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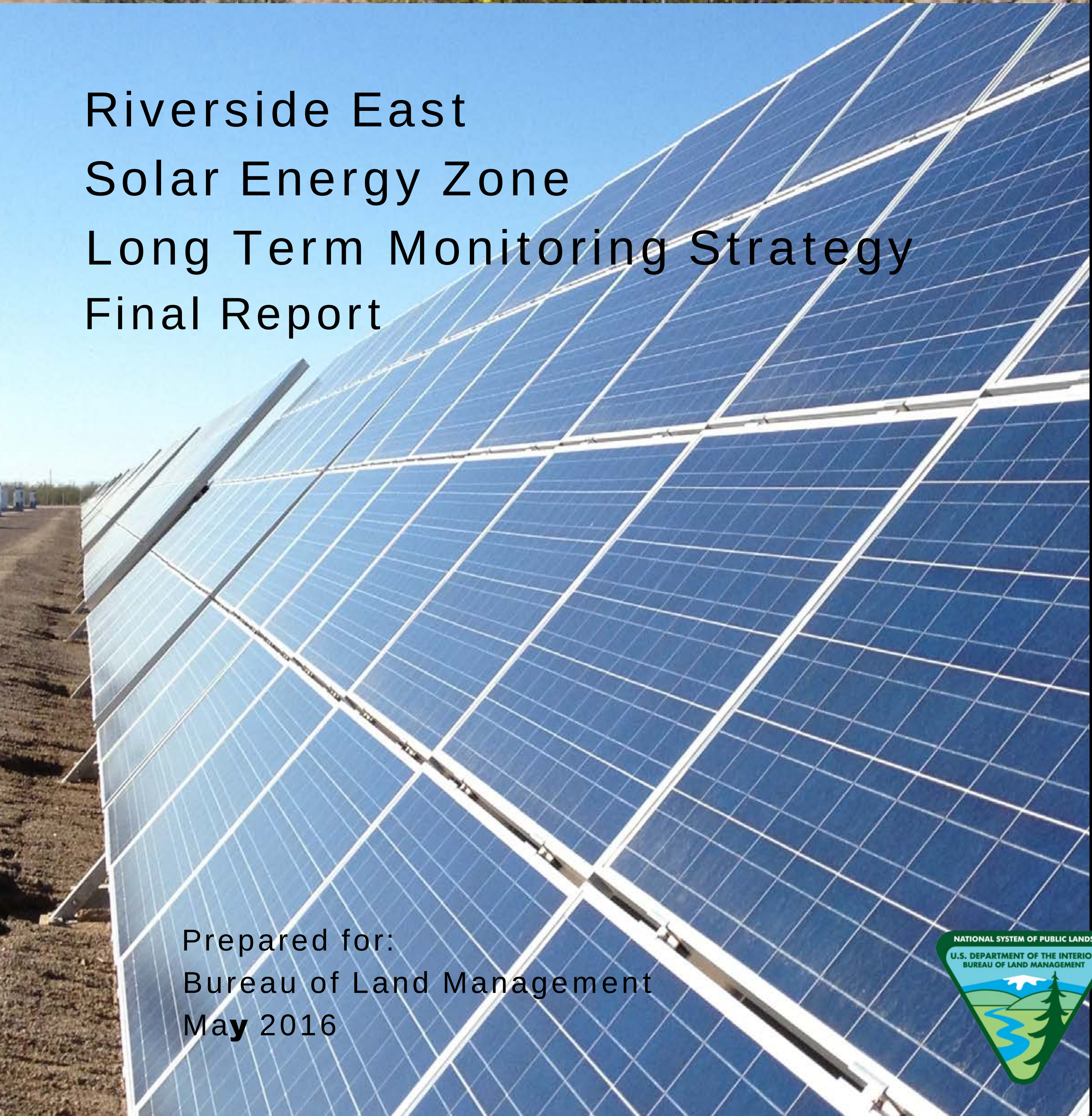

Riverside East Solar Energy Zone Long Term Monitoring Strategy Final Report

Prepared for:
Bureau of Land Management
May 2016

Riverside East Solar Energy Zone Long Term Monitoring Strategy

Final Report

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for
U.S. Department of the Interior
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ACKNOWLEDGMENTS

This Long-Term Monitoring Strategy is a product of a collaborative effort, funded jointly through the U.S. Bureau of Land Management (BLM) California State Office and the BLM Renewable Energy Coordination Office (RECO) in Washington D.C. The final content was approved by the BLM California Regional Mitigation Project Team and the national BLM RECO. Argonne National Laboratory's Environmental Science Division provided technical support, authored many of the document sections, and produced the final report.

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GENERAL ACRONYMS AND ABBREVIATIONS

AADT	annual average daily traffic
AIM	Assessment, Inventory, and Monitoring (strategy)
ANOVA	analysis of variance
APE	area of potential effect
ARB	Air Resources Board (California)
AVHRR	Advanced Very High Resolution Radiometer
BACI	Before After Control Impact
BLM	Bureau of Land Management
BSC	biological soil crust
BSCI	Biological Soil Crust Index
CASGEM	California Statewide Groundwater Elevation Monitoring (Program)
CASSP	California Archaeology Site Steward Program
CCD	charge-coupled device
CDCA	California Desert Conservation Area
CDFW	California Department of Fish and Wildlife
CHRIS	California Historical Resources Information System
CHU	critical habitat unit
CI	crust index
CSP	concentrating solar power
DSLR	digital single lens reflex
DSM	digital surface model
DRECP	Desert Renewable Energy Conservation Plan
DTC/C-AMA	Desert Training Center/California–Arizona Maneuver Area
DTW	depth to water
ECMP	Environmental and Compliance Monitoring Plan
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ERI	Erosion Resistance Index
ESD	ecological site description
GIS	Geographic Information System
GPS	Global Positioning System
I-10	Interstate 10
IDT	Interdisciplinary Team
IM	Instruction Memorandum
IOP	inventory observation point
JTNP	Joshua Tree National Park
KOP	key observation point
LiDAR	light detection and ranging
LPI	line-point intercept (method)
LTMS	Long-Term Monitoring Strategy

