) atmosphere with calm winds, which is unusual for typically changing atmospheric conditions. For a temperature lapse condition typical of daytime, the sound bends upward to the sky, and sound levels would be about 5 dB lower than those for the uniform condition (Saurenman et al. 2005). For a temperature inversion condition typical of nighttime, sound levels would be about 5 to 10 dB higher than those for the uniform condition. Just before sunrise, when the temperature inversion is the strongest, sound levels would be about 10 to 15 dB higher (but noise-producing operations at solar facilities are not anticipated to occur at this time of day). For implementation of TES for parabolic trough or power tower technology during nighttime hours, the following adjustment was made to estimate the nighttime noise level and L_{dn}. For nighttime hours under temperature inversion, 10 dBA was added to the value estimated under uniform atmosphere. This 10-dB addition was applied from 10 p.m. and beyond after 12 hours of daytime operation (7 a.m. to 7 p.m.) and 3 hours of nighttime operation (7 p.m. to 10 p.m.), which is a transition from lapse to inversion. In L_{dn} calculation, the noise level for the nighttime temperature inversion hours would be 20 dBA higher than that for the daytime lapse hours: 10-dB addition due to temperature inversion and 10-dB addition due to 10-dB penalty for nighttime hours.

---

[10] A shadow zone is defined as the region in which direct sound does not penetrate because of upward diffraction.

The sound propagation formula used in this analysis assumes uniform (isothermal) atmosphere with calm winds. However, actual noise levels at the receptors could be lower than estimated noise levels using the above formula. For example, mid- and high-frequency noise from construction activities is significantly attenuated by atmospheric absorption under the low-humidity conditions typical of an arid desert environment where most SEZs are located and by temperature lapse conditions typical of daytime hours. In addition, noise levels would be significantly reduced if the sound propagation path is blocked by intervening topographic features or man-made noise barriers or berms. However, depending on upwind/downwind locations, vertical wind gradients could increase or decrease noise levels at the receptors compared with those estimated from uniform atmosphere. Thus, the results presented in the analysis should be interpreted in this context. The estimate of noise level used in this analysis is considered conservative, considering all these factors.

M.15.4 Vibration

Construction activities could result in various degrees of ground vibration, depending on the equipment used and construction methods employed. All construction equipment causes ground vibration to some degree, but activities that typically generate the most severe vibrations are high-explosive detonations and impact pile driving. As is the case for noise, vibration would diminish in strength with distance. For example, vibration levels at receptors beyond 140 ft (43 m) from a large bulldozer (87 VdB at 25 ft [7.6 m]) would diminish below the threshold of perception for humans, which is about 65 VdB (Hanson et al. 2006). During the construction phase, no major construction equipment that can cause significant ground vibration would be used, and no residences or sensitive structures are located in close proximity.[11] Therefore, no adverse vibration impacts are anticipated from construction activities, including pile driving for dish engines.

During operations, no major ground-vibrating equipment would be used. In addition, no sensitive structures are located close enough to the most SEZs to experience physical damage. Therefore, potential vibration impacts on surrounding communities and vibration-sensitive structures during operation of any solar facility would be minimal.

M.16 PALEONTOLOGICAL RESOURCES

Methods used in the assessment of paleontological resources for the SEZs focused on assessing the potential disturbance of plant and animal fossils. Paleontological remains are protected under Paleontological Resources Preservation under the Omnibus Public Lands Act of 2009, as discussed in Section 4.14. The examination of impacts on paleontological resources ultimately relied on evidence of the existence, density, and nature of fossil deposits in areas that might be disturbed. Potential Fossil Yield Classification (PFYC) maps were used when available

[11] Typically, the heavy equipment operators would not allow public access any closer than 330 ft (100 m) for safety reasons. In other words, construction of a solar facility would not occur within this distance from the nearest residence.

to characterize the potential for paleontological resources. The region of influence (ROI) for paleontological resource assessment for the SEZs included the SEZ areas, assumed access road and transmission ROWs, and any additional off-development areas affected or likely to be affected by construction and operation or maintenance. A 5-mi (8-km) radius outside of SEZ boundaries was included as part of the ROI to take into account possible erosion-related issues present in a desert environment, as well as potential new routes of access to previously remote areas.

The assessment of potential impacts on paleontological resources involved identifying those activities that would result in surface or subsurface disturbance within the ROI. Activities evaluated included construction and operations that likely would disturb areas containing known paleontological resources or areas with PFYC classifications of Class 3 and higher. The identification of impacts relied on GIS-based overlays with PFYC maps, emphasizing either co-occurrence or geographical proximity of potential disturbance to known or potential deposits. Other potential sources of impacts included the effects of erosion and increased accessibility to intact paleontological remains, such as potential impacts on ACECs designated for paleontological values that may be located near SEZs. Of particular concern were any impacts potentially affecting known deposits of vertebrate fossils.

Several disciplines provided data relevant to the evaluation of impacts on paleontological resources. Geology/soils analyses provided information on the distribution of geological strata, affording insights on areas with a high potential for paleontological resources previously not documented and on areas lacking PFYC classifications. The hydrological evaluation provided information on changing waterways and the potential for erosion that might threaten paleontological deposits. Information on land use and recreation and wilderness resources identified areas of concentrated activity that may require additional monitoring if access to areas of paleontological sensitivity is made available as a result of solar energy development.

M.17 CULTURAL RESOURCES

The methods used to evaluate impacts on cultural resources for the SEZs focused on assessing the potential disturbance to archaeological sites, historic structures, and traditional cultural properties. The assessment of impacts on cultural resources relied primarily on *National Register of Historic Places* (NRHP) eligibility status, either determined or potential, when data were available. However, the evaluation also considered the quality of the available data, condition of known cultural resources, and potential for significant resources to be present in unsurveyed areas. The ROI for cultural resource assessment for the SEZs included the SEZ areas, assumed access road and transmission ROWs, and any additional off-development areas affected, or likely to be affected, by construction and operation or maintenance. A 5-mi (8-km) radius outside of SEZ boundaries was included as part of the ROI to take into account possible erosion-related issues present in a desert environment, as well as potential new routes of access to previously remote areas. A 25-mi (40-km) radius outside of SEZ boundaries was also included to take into account possible viewshed concerns when historic properties (where visual setting is a contributing factor to their significance) are affected, including traditional cultural properties, historic structures, and trails.

The evaluation of impacts on cultural resources required specific information on those resources. Archaeological sites, traditional cultural properties, and historic structures within the ROI were identified and assessed by using site and survey location information provided by the State Historic Preservation Offices or the BLM field offices, consultation results with affected Native American Tribes and available ethnographic literature regarding traditional cultural properties, and properties listed on the NRHP. Archaeological survey reports were reviewed when available from the BLM, but typically data were limited to the GIS coverages, and the quality of attribute data varied greatly from state to state. Prehistoric and historic contexts were gleaned from the open literature. Other information used included ACEC descriptions for those ACECs near SEZs designated for their cultural value.

The assessment of potential impacts on cultural resources involved identifying those activities that would result in surface or subsurface disturbance within the ROI. Activities evaluated included construction and operations that likely would disturb areas containing known cultural resources. Impacts, in turn, were defined as the effect of identified activities on intact known cultural resources or areas with a high potential to contain significant cultural resources. The identification of impacts relied on GIS-based overlays, emphasizing either co-occurrence or geographical proximity of potential disturbance to known resources. In those portions of the ROI where the extent of cultural resources is not well known, the analysis identified areas with high potential for sites based on similar environmental characteristics with known resources in the region. Other potential sources of impacts included the effects of erosion and increased accessibility on intact cultural remains.

Several disciplines provided data relevant to the evaluation of impacts on cultural resources. Geology/soils studies provided information on soil types. Soil erosion was a major concern during the analysis, primarily because of the number of dry lakes and washes that could alter archaeological resources during water events. Hydrology studies provided information on changing waterways and the resulting erosion that would accompany such changes. Information on land use and recreation and wilderness resources identified areas of concentrated activity that may require additional monitoring if access to areas of cultural sensitivity is made available as a result of solar energy development.

The potentially applicable mitigation measures identified in Section 5.15.3 are intended to extend beyond regulatory requirements and BLM policy and were derived from the literature on best management practices, communications from the Tribes, and information in past NEPA documents. These documents were examined to determine what forms of mitigation had been considered acceptable in the past or were suggested as acceptable for the current study.

M.18 NATIVE AMERICAN CONCERNS

Methods used in the assessment of resources of concern to Native Americans focused on assessing the potential disturbance of resources of Tribal significance. These resources included, but were not limited to, sacred places and landscapes, cultural resources, plant and animal resources, water rights, water quality and use, air quality and noise, human health and safety, and economics. The ROI for Native American concerns for the SEZ impact assessments included the

SEZ areas, assumed access road and transmission ROWs, and any additional off-development areas affected, or likely to be affected, by construction and operation or maintenance. A 25-mi (40-km) radius outside of SEZ boundaries was included as part of the ROI to take into account possible viewshed concerns.

The affected Tribes were determined by the location of the SEZs, as compared to traditional use areas as described in standard ethnographic sources such as the *Handbook of North American Indians* (a multivolume work being issued a volume at a time) (Sturtevant 1978–2008), the National Park Service *Native American Consultation Database* (NPS 2010), and any available information in the records of the Indian Claims Commission and California's Native American Heritage Commission. BLM field offices also were consulted to determine which Tribes they consult with regularly for projects in their jurisdiction. Past NEPA documents for projects within or close to the SEZs were consulted to determine which Tribes had been contacted for past projects in the area.

Concerns were identified through responses from Tribes to communications from national, state, and local BLM offices regarding this PEIS. Details on government-to-government consultation efforts are presented in Section 14 and Appendix K. Locations of the SEZs were examined for general and specific Tribal concerns. Native American and Cultural Resources sections of previous NEPA documents and the ethnographic literature were likewise examined for general and specific local concerns, including traditional cultural properties. Particular attention was given to culturally important/sacred places, culturally important plant resources, animal resources, water resources, and mineral resources.

Several disciplines provided data relevant to the evaluation of impacts on resources of concern to Native Americans. The susceptibility of physical features and landscapes to adverse effects from construction and operation was determined in conjunction with parallel studies of noise, air quality, visual resources (viewsheds), geology, hydrology, and so on. For ecological resources, species important to Tribes were compared with the descriptions of plants and wildlife in the area of the SEZs to determine whether such species had been observed or were likely in those locations.

The potentially applicable mitigation measures identified in Section 5.16.3 were derived from communications with the Tribes, ethnographic studies, and past NEPA documents. Those documents were examined to determine what forms of mitigation had been acceptable in the past or were suggested as acceptable for the current study.

M.19 SOCIOECONOMICS

The analysis of the socioeconomic impacts of solar development in the six states consisted of two interdependent parts. Using existing solar project labor and expenditure data, the analysis of *economic impacts* estimated the impacts of construction and operation of solar facilities on employment and income and on state income and sales tax revenues. Impacts on recreation are also considered by measuring the impact of reductions in activity in various recreation-related sectors (see Section 4.17.10). Other methods and data that might have been used in the analysis are reviewed in this section.

Because of the relative economic importance of solar development in small rural economies, and the consequent incapacity of local labor markets to provide sufficient workers in the appropriate occupations required for construction and operation in sufficient numbers, solar development is likely to result in the influx of a temporary population. On the basis of these considerations, the analysis of *social impacts* assessed the potential impacts of solar development on population, housing, and local public service employment. Impacts on crime, alcoholism, illicit drug use, divorce rates, and mental illness also were considered. Since social disruption may occur with rapid population growth and the "boom and bust" economic development that could be associated with solar facilities, a review of the literature on social disruption is included in this section.

The analysis assessed the impacts of solar development in an ROI. At the state level, the ROI for solar development consists of each entire state, while the ROI for each SEZ consists of the counties and communities most likely to be affected by solar development. Selection of these ROIs was based on assessments of the area in which workers are expected to spend most of their salaries and in which a significant portion of site purchases and non-payroll expenditures from the construction and operation phases of the proposed solar facilities are expected to take place.

M.19.1 Economic and Fiscal Impacts

M.19.1.1 General Approach to Estimating Economic Impacts

The assessment of economic impacts used representative data from various solar development projects (Solar Partners I, LLC 2007; SES Solar Two, LLC 2008; Topaz Solar Farms, LLC 2008) and from the DOE's JEDI model (DOE 2010) to estimate the direct impacts of solar facilities. These data cover labor costs and employment for project construction and operation. Employment and income data from these studies used in the PEIS analysis are summarized in Table M.19-1. Additional data on spending patterns associated with labor, material, and equipment were taken from Schwer and Riddel (2004) and Stoddard et al. (2006). These data sources were used to calculate impacts on direct employment, income, and state tax revenue (sales and income). The IMPLAN economic impact modeling software was used to estimate the indirect impacts of solar project development in each ROI (MIG, Inc. 2010). Economic multipliers for 2007 for various energy, manufacturing, and service sectors and personal consumption expenditures provided by the IMPLAN model captured the indirect (off-site) effects of construction and operation of solar facilities.

TABLE M.19-1 Employment and Income Factors by Phase and Solar Technology

Phase and Technology	Direct Employment (FTEs[a] per MW)	Direct Income ($ million 2008 per MW)
Construction		
Parabolic Trough	3.34	241.4
Power Tower	2.40	173.0
Dish Engine	0.97	70.3
PV	0.45	32.8
Operations		
Parabolic Trough	0.24	7.6
Power Tower	0.23	7.1
Dish Engine	0.22	6.9
PV	0.02	0.7

[a] FTE = full-time equivalent.

Sources: Solar Partners I, LLC (2007); SES Solar Two, LLC (2008); Topaz Solar Farms, LLC (2008); DOE (2009).

M.19.1.2 Comparison between the IMPLAN Input-Output Model and Other Available Regional Economic Models

Simple Input-Output Models. Input-output models, such as IMPLAN, are a widely used means of estimating the overall regional impact (direct plus indirect plus induced) of new energy development facilities and projects. Regional input-output models are based on national input-output accounts and include information for 528 separate industries based on the North American Industrial Classification System used by the U.S. Department of Commerce Bureau of Economic Analysis (BEA). These accounts show the flow of commodities between industries and institutional consumers. Industries represented are agriculture; mining; construction; manufacturing; wholesale and retail trade; utilities; finance, insurance and real estate; and consumer and business services. Each industry is described in terms of its purchases from and sales to all other industries in the local economy.

The accounts also provide information on value added by each industry and sales by each industry to final demand. Value added has four main components: employee compensation (wages and salary payments, benefits, life insurance, retirement, and so on), proprietary income (payments received by self-employed individuals as income), other property-type income (payments received from royalties and dividends), and indirect business taxes (primarily excise and sales taxes paid by individuals to businesses). Final demands include personal consumption expenditures (payments by individuals/households to industries for goods and services used for personal consumption); federal government purchases (military and nonmilitary) and sales; state and local government purchases (public education and noneducation) and sales; inventory purchases (unsold annual output) and sales (where inventory reduction exceeds additions from production); capital formation (expenditures made to obtain capital equipment); and exports outside the region and nation.

Basic input-output data were used to produce estimates of the economic impacts of changes in final demand by making a series of assumptions about economic behavior, as follows:

- *No supply constraints*. Supplies to each sector are available in unlimited quantities, with no production bottlenecks, transportation constraints, and the like.

- *Constant returns to scale*. Sector inputs vary in constant proportion to sector outputs, implying that the technology used to produce outputs in each sector does not change as demand for sector output changes.

- *Fixed commodity input structure*. Input price changes do not lead to changes in inputs used to produce the output of any given industry. Changes in the economy affect only industry output in any given industry, not production structure in any individual industry.

- *Homogenous sector output*. Many industries produce multiple products. Input-output models assume that changes in industry output do not change the proportion of each product produced in any given industry.

Given these assumptions, a series of matrix manipulations were used to produce multipliers for each sector in the ROI economy under consideration and for the ROI economy as a whole. These multipliers typically give the total (direct plus indirect plus induced) benefits to the ROI in terms of employment, output, and income.