LTVA	long-term visitor area
MODIS	Moderate Resolution Imaging Spectroradiometer
NAIP	National Agricultural Imagery Program
NASA	National Aeronautics and Space Administration
NECO	Northern and Eastern Colorado Desert Coordinated Management Plan
NEPA	National Environmental Policy Act of 1969
NHD	National Hydrology Dataset
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NDVI	Normalized Difference Vegetation Index
NWIS	National Water Information System
O_3	ozone
OHV	off-highway vehicle
$PM_{2.5}$	particles less than or equal to 2.5 μm in aerodynamic diameter
PM_{10}	particles less than or equal to 10 μm in aerodynamic diameter
PEIS	Programmatic Environmental Impact Statement
PM	particulate matter
PV	photovoltaic
PYFC	Potential Fossil Yield Classification (System)
RADAR	radio detection and ranging
RAWS	Remote Automated Weather System
RGB	red-green-blue
RMP	Resource Management Plan
ROD	Record of Decision
ROW	right-of-way
SEZ	Solar Energy Zone
SDA	Specially Designated Area
SfM	structure-from-motion
SLRU	sensitivity level rating unit
SMART	specific, measurable, achievable, relevant, and time sensitive
S-NPP	Suomi National Polar-orbiting Partnership
SPSD	Scented Predator Survey Disk
SQRU	scenic quality rating unit
SRMS	Solar Regional Mitigation Strategy
TCA	Tortoise Conservation Area
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
VARI	Visible Atmospherically Resistant Index
VCR	Visual Contrast Rating
VHSR	Very high spatial resolution
VIIRS	Visible Infrared Imaging Radiometer Suite

VLSA	very large scale aerial
VRI	Visual Resource Inventory
VRM	Visual Resource Management
VSA	visually sensitive area
VHSR	very high spatial resolution (<1 m)
WLMF	Westwide Landscape Monitoring Framework

UNITS OF MEASURE

cm	centimeter(s)
ft	foot (feet)
hr	hour(s)
in.	inch(es)
km	kilometer(s)
km^2	square kilometer(s)
m	meters(s)
mi	mile(s)
µm	micrometer(s)

Executive Summary

In 2012 the Bureau of Land Management (BLM) created a comprehensive solar energy program which identified solar energy zones (SEZs) on public lands where the BLM will prioritize solar energy development. Currently, monitoring requirements for solar energy development rights-of way in SEZs do not encompass areas or control sites outside of project boundaries or across varied landscapes. Further, such project-level data are not generally collected continuously over long-term temporal scales, making it difficult to assess long-term and cumulative impacts. Therefore, management decisions regarding solar development on public lands would benefit from more broadly and consistently collected ecological data and other non-biological (e.g., visual, noise, cultural, and socioeconomic) information.

To capture such potential regional or landscape-scale resource impacts, the BLM has committed to establishing a long-term monitoring strategy (LTMS) that includes adaptive management for all SEZs. Data from the LTMS will be used to generate essential information needed for sound decision making during the permitting, operation, and restoration phases of solar projects. A better understanding of the landscape-scale effects of solar energy development over time will enable the BLM to improve future project siting and mitigation decisions. The LTMS has several key characteristics. It will be regional in scale, rather than project-by-project, inform status and trend of key resources and ecological processes, leverage existing BLM/partner data collection, provide timely information to inform future decisions, and be consistent with the BLM Assessment, Inventory, and Monitoring (AIM) strategy.

The Riverside East SEZ, located in Riverside County in southeastern California, was chosen for the LTMS pilot project. A total of 147,910 acres (598.6 km2) has been designated as developable for utility-scale solar projects within the Riverside East SEZ. This document describes the development and monitoring plan for the Riverside East SEZ. The identified monitoring objectives address utility scale solar development effects on groundwater, surface water, soils, vegetation communities, wildlife, visual resources, traffic patterns, recreational uses, Native American concerns, and cultural and paleontological resources. Included are discussions of the relationship of the LTMS to the BLM Assessment, Inventory, and Monitoring Program (Section 2.1) and the development of management questions, and management goals and monitoring objectives (Section 2.2), including public involvement and the incorporation of stakeholder comments into the monitoring plan (Section 2.2.4). Also addressed are the sampling design and data collection methods. Section 2.4 describes measures to minimize the cost of monitoring including resource prioritization, remote sensing, and data sharing.

AIM Strategy and the Riverside East SEZ LTMS. The BLM AIM strategy guides the collection of quantitative data on the status, condition, trend, amount, location, and spatial pattern of resources on the nation's public lands. The Riverside East LTMS is one of the several field-level deployments of AIM-monitoring approach for terrestrial ecosystems. The AIM strategy serves as the basis for building a monitoring and adaptive management strategy consistent with the BLM's solar energy program.by providing a replicable framework for collecting monitoring data across solar program areas and for adaptively managing siting and permitting of solar energy projects in SEZs.