Two input-output models are available that can be readily calibrated to county-level input-output accounts. The RIMS II system produced by the BEA (BEA 2010) provides sets of multipliers for each sector in the national input-output table. The RIMS II system can be used to produce multipliers for any county or multicounty region in the United States to provide estimates of the indirect impacts of changes in final demand at the chosen level of sector and geographic interest. The IMPLAN model produced by MIG, Inc. (2009) provides county-level input-output models, which are used to estimate multipliers and can be used for more detailed analysis of the impacts of changes in final demand. Although both models can be readily applied to the estimation of the impacts of construction and operation of solar facilities, the IMPLAN model provides input-output baseline data for each ROI, in addition to sector multipliers also provided in the RIMS II modeling system.

Input-Output/Econometric Models. Combining input-output data with other economic and demographic data in a more complex modeling framework can provide estimates of a wider range of economic and demographic impacts of solar facility construction and operation. ROI baseline forecasts can also be provided. Although more complex modeling systems often use econometric techniques, these systems have a major advantage over simple econometric models in that they use the theoretical structural restrictions implied in the input-output accounts instead of econometric estimates based on single time-series observations for single regions. The combination of input-output and econometric techniques in a model allows the use of a range of policy options and the tracking of their effects on a range of variables in the model throughout each forecast period.

An example of a complex input-output based economic modeling system widely used in regional analyses is the REMI model (REMI 2010). At its core the model has an input-output structure representing inter-industry linkages and linkages to final demands for 53 individual industry groupings. In addition to the basic input-output structure, the model includes substitution between factors of production in response to changes in relative factor costs, migration in response to changes in expected income, wage responses to changes in labor market conditions, and changes in the share of local and export markets in response to changes in regional profitability and production costs. REMI models can be set up for any county or multicounty region in the United States.

Computable General Equilibrium (CGE) Models. Although input-output models have been widely used in the analysis of energy development facilities and projects, the framework assumes that responses to increases in output are linear and rigid. As a result, forms of economic adjustment behavior, such as input substitution or capacity restrictions in industries and labor markets, are not easily incorporated into the modeling framework. CGE models provide an alternative to input-output models insofar as they can incorporate producer and consumer responses to price signals, and nonlinear production functions allow the inclusion of input substitution and conservation measures. The framework includes price-responsive product and factor demand and supplies, predicated on the assumption of equilibrium in all product and factor markets. Models assume either perfect foresight market clearing over time or temporary market clearing if expectations are imperfect. Many models assume that the system does not clear product and factor markets continuously, with responses over time determined in the model through a combination of a given model structure with econometrically estimated parameters. As part of their underlying model structure, CGE models can incorporate sector production functions with differing characteristics. These functions may incorporate constant elasticity of substitution (CES), Cobb-Douglas (multiplicative), in addition to the Leontief (linear) production functions used in the basic input-output formulation. CES functions are useful for analyzing capacity restrictions, because they allow a range of substitution elasticities for different pairs of inputs.

M.19.1.3 Choice of Modeling Framework for Estimating the Economic Impacts of Solar Facility Development

The IMPLAN model was chosen as the modeling tool for analyzing economic impacts of solar development in this PEIS. The application of simple input-output models, calibrated to multicounty ROIs, represents an appropriate level of sophistication in the estimation of impacts of the construction and operation of solar facilities. Although local industry and labor market capacity restrictions may be relevant in the short term in some of the ROIs used in the analysis, assumptions made in this PEIS regarding the importation of materials and equipment and the in-migration of construction and operations labor circumvent the limiting assumption that there are no supply constraints in the economy being analyzed. The IMPLAN model was preferred to the RIMS II model, because the former provides input-output baseline data for each ROI, in addition to sector multipliers provided in the RIMS II modeling system. The REMI model was not selected because of its high initial cost and the availability of forecasts of ROI economic variables used in this PEIS from other sources. CGE models are applicable to scenarios in which impacts would be large, in which there may be sector capacity restrictions, and in an economy would require time to adjust to a new equilibrium. However, impacts of solar development are not likely to be large in any of the ROIs being analyzed, with peak construction employment of less than 5% of projected baseline employment in most cases. Additionally, data and considerations germane to the CGE framework mean that these models are usually customized by researchers for specific policy issues and are not widely available. Given the nature of the impacts expected from solar development, the greater degree of accuracy in measuring impacts provided by a CGE modeling framework would therefore not offset the resource cost and time required to calibrate models in sufficient sector and geographic detail for use in this PEIS.

M.19.1.4 Fiscal Impacts

State income tax revenue impacts were estimated by applying state income tax rates to projected income generated by construction and operations that employees spent within the ROI. State and local sales tax revenues were estimated by applying appropriate state and local sales tax rates to materials, equipment, and supplies that would be purchased for each solar technology within each ROI.

Although Nevada currently has no state income tax, the ROIs for three SEZs in Nevada (Dry Lake Valley North, Delamar Valley, and East Mormon Mountain) include counties in Utah, where state income taxes would be collected from solar construction and operations workers residing in the state. To estimate state tax revenues collected in Utah, a gravity model was used to assign in-migrating solar workers and their families to individual ROI communities. Gravity models mathematically estimate the interaction between pairs of points (the number of construction and operations workers and family members associated with each solar technology, nominally located at each SEZ centroid, and the population of each community in a state ROI) weighted by the linear distance between each pair of points. With a projected residential distribution estimated by using this method, state income tax rates for Utah were used to estimate income tax revenues based on the projected incomes of solar construction and operations workers who would reside in Utah.

M.19.1.5 Economic Valuation of Land Used for Recreation

A simple way to quantify the value of recreation on public land would be to measure revenue generated by user fees and other charges for public use. However, visitation statistics are often incomplete, and, in many cases, federal and state agencies do not charge visitors a fee for entrance to recreational resources on public lands; where fees are charged, they may be nominal compared with the value of the visit to recreational users. Recreation undertaken using privately owned facilities, such as golf courses, horse ranches, or fishing on private waters, has a quantifiable market value, with the user paying rates for visiting these facilities, which reflect the value of the resource to its owners and the cost of providing access to it to visitors. With the majority of recreation in the immediate vicinity of proposed solar projects likely to occur on public lands, however, the economic value of these resources is more difficult to quantify, since no valuation of the use of these resources can be made through the marketplace.

A number of methods have been used to determine the use value of nonmarketed recreational goods, or the value of recreational resources on public lands that may be for used for recreation. Because resources on public lands are scarce and recreational activities provide enjoyment and satisfaction, the amount visitors would pay over the actual cost of using these resources represents the value of the benefit of these resources to the public. One method of estimating the net willingness to pay, or consumer surplus, associated with resources on public lands used for recreation is the travel cost method. This method uses variation in the cost of traveling different distances, and the number of trips taken over each distance, as a way to represent the demand for recreational resources in any given location (Loomis and Walsh 1997).

In addition to use values, a certain portion of the value of resources used for recreation may lie in the passive use of a resource, or the extent of the availability of the resource to current and future generations. Attempts to establish passive use values or the willingness to pay for or accept compensation for the loss of different levels of nonmarketed recreational resources on public lands have used contingent valuation methods, which rely on telephone interviews or questionnaire surveys. Typically, a description of a particular resource is presented to respondents, who are then asked to place a dollar value on their use of the resource or on the preservation of the resource (Loomis 2000). Although the travel cost and contingent valuation methods have weaknesses, particularly with regard to the accuracy of questions asked and respondents' self-reporting errors, both have been used widely by government agencies and academics in cost-benefit analyses of outdoor recreation. The Bureau of Reclamation (BOR), for example, used contingent valuation to place a value on the impact of hydropower activities in Utah and Colorado on fishing and rafting (BOR 1995). The method was used in establishing the value of natural resources damaged by oil spills in Alaska (Carson et al. 2003; DOI 1994), and various state agencies have used travel cost and contingent valuation methods for valuing wildlife-related recreation (Loomis 2000). Contingent valuation methods have also been used to value natural resource amenities, such as improvements in visibility in the Grand Canyon (Schulze and Brookshire 1983) and the value of protecting endangered species (Boyle and Bishop 1987) and wilderness areas (Koontz and Loomis 2005).

Loomis (2000) reports the results of various studies that used survey data and travel cost and contingent valuation methods to estimate the value of recreation in wilderness areas in Colorado and Wyoming. On the basis of data reported in these studies, the average value per day of visiting a wilderness area for recreation was estimated to be $26 (1996 dollars); that is, a visitor would be willing to pay this amount more than trip travel cost rather than lose a day visiting an area for recreation. Multiplying this number by the number of visitors to a specific wilderness resource would give the value of the resource to the public (Loomis 2000).

Contingent valuation also has been used to establish willingness to pay to preserve existing wilderness areas and additional acreage that might be designated as wilderness. On the basis of two surveys of Colorado and Utah residents, Walsh et al. (1984) and Pope and Jones (1990) found that passive use values varied with the level of wilderness already designated in a state, but at a decreasing rate. Passive use value also was found to represent about half of the economic value of a resource, equaling the use value of the resource to the household as a place for recreation. The same surveys found that residents in Colorado and Utah, and in the rest of the United States, would pay from $220 per additional acre if 5−10 million acres of wilderness resources were to be preserved in the two states to $1,246 per acre if only 1.2 million additional acres were preserved. Passive use values in the western United States were estimated to be $168 per acre, or about $7.2 billion when applied to all wilderness land in the West. Barrick (1986) estimated the value of the wilderness resources in the Washakie Basin, Wyoming, for future visits (option values) at $69 (1996 dollars) for on-site users and $15 and $13 for urban and rural, nonvisiting U.S. residents.

M.19.2 Social Impacts

M.19.2.1 Population

An important consideration in the assessment of impacts of solar development is the number of workers and their families (including children) that would migrate into the ROI, either temporarily or permanently, with the construction and operation of solar facilities. The capacity of regional labor markets to provide sufficient numbers of workers in the occupations required for solar development construction and operation is generally related to the occupational profile of the ROI and occupational unemployment rates. In the context of these considerations, the PEIS analysis assumed that the number of in-migrating solar facility workers would be related to population size in each SEZ. SEZs were placed into three population-size groups: less than 125,000 people, 125,000 to 750,000 people, and more than 750,000 people, with the percentage of in-migrants in each SEZ assumed for various labor categories—construction workers and managerial/supervisory workers for construction, and field, administrative, and managerial workers for operations. Based on other analyses of energy project labor in-migration (Fahys-Smith 1983), it was assumed that 28% of the workers in-migrating into each ROI would bring their family members with them. The national average household size (2.6 people) was used to calculate the number of additional family members accompanying direct in-migrating workers.

Impacts on population are described in terms of the total number of in-migrants arriving in the region in the peak year of construction. The relative impact of the increase in population in the ROI was calculated by comparing total solar development construction in-migration over the period in which construction is projected with baseline ROI population forecasts over the same period. Forecasts were based on data provided by individual state demography agencies.

M.19.2.2 Housing

The in-migration of workers during construction and operation associated with solar facility development could affect the housing market in each ROI. The analysis considered these impacts by estimating the increase in demand for vacant housing units in the peak year of construction and in the first year of operation that would result from the in-migration of direct solar facility workers into each ROI. The relative impact on existing housing in the ROI was estimated by calculating the impact of solar–related housing demand on the forecasted number of vacant housing units in the peak year of construction and in the first year of operation.

M.19.2.3 Public Services

Population in-migration associated with construction and operation of solar facilities would translate into increased demand for educational services and for public services (police and fire protection, health services, etc.) in each ROI. The impacts of in-migration associated with solar facilities on county, city, and school district employment were estimated on the basis of publicly available data. Impacts on public service employment were calculated by using the existing levels of service (the number of employees required to provide each community service per 1,000 people) to estimate the number of new police officers and firefighters required in the peak year of construction and in the first year of operations. Similarly, the number of teachers in each school district required to maintain existing teacher-student ratios across all student age groups was estimated. Impacts on health care employment were estimated by calculating the number of physicians in each county required to maintain the existing level of service, based on the existing number of physicians per 1,000 people.

M.19.2.4 Energy Development and the Potential for Social Change in Small Rural Communities

The relative economic importance of solar facilities in smaller rural communities is likely to create an influx of temporary population both during construction and at the start of the operation phases of each project. Because population increases are likely to be rapid, in the absence of adequate planning measures local communities may be unable to cope quickly with the large number of new residents; social disruption and changes in social organization are likely to occur. Community disruption can also lead to increases in social distress, in particular, increases in drug use, alcoholism, divorce, juvenile delinquency, and deterioration in mental health and perceived quality of life. Changes in cultural values may also occur as the resident population is exposed to, and may be required to at least partially adapt to, the cultural values of the in-migrant population.

Social problems associated with rapid population growth related to energy development and power generation projects in small rural communities were first studied extensively in the 1970s and 1980s. Gilmore and Duff (1975) and Gilmore (1976), for example, found that rapid growth led to higher divorce and school dropout rates, suicide attempts, social alienation and isolation, juvenile delinquency, and crime, while Gold (1982) found that resource developments led to a weakening of social ties in the local community. Other studies suggested that boomtown growth was responsible for deterioration in the mental health of existing long-term residents and of in-migrants (Lantz and McKeown 1977; Dixon 1978; Weisz 1979; Freudenburg et al. 1982). Increases in crime, violence, and deviance were reported by Lantz and McKeown (1977), Little (1977), and Dixon (1978). Changes in the level of community integration were also studied (Little 1977; Jirovec 1979; Boulding 1981), as were changes in community satisfaction (Murdock and Schriner 1979). On the basis of the ideas of Ferdinand Toennies on the transition of small rural communities through industrialization and urbanization (Toennies 1887), it was often suggested that these changes occurred as a result of the breakdown of established informal social structures in small rural communities and the inadequacy of new, formal social institutions to provide social integration and social control (Cortese and Jones 1977; Little 1977; Cortese 1982).

The relationship between rapid energy boomtown growth and social disruption came under closer scrutiny in the early 1980s. It was suggested that many of the earlier studies relied on poorly documented or unreliable data and assertions on the nature and extent of boomtown social problems, preferring to accept the presence of social disruption largely in the absence of reliable evidence (Wilkinson et al. 1982). Problems with research design in many of the earlier studies also were highlighted, in particular, the tendency to base research findings on data collected in single communities rather than in numerous communities affected by energy developments (Krannich and Greider 1984), and the use of cross-sectional rather than longitudinal data to chart community social change over time (Brown et al. 1989).

Subsequent work replaced the widespread sense of “alarmed discovery” prevalent in earlier research by more cautious and systematic approaches to the analysis of social change (Smith et al. 2001). Much of the focus shifted to the study of multiple communities in order to separate and understand social change affecting boomtowns and change affecting communities outside energy development regions (England and Albrecht 1984; Freudenburg 1984; Krannich and Greider 1984; Greider and Krannich 1985; Brown et al. 1989; Berry et al. 1990).

Numerous studies have found that rapid growth led to certain forms of social disruption. Brown et al. (1989) found that boomtown growth led to community dissatisfaction, while England and Albrecht (1984) and Greider and Krannich (1985) found evidence of dissatisfaction with community facilities and services. Freudenburg (1986) and Brown et al. (1989) found higher fear of crime in boomtown communities than elsewhere. Brown et al. (1989) also found a reduction in local friendship ties and increases in residential transiency. Greider et al. (1991) found increased isolation, while Greider and Krannich (1985) found a decline in social support among residents of boomtown communities compared with more stable communities. The conclusions of these studies are quite different from those of earlier work on boomtowns, and indicate that periods of rapid population growth are not necessarily associated with social disruption and change in small rural communities.

In addition to studies of impacts across multiple communities, various longitudinal studies of social change also were made. Data collected in communities experiencing rapid growth indicate that divorce and crime rates did not increase significantly (Brookshire and D’Arge 1980; Wilkinson 1983; Wilkinson et al. 1984), although there were increases in delinquency during boom years (Wilkinson and Camasso 1984). Freudenburg and Jones (1991) showed increases in victimization rates in some communities, although Krannich et al. (1989) found no increases in victimization during boom years in several energy communities.