Development of the Long-Term Monitoring Strategy. In keeping with the AIM strategy, developing management goals, monitoring objectives, and ultimately monitoring indicators were key steps in the LTMS. These steps included identifying specific management questions and geographies of interest for the Riverside East SEZ LTMS. The management questions provided the basis for developing monitoring goals and addressed the issues relevant to landscape-level impact assessment of solar energy development as well as existing land management plan requirements. Management goals were developed in response to each management question to define the desired resource conditions.

Ultimately, the BLM will establish quantitative monitoring objectives that will specify the desired precision of statistical change detection for the monitoring indicators as well as the magnitude of change that is considered to be of management significance. The ability to detect change in a resource-monitoring indicator is a function of the natural variability of the indicator and the number of samples that can be feasibly collected. These key pieces of information are currently uncertain for many resources of interest to the LTMS. Therefore, in general, quantitative change detection objectives cannot be established at this time. However, as baseline indicator data are obtained for the LTMS, information will become available to address these data gaps.

Monitoring indicators were identified to address each monitoring objective related to physical, ecological, and sociocultural resources. All monitoring indicators and objectives were formulated to be specific, measurable, achievable, relevant, and time sensitive (SMART). Monitoring objectives need to indicate the desired limit to the amount of change (specific), level of confidence for the measured change (measurable), funding and capacity requirements (achievable), relationship to the management question (relevant), and time frame during which the measurement occurs to effectively inform management (time sensitive). In addition to the AIM core indicators, multiple supplemental indicators were identified when the AIM core indicators alone were not adequate to address the monitoring objectives.

Sampling Design, Sampling Methods, and Data Analysis. The Riverside East SEZ LTMS incorporates existing baseline and ongoing monitoring data whenever possible. The LTMS also adopts the Before-After-Control-Impact (BACI) design which requires that indicator data be collected both before development begins (to define baseline conditions) and after development occurs. The collection of baseline data that reflect the conditions of resources before construction and operation is necessary to detect long-term deviations from baseline conditions. The BACI approach also requires that resource indicator data be collected at both impact sites and multiple control sites (i.e., sites considered to be outside the area of potential effect but that otherwise have characteristics similar to those of impact sites). To accommodate a BACI design, three broad impact strata were created: 1) the solar buffer stratum consists of a 2-mi (3-km) buffer area around existing and potential solar developments, representing the area of indirect effects that is feasible to monitor, 2) the non-buffer SEZ stratum (representing the remainder of the SEZ where impacts are uncertain), and 3) the reference stratum representing “control” sites that are not expected to be affected by solar development. Additional sampling stratification may be necessary to examine solar development impacts on specific soil and vegetation communities of high interest or value. The elements of the monitoring plan are summarized in Table ES 1.

ES-1 Summary and Prioritization of Monitoring Indicators Used for the Riverside East SEZ

Indicator(s)	Method	Sampling Strata	Point Sampling versus RM	Data Analysis
Soil aggregate stability; texture, infiltration; depth	1. Data on soil aggregate stability, soil texture, soil depth, and soil infiltration will be collected once per year. Qualitative visual observations of signs of erosion at each sampling plot with data sheets covering rills, gullies, pedestals, deposition and runoff, and water flow. Photographs at each sampling site for visual signs of erosion.	Three solar impact strata (buffer, SEZ, and reference). Within the buffer strata, plots located down slope and downwind of solar development projects where wind- and water-related soil erosion is most likely to occur.	Point sampling within established plots	The number of rills can be quantified by manual counts using ground-based photographs. For each biophysical stratum, changes in the number of rills and the five soil indicators will be compared among impact strata (buffer, SEZ, and reference) and time (before and after solar facility construction) for evidence of an impact using a BACI statistical analysis.
Groundwater elevation	Well monitoring using electronic probe or programmable data-loggers	Data from existing wells (individual project; USGS National Water Information System [NWIS] wells); new wells may be needed but not initially called for because of high cost and because optimal locations will come into focus in the future.	Point sampling	Data evaluation should include graphs of water levels versus time at solar power plant monitoring wells, NWIS wells, and other wells within the SEZ; Anticipated drawdown may be evaluated through analytical or numerical flow models.
Stream channel depth, width, and location	Ground-based photography and archived photographs	Three solar impact strata (buffer, SEZ, and reference). Imagery will be obtained for randomly selected streams and washes downslope of existing or planned solar facilities within the (3-km) buffer zone. Further stratification may be used to target streams by erosion risk and channel size; reference streams.	Discreet photography locations	Changes in channel morphology metrics at solar impact and reference areas quantified from imagery and compared before and after solar development using a BACI statistical analysis

ES-1 (Cont.)