While it is clear that some level of social disruption seems to have occurred during boom years, underlying social structures may not have fundamentally changed. England and Albrecht (1984), for example, found no evidence of the replacement of informal social ties common in rural areas with formal associations found in urban areas. Informal and external ties may actually strengthen with length of residence, and boomtown development may facilitate rather than diminish informal social ties. England and Albrecht (1984) found no dramatic shift in community perceptions during years of population growth, and Seyfrit and Sadler-Hammer (1988) found only a limited connection between rapid growth and changing youth attitudes toward community and family. Berry et al. (1990) suggested that interactions among neighbors during rapid growth periods are relatively stable, while Greider et al. (1991) reported no large increases in the level of distrust among neighbors. Greider and Krannich (1995) found that increasing heterogeneity accompanying rapid population growth does not significantly decrease neighboring interaction. Residents of rapidly growing communities may experience expanded opportunities for obtaining social support beyond their local neighborhood, while at the same time maintaining adequate relations with their neighbors.

Rapid population growth seems to have had differential effects across social groups. Freudenberg (1984) found no differences in attitudes among adults in boomtowns and in neighboring communities, but noted higher levels of dissatisfaction and alienation among boomtown adolescents. Krannich and Greider (1984) noted deterioration in perceived social integration among temporary mobile home residents in boomtown communities.

Studies of the long-term effects on community attitudes and perceptions show varying levels of community social disruption during the different phases of energy development, including the boom, decline, and post-boom recovery periods. The disruptive effects associated with boom growth may not have been permanent in some communities, dissipating in the years after the boom phase ended (Smith et al. 2001), while community satisfaction often has rebounded after declining during boom growth periods, producing an improvement in the sense of community well-being at the end of the boom period (Brown et al. 2005). The decline in the sense of community identity and solidarity during periods of instability caused by rapid population growth rebounded fairly quickly with the return to more stable growth (Greider et al. 1991).

Although construction and operation of solar facilities is unlikely to lead to a "boom and bust" development scenario in most of the ROIs because of the relatively minor population increases associated with in-migration, some social disruption and resulting community adjustment may occur in small, relatively self-contained communities. These surges in population size may have a number of components (Figure M.19-1). An initial stimulus provides new jobs that bring growth in population size and change the demographic composition of the community. Social change resulting from the need to accommodate new residents changes the perceived quality of life and leads to changes in social relations. Social problems, such as divorce, substance abuse, and crime, can occur. Social problems may be mitigated by community

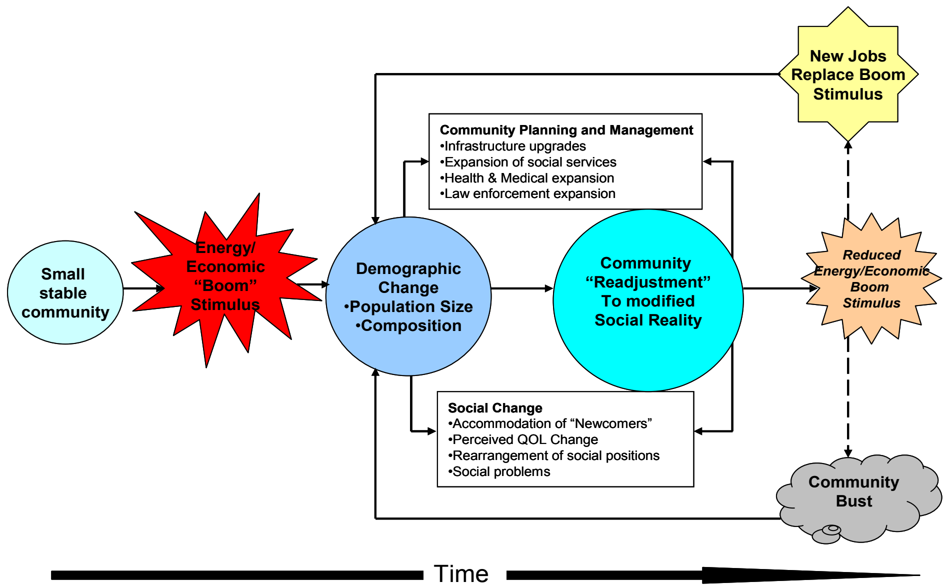

FIGURE M.19-1 The Cycle of Social Adjustment to "Boom" and "Bust"

planning and management of growth, allowing the community to more easily adjust to new residents. After some period of time, employment associated with the initial economic stimulus may decrease, whereby the community may replace the jobs afforded by the initial stimulus, or employment is reduced in size, with the cycle of adjustment mitigated to a greater or lesser degree by community planning efforts.

M.20 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.

Anderson, G.S., and U.J. Kurze, 1992, "Outdoor Sound Propagation," in *Noise and Vibration Control Engineering: Principles and Applications*, L.L. Beranek and I.L. Vér (editors), John Wiley & Sons, Inc., New York, N.Y.

AZGFD (Arizona Game and Fish Department), 2010a, *Plant and Animal Abstracts, Distribution Maps, & Illustrations*. Available at http://www.azgfd.gov/w_c/edits/hdms_abstracts.shtml. Accessed June 16, 2010.

AZGFD, 2010b, *Arizona's Natural Heritage Program: Heritage Data Management System* (HDMS). Available at http://www.azgfd.gov/w_c/edits/species_concern.shtml. Accessed March 16, 2010.

Barrick, K.,1986, *Option Value in Relation to Distance Effects and Selected User Characteristics for the Washakie Wilderness, Northeast Wyoming,* National Wilderness Research Conference, U.S. Forest Service, Intermountain Research Station, Ogden, Utah.

BEA (Bureau of Economic Analysis), 2010, *Regional Input-Output Modeling System (RIMS II)*. U.S. Department of Commerce. Available at http://www.bea.gov/regional/rims./

Beacon Solar, LLC, 2008, "Application for Certification for the Beacon Solar Energy Project," submitted to the California Energy Commission, March. Available at http://www.energy.ca.gov/sitingcases/beacon/index.html.

Beranek, L.L., 1988, *Noise and Vibration Control*, rev. ed., Institute of Noise Control Engineering, Washington, D.C.

Berry, E.H., et al., 1990, "A Longitudinal Analysis of Neighboring in Rapidly Changing Rural Places," *Journal of Rural Studies* 6:175−186.

BLM (Bureau of Land Management), 1992, *Introduction, Transplant, Augmentation, and Reestablishment of Fish, Wildlife, and Plants*, BLM Manual 1745, U.S. Department of the Interior.

BLM, 2007a, *Burned Area Emergency Stabilization and Rehabilitation*, BLM Handbook H-1742-1, U.S. Department of the Interior.

BLM, 2007b, *Vegetation Treatments Using Herbicides on Bureau of Land Management Lands in 17 Western States, Final Programmatic Environmental Impact Statement*, U.S. Department of the Interior, Washington, D.C.

BLM, 2008a, *Proposed Oil Shale and Tar Sands Resource Management Plan Amendments to Address Land Use Allocations in Colorado, Utah, and Wyoming and Final Programmatic Environmental Impact Statement,* FES 08-32, Sept. 2008.

BLM, 2008b, *Renewable Resource Improvements and Treatments*, BLM Manual 1740, U.S. Department of the Interior.

BLM, 2008c, *Integrated Vegetation Management Handbook*, BLM Handbook H-1740-2, U.S. Department of the Interior.

BLM, 2010a, *Wild Horse and Burro Statistics and Maps*, Washington, D.C. Available at http://www.blm.gov/wo/st/en/prog/wild_horse_and_burro/wh_b_information_center/statistics_and_maps.html. Accessed June 25, 2010.

BLM, 2010b, *Land & Mineral Legacy Rehost 2000 System–LR2000*. Available at http://www.blm.gov/lr2000/.

BLM and USFS (U.S. Forest Service), 2010, *GeoCommunicator, Solar Energy Map*. Available at http://www.geocommunicator.gov/GeoComm/index.shtm.

BOR (U.S. Bureau of Reclamation), 1995, *Operation of Glen Canyon Dam: Colorado River Storage Project: Final Environmental Statement*, March. Available at http://www.usbr.gov/uc/library/envdocs/eis/gc/pdfs/Cov-con/cov-con.pdf.

Boulding, E., 1981, "Women as Integrators and Stabilizers," pp. 119−149 in *Women and the Social Cost of Energy Development: Two Colorado Case Studies,* E. Moen et al. (editors), Westview Press, Boulder, Colo.

Boyle, K. J., and R.C. Bishop, 1987, "Valuing Wildlife in Benefit-Cost Analyses: A Case Study Involving Endangered Species," *Water Resources Research* 23:943–950.