Indicator(s)	Method	Sampling Strata	Point Sampling versus RM	Data Analysis
Particulate matter monitoring	New climate stations	It is recommended that four monitors be set up at locations both upwind and downwind of the primary and secondary prevailing wind directions around the impact site; PM10 will be monitored at the eastern side of Joshua Tree National Park near the SEZ boundary.	Point Sampling	Pre-construction monitoring data will be compared to dust concentrations and dispersion from solar facility activities; identify potential dust dispersion patterns.
Desert pavement cover and integrity	Quantify cover of desert pavement and degree of disturbance using remote sensing	Remotely sensed imagery will be used to map continuous cover and disturbance to desert pavement within each solar impact stratum (buffer, SEZ, and reference).	Continuous mapping using remote sensing	BACI; comparison of quantitative changes in desert pavement within buffer, SEZ, and reference impact strata before and after facility construction.
Dune location and sand transport rates	Quantify cover of dune cover, location, and movement	Dale Lake–Palen Dry Lake sand Corridor and the Palen Valley corridor, Palen-McCoy Valley through Chuckwalla Valley sand transport corridor. Bristol Trough sand path could serve as a potential reference site.	Continuous mapping using remote sensing	BACI; comparison of quantitative changes in sand dune cover location, and movement in buffer, SEZ, and reference impact strata before and after facility construction
Biological soil crust (BSC) cover	Quantify cover of biological soil crusts using remote sensing and image analysis	Remotely sensed imagery will be used to map continuous groundcover of BSCs within each solar impact stratum (buffer, SEZ, and reference).	Continuous mapping using remote sensing	BACI; comparison of quantitative changes in BSCs within buffer, SEZ, and reference impact strata before and after facility construction.
Vegetation cover	Quantify cover of vegetation, using remote sensing and image analysis	Remotely sensed imagery will be used to map continuous groundcover of vegetation within each solar impact stratum (buffer, SEZ, and reference).	Continuous mapping using remote sensing	BACI; comparison of quantitative changes in vegetation cover within buffer, SEZ, and reference impact strata before and after facility construction.
AIM core vegetation indicators	As specified in Herrick et al. (2015)	Biophysical strata and three solar impact strata (buffer, SEZ, and reference).	Random stratified plots sampling	BACI; comparison of quantitative changes in AIM core indicators in buffer, SEZ, and reference impact strata before and after facility construction.

ES-1 (Cont.)

Indicator(s)	Method	Sampling Strata	Point Sampling versus RM	Data Analysis
Abundance and distribution of wildlife indicator species.	Point count surveys and nesting surveys for abundance nest number, clutch size, hatching success, and fledging success (birds only) of black-tailed gnatcatcher loggerhead shrike, and verdin; methods for desert kit fox abundance not specified	Surveys should be confined to areas representing potential habitat for each wildlife indicator within each solar impact stratum (buffer, SEZ, and reference) to establish baseline. Post-construction surveys should be conducted annually (at minimum).	Point sampling within established plots	Spatial and temporal trends in relative abundance, nest numbers, clutch size, hatching success, and fledging success will be quantified at the three impact strata (buffer, SEZ, reference areas) and analyzed for evidence of solar development impacts using a BACI statistical framework.
Raven and coyote abundance	Methods for coyote abundance not specified; point count surveys for raven abundance	Surveys should be confined to areas representing potential habitat for coyote and ravens within each general solar impact monitoring stratum (buffer, SEZ, and reference). Additional monitoring locations will focus on detecting changes in raven and numbers in the Chuckwalla CHU.	Point sampling within established plots	Spatial and temporal trends in raven and coyote abundance will be analyzed within the three impact strata (buffer, SEZ, reference area) over time using a BACI statistical framework.
Special status species indicators	Monitoring habitat and habitat linkages for desert tortoise, Mojave fringe-toed lizard, burro deer, and bighorn sheep Direct species monitoring of burro deer, bighorn sheep, and Mojave fringe-toed lizard	Habitat and species monitoring should be conducted in potential habitat or movement corridors within each solar impact stratum buffer, SEZ, and reference).	RM and field monitoring of habitat; direct species monitoring will use transects and aerial surveys.	Habitat monitoring methods for the Riverside East SEZ LTMS include sand dunes and vegetation. Temporal trends in habitat monitoring indicators will be compared within each impact stratum (buffer, SEZ, and reference) using a BACI statistical framework. Spatial and temporal trends in relative abundance of the Mojave fringe-toed lizard, burro deer, and bighorn sheep will be quantified in their respective habitat and corridor areas located within the three impact strata (buffer, SEZ, and reference) and analyzed for evidence of solar development impacts using a BACI statistical framework.

ES-1 (Cont.)

Indicator(s)	Method	Sampling Strata	Point Sampling versus RM	Data Analysis
Visual contrast at VSAs	Field assessment, using the BLM Visual Contrast Rating (VCR) process at each key observation point (KOP) within a VSA.	KOPs within VSAs within the viewshed of the SEZ, as identified and assessed in the PEIS. The PEIS visual impact analysis did not include areas important to tribes, nor were VSAs selected with input from BLM staff or local stakeholders. These parties should be engaged to identify new VSAs and KOPs.	Point sampling	The VCR results and photographs for each KOP should be compared to the VCRs and simulations from the project EIS. Any significant differences should be documented, and similarly, discrepancies between the simulations in the project EIS and the photographs taken during the monitoring assessment should be documented. Visual impact mitigation monitoring involves analyzing the photographic and text-based record of the observed measures taken to mitigate visual impact associated with the various stages of development of a utility-scale solar energy facility.
Nighttime Illumination (night sky)	Estimation of limiting magnitude by star counts using Bortle scale or night sky meters; measuring brightness using charge-coupled device (CCD) images from an automated camera system	Establish a network of photo monitoring points within the SEZ. It may be possible to cover the entire SEZ with as few as six points.	Point sampling	Change in night sky over time
VRI factors and VRI class	VRI class determined from the VRI factor ratings using BLM VRI handbook	The VRI assessments should be conducted at the inventory observation points (IOPs) used for PEIS (2011). New IOPs may be established if the new solar facility or facilities are so far from existing IOPs that effects on scenic quality cannot be detected or assessed.	Point sampling	Using the 2011 inventory as a baseline, any changes over time to either the sensitivity or the scenic quality components, or the composite scores for the factors, or the overall VRI class recorded and discussed in a report prepared for the assessment.

ES-1 (Cont.)