Brookshire, D.S., and R.C. D'Arge, 1980, "Adjustment Issues of Impacted Communities or, Are Boomtowns Bad?" *Natural Resources Journal* 20:523−546.

Brown, R.B., et al., 1989, "Community Satisfaction and Social Integration in a Boomtown: A Longitudinal Analysis," *Rural Sociology* 54:568−586.

Brown, R.B., et al., 2005, "The Boom-Bust-Recovery Cycle: Dynamics of Change in Community Satisfaction and Social Integration in Delta, Utah," *Rural Sociology* 70:28–49.

Bryce, S.A., et al., 2003, *Ecoregions of Nevada*, (color poster with map, descriptive text, summary tables, and photographs), U.S. Geological Survey, Reston, Va.

Carson, R.T., et al., 2003, "Contingent Valuation and Lost Passive Use: Damages from the Exxon Valdez Oil Spill," *Environmental and Resource Economics* 25:257-286.

CASLC (California State Land Commission), 2006, *North Baja Pipeline Expansion Project, Appendix L, Dust Control Plan*. Available at http://www.slc.ca.gov/Division_Pages/DEPM/DEPM_Programs_and_Reports/North_Baja_Pipeline_Expansion_Project/Final_EIR/Documents/Word/Appendix%20L%20Dust%20Control%20Plan.doc. Accessed Sept. 2009.

CDFG (California Department of Fish and Game), 2010a, *California Wildlife Habitat Relationships System, Life History Accounts and Range Maps.* Available at http://www.dfg.ca.gov/biogeodata/cwhr/cawildlife.aspx. Accessed June 15, 2010.

CDFG, 2010b, *California Natural Diversity Database (CNDDB)*. Available at http://www.dfg.ca.gov/biogeodata/cnddb/. Accessed March 4, 2010.

CDOW (Colorado Division of Wildlife), 2009, *Natural Diversity Information Source, Wildlife Species Page,* Denver, Colo. Available at http://ndis.nrel.colostate.edu/wildlife.asp. Accessed Aug. 29, 2009.

CEC (California Energy Commission), 2009a, *Final Staff Assessment, Beacon Solar Energy Project Application for Certification,* Aug. Available at http://www.energy.ca.gov/sitingcases/beacon/documents/index.html. Accessed Nov. 20, 2009.

CEC, 2009b, *Final Staff Assessment and Draft Environmental Impacts Statement and Draft California Desert Conservation Area Plan Amendment, Ivanpah Solar Electric Generating System Application for Certification,* Oct. Available at http://www.energy.ca.gov/2008publications/CEC-700-2008-013/FSA/. Accessed Nov. 20, 2009.

CEC and BLM, 2009, *Staff Assessment and Draft Environmental Impact Statement and Draft California Desert Conservation Area Plan Amendment, SES Solar Two Project Application for Certification*. Feb. Available at http://www.energy.ca.gov/2010publications/CEC-700-2010-002/CEC-700-2010-002-SA-DEIS.PDF. Accessed June 30, 2010.

CGS (California Geologic Survey), 2010, *Alquist-Priolo Earthquake Fault Zones.* Available at http://www.conservation.ca.gov/cgs/rghm/ap/Pages/Index.aspx. Accessed July 11, 2010.

Chapman, S.S., et al., 2006, *Ecoregions of Colorado* (color poster with map, descriptive text, summary tables, and photographs; map scale 1:1,200,000), U.S. Geological Survey, Reston, Va.

CNHP (Colorado Natural Heritage Program), 2009, *Summary of Services*. Available at http://www.cnhp.colostate.edu/. Accessed Sept. 9, 2009.

CNPS (California Native Plant Society), 2010, Home Page. Available at http://www.cnps.org/. Accessed June 15, 2010.

Colorado Rare Plant Technical Committee, 2010, *Colorado Rare Plant Field Guide*. Available at http://www.cnhp.colostate.edu/download/projects/rareplants/cover.html. Accessed June 15, 2010.

Cortese, C.F., 1982, "The Impacts of Rapid Growth on Local Organizations and Community Services," pp. 115−136 in *Coping with Rapid Growth in Rural Communities,* B. Weber and R. Howell (editors), Westview Press, Boulder, Colo.

Cortese, C.F., and B. Jones, 1977, "The Sociological Analysis of Boom Towns," *Western Sociological Review* 8:76–90.

Cowherd, C., et al., 1988, *Control of Open Fugitive Dust Sources*, EPA 450/3-88-008, U.S. Environmental Protection Agency, Research Triangle, N.C.

Davis, F.W., et al., 1998, *The California Gap Analysis Project—Final Report,* University of California, Santa Barbara, Calif. Available at [http://www.biogeog.ucsb.edu/projects/gap/gap_rep.html. Accessed July 13, 2010.

Desert Tortoise Council, 1994 (Revised 1999), *Guidelines for Handling Desert Tortoises during Construction Projects*, Edward L. LaRue, Jr. (editor), Wrightwood, Calif.

Dixon, M., 1978, *What Happened to Fairbanks? The Effects of the Trans-Alaska Oil Pipeline in the Community of Fairbanks, Alaska*, Westview Press, Boulder, Colo.

DOE (U.S. Department of Energy), 2009, *Report to Congress, Concentrating Solar Power Commercial Application Study: Reducing Water Consumption of Concentrating Solar Power Electricity Generation*, Jan. 13.

DOE, 2010, *Jobs and Economic Development Impacts (JEDI) Model*, Wind & Water Program, last updated March 23, 2010. Available at http://www.windpoweringamerica.gov/filter_detail.asp?itemid=707. Accessed July 7, 2010.

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

DOI (U.S. Department of Interior), 1994, "Natural Resource Damage Assessments: Final Rule," *Federal Register* 59:14261–14288, Washington D.C.

Eldred, K.M., 1982, "Standards and Criteria for Noise Control—An Overview," *Noise Control Engineering* 18(1):16–23.

England, J.L., and S.L. Albrecht, 1984, "Boomtowns and Social Disruption," *Rural Sociology* 49:230–246.

EPA (U.S. Environmental Protection Agency), 1974, *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*, EPA-550/9-74-004, Washington, D.C., March. Available at http://www.nonoise.org/library/levels74/levels74.htm. Accessed Nov. 17, 2008.

EPA, 2007, *Level III Ecoregions*, Western Ecology Division, Corvalis, Ore. Available at http://www.epa.gov/wed/pages/ecoregions/level_iii.htm. Accessed Oct. 2, 2008.

EPA, 2009a, *eGRID*. Available at http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html, last updated Oct. 16, 2008. Accessed Jan. 12, 2009.

EPA, 2009b, "Preferred/Recommended Models – AERMOD Modeling System." Available at http://www.epa.gov/scram001/dispersion_prefrec.htm. Accessed Nov. 8, 2009.

EPA, 2010, *AirData: Access to Air Pollution Data*. Available at http://www.epa.gov/oar/data/.

Fahys-Smith, V., 1983, "Migration of Boom-town Construction Workers: The Development of an Analytic Framework," *Environmental Geochemistry and Health* 5:104-112.

Freudenburg, W.R., 1984, "Boomtown's Youth: The Differential Impacts of Rapid Community Growth on Adolescents and Adults," *American Sociological Review* 49:697–705.

Freudenburg, W.R., 1986, "The Density of Acquaintanceship: An Overlooked Variable in Community Research?" *American Journal of Sociology* 92:27−63.

Freudenburg, W.R., and R.E. Jones, 1991, "Criminal Behavior and Rapid Community Growth: Examining the Evidence," *Rural Sociology* 56:619−645.

Freudenburg, W.R., et al., 1982, "Mental Health Consequences of Rapid Growth: A Report from the Longitudinal Study of Boom Town Mental Health Impacts," *Journal of Health and Human Resources Administration* 4:334−352.

Gilmore, J.S., 1976, "Boom Towns May Hinder Energy Resource Development," *Science* 191:535−540.

Gilmore, J.S., and M.K. Duff, 1975, *Boomtown Growth Management,* Westview Press, Boulder, Colo.

Gold, R.L., 1982, "Commentary on Local Social Disruption and Western Energy-Development: A Critical Review by Wilkinson, K.P. et al.," *Pacific Sociological Review* 25:349−356.