Indicator(s)	Method	Sampling Strata	Point Sampling versus RM	Data Analysis
Number of requested and issued use permits for the LTVA	Midland LTVA data for the previous season should be collected after April 15 and prior to September 15 annually. Data currently collected by BLM.	Data should be collected for a Midland LTVA; the Mule Mountains LTVA can be used as a control site.	NA	Visitation data and permits issued will be calculated for the Midland LTVA and the reference site before and after solar development activities. Relative changes in permits and visitation at the two areas over time will be analyzed using a BACI statistical framework to determine whether any changes are related to solar development.
Traffic amount and distribution	Traffic counts by the California Department of Transportation; off-highway vehicle (OHV) traffic within the SEZ currently collected by the Palm Springs Field Office	Key intersections along I-10 and other major roads through and near the SEZ	NA	Calculate percentage change from previous year and percentage change from baseline year.
Number of reported impacts on cultural resources and areas of Native American concern	Site stewards supplied with monitoring forms; monitoring of vehicles, footprints, tire tracks, animal tracks, trash, spent ammunition, targets, fire pits/rings, camping; ground disturbance; incident reports from law enforcement officers, tribal representatives, and general public	Several project-specific cultural resource inventories and impact assessments in the SEZ have been completed; potential ongoing monitoring locations include NRHP/CRHP-listed sites, sites susceptible to a particular impact, highly visible, frequently used trails; areas of Native American concern include important trail systems, sacred sites and traditional use areas, as determined through consultation with tribal representatives; sample selection and size will be dependent on staff and volunteer resources available; control sites for cultural resources would be monitored in a similar fashion.	NA	Comparing baseline data against data collected from follow-up visits using photo documentation and a written record of impacts. Emphasis should be placed on changes in site condition due to increased visitation, fluctuations in water runoff patterns, aeolian sediment deposition or removal, or on land subsidence caused by increased groundwater use, as a result of solar development.

ES-1 (Cont.)

Indicator(s)	Method	Sampling Strata	Point Sampling versus RM	Data Analysis
Number of reported impacts on paleontological resources	BLM California should adopt a site steward program modeled on the BLM Utah Paleontological Site Stewardship Program; requires trained stewards to monitor their assigned locality four times a year.	Sites under the greatest threat of erosion, sites with the highest PYFC value, or sites that are frequently visited for recreation. Special consideration should be given to areas where known fossiliferous formations were surveyed.	NA	Data analysis would be similar to the methods used for cultural resources: comparing baseline data against data collected from follow-up visits using photo documentation and written record of impacts to determine new or potential future impacts.

Adaptive Management. Learning is central to adaptive management, and the Riverside East SEZ LTMS will provide critical data for adaptive management decisions (Williams et al. 2009). Data generated from the LTMS will serve several key purposes in the adaptive management process 1) evaluating progress toward achieving objectives, 2) determine resource status, in order to identify appropriate management actions, 3) increase understanding of resource dynamics; 4) enhance and develop models of resource dynamics as needed and appropriate, 5) detect changes in resource conditions in relation to a management threshold, and 6) amend solar LTMS conceptual models, monitoring objectives and indicators based on the monitoring data.

Monitoring indicators of resource status will be interpreted against management goals, monitoring objectives, ecological potential, and land health standards, and actions will be taken if such objectives are not met or resource change thresholds are exceeded. With regard to impact thresholds, the ultimate goal will be to establish resource management triggers (developed by BLM with stakeholder input) for beginning more intensive and research-oriented data collection to determine whether there is a causal relationship between the observed resource change and solar energy development. If the change in the resource is found to be related to solar energy development, new or revised design features and/or management recommendations may be developed to return the resource to the desired state. In addition, the BLM may use monitoring information to adapt the Solar LTMS to increase or decrease the frequency of sample collection, accommodate precision and accuracy requirements, or add or remove supplemental monitoring indicators.

Public Involvement. Given the public interest, the BLM has emphasized public engagement, transparency, and data availability in developing the LTMS. For the preparation of this draft monitoring strategy, stakeholder involvement has included one workshop in Palm Springs, California, and one web-based meeting to date. Representatives from federal, state, and local government agencies; nongovernmental organizations concerned with issues such as environmental or recreational impacts; representatives from the solar development industry and utilities; tribal representatives; and individual members of the public were invited to and attended these activities.

Cost. In order to reduce costs and ensure the LTMS is feasible to implement, the BLM proposes to rely on existing data collection efforts when appropriate, use lower cost remote sensing techniques, and prioritize new monitoring activities so available funding can be applied to highest priority monitoring activities. It was necessary to prioritize resource-monitoring objectives because it is not possible to directly and comprehensively monitor all resources given the variety of social, ecological, and physical resources the LTMS was designed to address. The highest priority monitoring objective indicators were related to potential physical and biological impacts, such as groundwater elevation, soil erosion, and AIM vegetation indicators. Lower priority indicators included traffic, long-term visitor area (LTVA) visitation, and visual resource impact indicators. If funding is inadequate to monitor all the indicators addressed in this document, funding allocations will focus on the highest priority indicators first. The proposed list of prioritized monitoring indicators is provided in Table ES-2.

The BLM is hopeful that other state and federal agencies and nongovernmental organizations will partner with BLM in providing human and economic resources to meet long-term monitoring objectives. The BLM proposes to allocate funding in the short term for initial data collection efforts and add requirements for right-of-way holders of future solar energy projects authorized in the Riverside East SEZ to contribute funding for the Riverside East LTMS. Although the collection of project-level baseline data will largely be the responsibility of developers, the BLM will take an active role in identifying and collecting priority baseline data for the SEZ and in developing consistent monitoring schema to reduce administrative and financial burdens to developers. Costs are also expected to be reduced in SEZs because of the ability to pool investments for monitoring and to coordinate with other federal, state, and local agencies in maximizing partnerships and data sharing.