Greider, T., and R.S. Krannich, 1985, "Neighboring Patterns, Social Support and Rapid Growth: A Comparison Analysis from Three Western Communities," *Sociological Perspectives* 28:51−70.

Greider, T., et al., 1991, "Local Identity, Solidarity, and Trust in Changing Rural Communities," *Sociological Focus* 24:263−282.

Griffith, G.E., et al., 2006, *Ecoregions of New Mexico* (color poster with map, descriptive text, summary tables, and photographs; map scale 1:1,400,000), U.S. Geological Survey, Reston, Va.

Hanson, C.E., et al., 2006, *Transit Noise and Vibration Impact Assessment*, FTA-VA-90-1003-06, prepared by Harris Miller Miller & Hanson Inc., Burlington, Mass., for U.S. Department of Transportation, Federal Transit Administration, Washington, D.C., May. Available at http://www.fta.dot.gov/documents/FTA_Noise_and_Vibration_Manual.pdf.

Jirovec, R., 1979, "Preparing a Boom Town for the Impact of Rapid Growth," pp. 79−90 in *BoomTowns and Human Services,* J. Davenport and J. Davenport (editors), University of Wyoming Press, Laramie, Wyo.

Koontz, L., and J. Loomis, 2005, *Economic Importance of Elk Hunting in Jackson Hole, Wyoming*, U.S. Geological Survey Open-File Report 2005-1183.

Krannich, R.S., and T. Greider, 1984, "Personal Well-Being in Rapid Growth and Stable Communities: Multiple Indicators and Contrasting Results," *Rural Sociology* 49:541−552.

Krannich, R., et al., 1989, "Fear of Crime in Rapidly Changing Communities: A Longitudinal Analysis," *Rural Sociology* 54:195–212.

Lantz, A., and R. McKeown, 1977, *Rapid Growth and the Impact on Quality of Life in Rural Communities: A Case Study,* Denver Research Institute, University of Denver, Denver, Colo.

Little, R.I., 1977, "Some Social Consequences of Boom Towns," *North Dakota Law Review* 53:401–425.

Loomis, J., 2000, *Economic Values of Wilderness Recreation and Passive Use: What We Think We Know at the Beginning of the 21st Century*, U.S. Forest Service Proceedings, RMRS-P-15_Vol-2. 2000. Available at http://www.fs.fed.us/rm/pubs/rmrs_p015_2/ rmrs_p015_2_005_013.pdf

Loomis, J., and R. Walsh, 1997, *Recreation Economic Decisions: Comparing Benefits and Costs*, Venture Press, State College, Pa.

Ludington, S. et al., 2007, *Preliminary Integrated Geologic Map Databases for the United States – Western States: California, Nevada, Arizona, Washington, Oregon, Idaho, and Utah*, U.S. Geological Survey Open File Report 2005-1305, Version 1.3, original file updated in December 2007. Available at: http://pubs.usgs.gov/of/2005/1305/index.htm.

MIG (Minnesota IMPLAN Group, Inc.), 2010, *IMPLAN Version 3 Software System*, Hudson, Wisc. Available at http://implan.com/v3/index.php?option=com_kb&task=article&article= 07&Itemid=166. Accessed July 13, 2010.

MRI (Midwest Research Institute), 1996, *Improvement of Specific Emission Factors (BACM Project No. 1)*, Final Report, Kansas City, Mo., prepared for the South Coast Air Quality Management District, Diamond Bar, Calif., March 29.

MRI, 2006, *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors*, Kansas City, Mo., prepared for the Western Governors' Association, Western Regional Air Partnership, Denver, Colo., Nov. 1. Available at http://www.epa.gov/ttn/chief/ap42/ch13/bgdocs/b13s02.pdf. Accessed Aug. 30, 2009.

Murdock, S.H., and E.C. Schriner, 1979, "Community Service Satisfaction and Stages of Community Development: An Examination of Evidence from Impacted Communities," *Journal of the Community Development Society* 10:109–124.

NatureServe, 2010, *NatureServe Explorer: An Online Encyclopedia of Life*. Available at http://www.natureserve.org/explorer/. Accessed March 4, 2010.

NCDC (National Climatic Data Center), 2010a, "Local Climatological Data Annual Summary with Comparative Data," Available at http://www7.ncdc.noaa.gov/IPS/lcd/lcd.html.

NCDC, 2010b, "Integrated Surface Hourly Data." Available at ftp://ftp3.ncdc.noaa.gov/pub/ data/noaa/.

NDCNR (Nevada Department of Conservation and Natural Resources), 2010, *Nevada Natural Heritage Program*. Available at http://heritage.nv.gov/. Accessed May 21, 2010.

NDOW (Nevada Department of Wildlife), 2010, *Wildlife & Habitat*. Nevada Department of Wildlife, Reno, Nev. Available at http://www.ndow.org/wild. Accessed June 3, 2010.

NHNM (Natural Heritage New Mexico), 2010, *Natural Heritage New Mexico*, Museum of Southwestern Biology, University of New Mexico, Albuquerque, N.M. Available at http://nhnm.unm.edu/. Accessed June 15, 2010.

NMDGF (New Mexico Department of Game and Fish), 2010, *Biota Information System of New Mexico*. Available at http://www.bison-m.org/. Accessed Aug. 17, 2010.

NNHP (Nevada Natural Heritage Program), 2010a, *Index to Reports and Publications Available or Planned*. Nevada Natural Heritage Program, Department of Conservation and Natural Resources, Carson City, Nev. Available at http://heritage.nv.gov/reports.htm. Accessed June 3, 2010.

NNHP, 2010b, *Nevada Rare Plant Atlas*. Available at http://heritage.nv.gov/atlas/atlas.html. Accessed June 23, 2010.

NOAA (National Oceanic and Atmospheric Administration), 2010, *NOAA/ESRL Radiosonde Database Access.* Available at http://esrl.noaa.gov/raobs/.

NPS (National Park Service), 2010, "Native American Consultation Database" part of *National NAGPRA Online Databases.* Available at http://grants.cr.nps.gov/nacd/index.cfm. Accessed June 30, 2010.

Nussear, K.E., et al., 2009, *Modeling Habitat for the Desert Tortoise* (Gopherus agassizii) *in the Mojave and Parts of the Sonoran Deserts of California, Nevada, Utah, and Arizona,* U.S. Geological Survey Open-File Report 2009-1102. Available at http://pubs.gov/of/2009/1102/. Accessed June 15, 2010.

Pope, C., and J. Jones, 1990, "Value of Wilderness Designation in Utah," *Journal of Environmental Management* 30:157–174.

REMI (Regional Economic Models), 2010, *The REMI Model.* Available at http://www.remi.com/index.php?page=model&hl=en_US. Accessed July 13, 2010.

Sanborn Mapping, 2008, *GAP Ecological Systems*, *USGS Mapping Zones 12 and 13*, Portland, Ore., prepared for the USGS GAP Program, Dec. Available at http://gapanalysis.nbii.gov/portal/community/GAP_Analysis_Program/Communities/Maps,_Data,_&_Reports/Find_Updated_GAP_Regional_Data.

Saurenman, H., et al., 2005, *Atmospheric Effects Associated with Highway Noise Propagation*, prepared for Arizona Department of Transportation, Phoenix, Ariz., Aug.

Schulze, W.D., and D.S. Brookshire, 1983, "The Economic Benefits of Preserving Visibility in the National Park Lands of the Southwest," *Natural Resources Journal* 23:149–173.

Schwer, R., and M. Riddel, 2004, *The Potential Economic Impact of Constructing and Operating Solar Power Generation Facilities in Nevada*, prepared for National Renewable Energy Laboratory, Feb.

SES (Stirling Energy Systems) Solar Two, LLC, 2008, "Application for Certification," submitted to the Bureau of Land Management, El Centro, Calif., and the California Energy Commission, Sacramento, Calif., June. Available at http://www.energy.ca.gov/sitingcases/solartwo/documents/applicant/afc/index.php. Accessed Oct. 1, 2008.

Seyfrit, C.L., and N.C. Sadler-Hammer, 1988, "Social Impact of Rapid Energy Development on Rural Youth: A Statewide Comparison," *Society and Natural Resources* 1:57−67.