Table ES-2. Summary and Prioritization of Monitoring Indicators Used for the Riverside East SEZ

Priority	Indicator (s)
Physical Resource Indicators	
High	Dune location and sand transport rates
High	Groundwater elevation
High	Particulate matter monitoring
High	Soil aggregate stability, texture, infiltration, depth
Medium	Desert pavement cover and disturbance
Medium	Stream channel depth, width, and location
Biological Resources Indicators	
High	AIM core vegetation indicators
Medium	Abundance and distribution of wildlife Indicator Species
Medium	Biological soil crusts
Medium	Raven and coyote abundance
Medium	Special Status Species Indicators
Medium	Vegetation cover (photography and remote sensing based monitoring)
Sociocultural Resources	
Medium	Number of reported Impacts on cultural resources and areas of Native American concern
Lower	Long-term and short-term passes issued; number of visits and visitor days
Lower	Nighttime illumination (night sky)
Lower	Paleontological resources impacts reported
Lower	Traffic amount and distribution
Lower	Visual Contrast at VSAs
Lower	VRI factors and VRI class

1 INTRODUCTION

1.1 Background and Need for the Riverside East SEZ Long-term Monitoring Strategy

The Bureau of Land Management (BLM) created a comprehensive solar energy program in 2012 through the publication of the “Final Programmatic Environmental Impact Statement (PEIS) for Solar Energy Development in Six Southwestern States” (BLM and DOE 2012), and the subsequent “Approved Resource Management Plan Amendments/Record of Decision (ROD) for Solar Energy Development in Six Southwestern States” (BLM 2012). As part of its solar energy program, the BLM designated solar energy zones (SEZs) on public lands in six southwestern states, totaling more than 200,000 acres of public lands (BLM 2012). In addition, the Solar ROD implemented comprehensive programmatic and SEZ-specific design features into land use plans in the six-state study area (design features are measures required to avoid and/or minimize the impacts of solar development).

The Solar ROD defined SEZs as areas well-suited for utility-scale production of solar energy, where the BLM has prioritized solar energy and associated transmission infrastructure development. As a permitting requirement to inform management decisions and to ascertain site-specific impacts, project-specific monitoring data are collected during construction and operations for solar energy facilities located on BLM-administered lands both within and outside of SEZs. However, the data collected often do not encompass areas or control sites outside of project boundaries or across varied landscapes. Further, such project-level data are not generally collected continuously over long-term temporal scales. Project-level decisions would benefit from more broadly and consistently collected ecological data and other nonbiological (e.g., visual, noise, cultural, and socioeconomic) information.

To capture such potential “landscape-scale” resource impacts, the BLM has committed to establishing a long-term monitoring strategy (LTMS) that includes adaptive management for all SEZs (BLM 2012). The BLM will take an active role in collecting priority baseline data for SEZs (especially at broader scales and via remote sensing) and developing consistent monitoring schema that include control sites. This information will be used to generate essential information needed for sound decision making during the permitting, operation, and restoration phases of solar projects. The LTMS has several key characteristics. It is intended to

- Be regional in scale, rather than project-by-project;
- Inform status and trend of key resources and ecological processes;
- Leverage existing BLM/partner data collection;

- Provide timely information to inform future decisions;
- Be consistent with the BLM Assessment, Inventory, and Monitoring (AIM) strategy;
- Be complementary to existing monitoring; and
- Incorporate, but not duplicate, project-specific compliance monitoring.

A better understanding of the landscape-scale effects of solar energy development over time will enable the BLM to improve future project siting and mitigation decisions.

The Riverside East SEZ was chosen as the pilot for implementing a LTMS. The Riverside East SEZ is the largest of the SEZs and includes the largest number of permitted and approved solar projects within its boundaries. The total area designated for utility-scale solar energy projects within the SEZ is 147,910 acres (598.6 km^2). As of April 2015, there were four authorized and three pending project applications located within or partially within the Riverside East SEZ (see Table 1-1). These projects cover an area of about 30,000 acres (118 km^2), which equates to approximately 20% of the SEZ. The high development potential at the Riverside East SEZ makes it well suited for a pilot landscape level monitoring program.

Table 1-1 Utility-Scale Solar Energy Projects Permitted or Proposed at the Riverside East SEZ[a]

Project Name and Applicant	Technology	Status	Acres	MW
Desert Harvest–Desert Harvest Solar	PV	Authorized	1,298	150
Genesis Solar–Genesis Solar, LLC	CSP/Trough	Authorized	1,952	250
McCoy–Nextera Energy Resources, LLC	PV	Authorized	5,440	750
Blythe Solar Energy Center–NextEra	PV	Authorized	4,313	485
Total Authorized			**16,723**	**2,185**
Desert Quartzite–First Solar	PV	Pending	4,917	700
Sonoran West SEGS–Brightsource Energy	CSP	Pending	6,921	1000
Almasol–Palen Solar III, LLC	CSP	Pending	5,213	500
Total Pending			**17,051**	**2,200**

[a] Several other solar energy projects are either proposed or approved just outside the Riverside East SEZ. The Desert Sunlight facility is located just outside the northwest boundary of the SEZ. The Blythe Mesa private land solar project just east of the SEZ has been approved by Riverside County, and the Mule Mountain III solar project is proposed for BLM lands near the southeastern boundary of the SEZ.

Source: BLM 2015.