Shultz, L.M., et al., 2006, *Revised Atlas of Utah Plants*, College of Natural Resources, RS/GIS Laboratory, Utah State University. Available at http://www.gis.usu.edu/. Accessed May 14, 2010.

Smith, M., et al., 2001, "Growth, Decline, Stability and Disruption: A Longitudinal Analysis of Social Well-Being in Four Western Communities," *Rural Sociology* 66:425−450.

Solar Partners I, LLC, 2007, "Application for Certification," submitted to California Energy Commission, Aug.

Stoddard, L., et al., 2006, *Economic, Energy and Environmental Benefits of Concentrating Solar Power in California,* prepared for National Renewable Energy Laboratory, April.

Stoeser, D.B., et al., 2007, *Preliminary Integrated Geologic Map Databases for the United States – Central States: Montana, Wyoming, Colorado, New Mexico, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Texas, Iowa, Missouri, Arkansas, and Louisiana,* U.S. Geological Survey Open File Report 2005-1351, Version 1.2, original file updated in December 2007. Available at: http://pubs.usgs.gov/of/2005/1351/index.htm.

Sturtevant, W.C. (general editor), 1978–2008, *Handbook of North American Indians,* Smithsonian Institution, Washington, D.C.

Toennies, F., 1887, *Gemeinschaft und Gesellschaft*, 1988 translation, Transaction Books, New Brunswick, N.J.

Topaz Solar Farms, LLC, 2008, "Conditional Use Permit Application, Topaz Solar Farm," submitted to the San Luis Obispo Planning and Building Department, San Luis Obispo County, Calif., July 18. Available at http://www.slocounty.ca.gov/planning/environmental/EnvironmentalNotices/optisoloar/Optisolar_App_Submit.htm. Accessed July 14, 2009.

UDWR (Utah Division of Wildlife Resources), 2009, *Utah Conservation Data Center*. Available at http://dwrcdc.nr.utah.gov/ucdc/default.asp. Accessed Nov. 3, 2009.

UDWR, 2010, *Government Records Access & Management Act (GRAMA)*. Available at http://wildlife.utah.gov/about/grama.php. Accessed June 23, 2010.

UNPS (Utah Native Plant Society), 2009, *Utah Rare Plants Guide*. Available at http://www.utahrareplants.org/. Accessed Nov 3, 2009.

USDA (U.S. Department of Agriculture), 1999, *Soil Taxonomy–A Basic System of Soil Classification for Making and Interpreting Soil Surveys*, Natural Resources Conservation Service Agricultural Handbook Number 436, 2nd ed.

USDA, 2010a, *Web Soil Survey*, operated by the Natural Resources Conservation Service. Available at http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm. Accessed July 11, 2010.

USDA, 2010b, *Plants Database*, Natural Resources Conservation Service. Available at http://plants.usda.gov/.

USFS (U.S. Forest Service), 2007, *Wild Horse and Burro Territories*, U.S. Forest Service, Rangelands, Washington, D.C. Available at http://www.fs.fed.us/rangelands/ecology/wildhorseburro//territories/index.shtml. Accessed Oct. 20, 2009.

USFWS (U.S. Fish and Wildlife Service), 2002, *Critical Habitat*, U.S. Fish and Wildlife Service Endangered Species Program. Available at http://www.fs.fed.us/r9/wildlife/tes/docs/esa_references/critical_habitat.pdf. Accessed June 17, 2010.

USFWS, 2009, *National Wetlands Inventory*, U.S. Department of the Interior, Washington, D.C. Available at http://www.fws.gov/wetlands.

USFWS, 2010a, *U.S. Fish and Wildlife Service Environmental Conservation Online System (ECOS).* Available at http://www.fws.gov/ecos/. Accessed May 28, 2010.

USFWS, 2010b, *U.S. Fish and Wildlife Service Critical Habitat Portal*. Available at http://criticalhabitat.fws.gov/. Accessed June 15, 2010.

USGS (U.S. Geological Survey), 2004, *National Gap Analysis Program, Provisional Digital Land Cover Map for the Southwestern United States*, Version 1.0, RS/GIS Laboratory, College of Natural Resources, Utah State University. Available at http://earth.gis.usu.edu/swgap/landcover.html. Accessed March 15, 2010.

USGS, 2005, *National Gap Analysis Program, Southwest Regional GAP Analysis Project—Land Cover Descriptions*, RS/GIS Laboratory, College of Natural Resources, Utah State University. Available at http://earth.gis.usu.edu/swgap/legend_desc.html. Accessed March 15, 2010.

USGS, 2007, *National Gap Analysis Program, Digital Animal-Habitat Models for the Southwestern United States*. Version 1.0. Center for Applied Spatial Ecology, New Mexico Cooperative Fish and Wildlife Research Unit, New Mexico State University. Available at http://fws-nmcfwru.nmsu.edu/swregap/HabitatModels/default.htm. Accessed March 15, 2010.

USGS, 2008, *Gap Analysis Program, California Land Cover*. Available at http://gap.uidaho.edu/index.php/gap-home/california-land-cover. Accessed July 14, 2010.

USGS, 2010a, *Quaternary Fault and Fold Database of the United States*. Available at http://earthquake.usgs.gov/hazards/qfaults/. Accessed July 11, 2010.

USGS, 2010b, *Earthquake Hazards Program–National Earthquake Information Center Database Circular Area Earthquake Search*. Available at http://earthquake.usgs.gov/earthquakes/eqarchives/epic/epic_circ.php. Accessed July 11, 2010.

USGS, 2010c, *Earthquake Hazards Program–Geologic Hazards Team Interactive Map Server National Seismic Hazard Maps (2008).* Available at http://gldims.cr.usgs.gov/website/nshmp2008/viewer.htm. Accessed July 11, 2010.

USGS, 2010d, *Volcano Hazards Program*. Available at http://volcanoes.usgs.gov/publications/index.php. Accessed July 11, 2010.

USGS, 2010e, *The National Map Seamless Server*. Available at http://seamless.usgs.gov/index.php.

Walker, J.D. and J.W. Geissman, 2009, *Geologic Time Scale*, Geological Society of America, Boulder, Colo.

Walsh, R.G., et. al., 1984, "Valuing Option, Existence and Bequest Demand for Wilderness," *Land Economics* 60:14–29.

Weisz, R., 1979, "Stress and Mental Health in a Boom Town," pp. 31−47 in *BoomTowns and Human Services,* J. Davenport and J. Davenport (editors), University of Wyoming Press, Laramie, Wyo.

Wilkinson, K.P., 1983, "Divorce and Recent Net Migration into the Old West," *Journal of Marriage and the Family* 45:437−445.

Wilkinson, K.P., and M. Camasso, 1984, "Juvenile Delinquency and Energy Development in a Traditional Setting," unpublished manuscript, Department of Rural Sociology, Pennsylvania State University, State College, Pa.

Wilkinson, K.P., et al., 1982, "Local Social Disruption and Western Energy Development: A Critical Review," *Pacific Sociological Review* 25:275−296.

Wilkinson, K.P., et al., 1984, "Violent Crime in the Western Energy-Development Region," *Sociological Perspectives* 27:241–256.

Woods, A.J., et al., 2001, *Ecoregions of Utah (color poster with map, descriptive text, summary tables, and photographs)*, U.S. Geological Survey, Reston, Va. Available at http://www.epa.gov/wed/pages/ecoregions/ut_eco.htm. Accessed Nov. 24, 2009.

WRCC (Western Regional Climate Center), 2010a, *Average Pan Evaporation Data by State*. Available at http://www.wrcc.dri.edu/htmlfiles/westevap.final.html. Accessed Jan. 19, 2010.

WRCC, 2010b, "*Western U.S. Climate Historical Summaries,*" Available at http://www.wrcc.dri.edu/Climsum.html.

Young, K.E., et al., 2002, *Characterizing and Predicting Suitable Aplomado Falcon Habitat for Conservation Planning in the Northern Chihuahuan Desert,* New Mexico Cooperative Fish and Wildlife Research Unit, Las Cruces, N.M. Available at http://fws-nmcfwru.nmsu.edu/aplomado/aplomado2002.htm. Accessed June 15, 2010.