1.2 Description of the Riverside East SEZ

The Riverside East SEZ is located in Riverside County in southeastern California, within Chuckwalla Valley, Palo Verde Mesa, and the BLM California Desert Conservation Area (CDCA) (Figure 1-1). A total of 147,910 acres (598.6 km^2) has been designated as developable for utility-scale solar projects within the Riverside East SEZ. Under the Solar PEIS ROD, 11,547 acres (46.7 km^2) within the SEZ boundaries was identified as nondevelopment areas (BLM 2012). The eastern boundary of the SEZ is about 6 mi (10 km) west of the Arizona border at its closest point. The western boundary is approximately 0.7 mi (1 km) east of Joshua Tree National Park at its closest point. The closest large cities are Moreno Valley, San Bernardino, and Riverside (all located slightly more than 100 mi [161 km] west of the SEZ via Interstate 10 [I-10]).

The Riverside East SEZ is within basin and range topography. Most of the SEZ consists of broad, sparsely vegetated basins with widely spaced creosote bushes (*Larrea tridentata*) and other low shrubs. There are also two large dry lake beds or playas (Ford and Palen dry lake beds), sand dunes, areas of desert pavement, and dry washes. The larger dry washes have microphyll woodland consisting chiefly of desert ironwood (*Olneya tesota*) and blue palo verde (*Parkinsonia florida*). The playas, desert pavement, and portions of the sand dunes are devoid or nearly devoid of perennial vegetation. While the lands to the north and west of the SEZ are generally undeveloped mountains (and are within federally designated wilderness), the lands to the southeast within the floodplain of the Colorado River are agricultural, and there is development along I-10 just south of the SEZ, though areas south of the SEZ beyond I-10 are generally undeveloped. The small town of Desert Center is located at the far western edge of the SEZ, along I-10. There are ranches, homes, and associated structures on private lands near the SEZ, as well as local roads and airstrips.

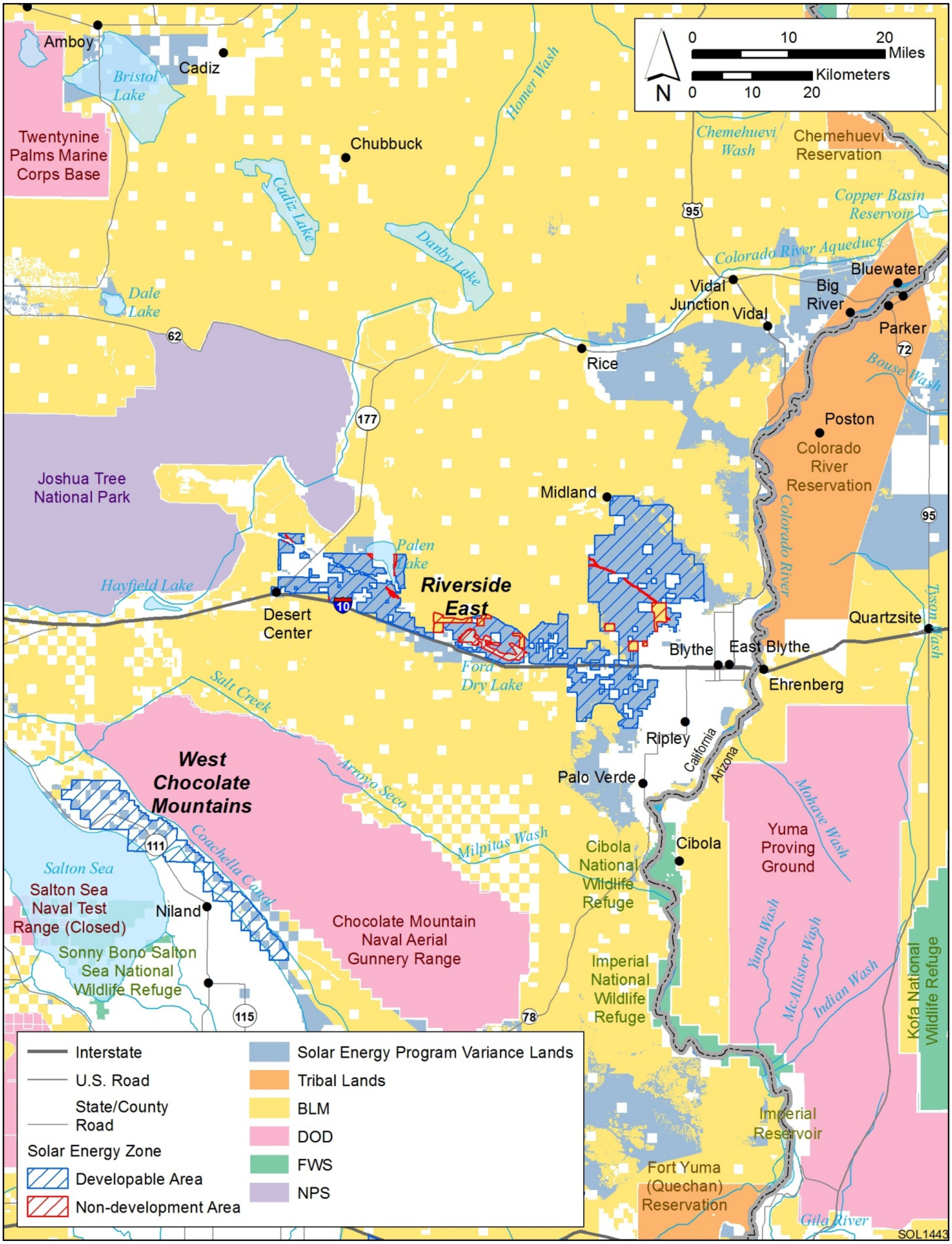

Figure 1-1 The Location of the Riverside East SEZ

1.3 Adaptive Management: Rationale for Monitoring

Comments on the Final Solar PEIS (BLM and DOE 2011) indicated substantial public interest in a robust, long-term, scientifically sound monitoring and adaptive management strategy for the BLM Solar Energy Program. The BLM defines adaptive management as:

"(1) a system of management practices based on clearly defined outcomes, monitoring to determine if management actions are meeting outcomes, and, if not, facilitating management changes that will best ensure that outcomes are met or re-evaluated (BLM 2008c); or (2) an iterative learning process producing improved understanding and improved management over time….[that] promotes flexible decision-making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process….It is not a "trial and error" process, but rather emphasizes learning while doing" (Williams et al. 2009).

The Riverside East SEZ LTMS contains many elements of traditional adaptive management, such as involving stakeholders and defining management goals and quantifiable monitoring objectives (Williams et al. 2009). It differs from traditional adaptive management in that it does not develop models and experimental tests of the hypothesized outcome of specific management actions. However, LTMS monitoring data can still inform specific management decisions even if the monitoring is not conducted in an experimental framework (Hutto and Belote 2013). In fact, learning is central to adaptive management, and the LTMS will provide critical data for adaptive management decisions (Williams et al. 2009). Data generated from the LTMS will serve four key purposes in the adaptive management process as defined by Williams et al. (2009):

- Evaluating progress toward achieving objectives;
- Determining resource status, in order to identify appropriate management actions;
- Increasing understanding of resource dynamics; and
- Enhancing and developing models of resource dynamics as needed and appropriate.

Monitoring data are also necessary considering the iterative nature of the adaptive management process. The BLM will use data from specific solar development projects as well as information derived from the Riverside East SEZ LTMS to make necessary adjustments to meet resource management goals described at project, resource management plan, and/or national program levels. There are several uses for the LTMS monitoring data that are integral to the adaptive management of solar development, specifically to:

- Provide information on whether there are impacts from solar energy development that are not currently predicted;
- Assess cumulative impacts of multiple solar energy projects;
- Detect changes in resource conditions in relation to a management threshold;
- Trigger adoption of new or revised programmatic design features, other project requirements, and/or related management actions, if LTMS data suggest some are not effective; and
- Amend solar LTMS conceptual models, monitoring objectives and indicators based on the monitoring data.

Monitoring indicators will be interpreted against monitoring objectives, ecological potential, land health standards, and/or management thresholds (identified, e.g., within land use plans), and actions will be taken if such objectives are not met or thresholds are exceeded. With regard to impact thresholds, the ultimate goal will be to establish resource management triggers for beginning more intensive and research-oriented data collection to determine whether there is a causal relationship between the observed resource change and solar energy development. If the change in the resource is found to be related to solar energy development, new or revised design features and/or management recommendations may be developed to return the resource to the desired state. In addition, the BLM may use monitoring information to adapt the Solar LTMS to increase or decrease the frequency of sample collection, accommodate precision and accuracy requirements, or add or remove supplemental monitoring indicators.

1.4 Public Involvement

Given the public interest in a robust, long-term, and scientifically sound monitoring and adaptive management strategy for the BLM Solar Energy Program, the BLM has emphasized public engagement, transparency, and data availability in developing the LTMS. A description of the long-term monitoring strategy approach was outlined in the Final Solar PEIS, and the BLM has solicited stakeholder input during each phase of monitoring strategy development.

For the preparation of this draft monitoring strategy, stakeholder involvement has included one workshop in Palm Springs, California, and one web-based meeting to date. Representatives from federal, state, and local government agencies; nongovernmental organizations concerned with issues such as environmental or recreational impacts; representatives from the solar development industry and utilities;

tribal representatives; and individual members of the public were invited to attend these activities. A two-day kickoff workshop was held December 11–12, 2013, at which stakeholders were asked to identify top potential impacts of concern and create monitoring objectives to help understand the extent and magnitude of those impacts. All presentations from the December workshop and webinar are posted on the project documents web page at http://www.blm.gov/ca/st/en/fo/palmsprings/Solar_Projects/Riverside_East_Monitoring.html. In addition, stakeholder input was solicited on monitoring objectives and monitoring indicators presented in a May 28, 2014, webinar. Stakeholders also provided valuable information on baseline resource data and ongoing monitoring data collection in the Riverside East SEZ that could be incorporated into the LTMS. A description of how stakeholder inputs were incorporated into the LTMS is provided in Section 2.2.4.

1.5 Funding

A key consideration in the development of the Riverside East LTMS has been the feasibility of collecting data to fulfill the proposed monitoring objectives. An important component of feasibility is cost. In order to reduce costs and ensure the LTMS is feasible to implement, the BLM proposes to

1. Rely on existing data collection efforts when appropriate;
2. Use lower cost remote sensing techniques when appropriate; and
3. Prioritize monitoring activities so available funding can be applied to the highest priority monitoring activities.

The BLM anticipates funding for the Riverside East LTMS to come from multiple sources:

1. The BLM has already begun, and intends to continue to allocate funding for initial data collection efforts.
2. The BLM will work to partner with state and federal agencies and nongovernmental organizations in providing human and financial resources to meet long-term monitoring objectives.
3. The BLM intends to add requirements for future solar energy rights-of-way on public lands in the Riverside East SEZ (i.e. those rights-of-way that are approved after the completion of this LTMS) to contribute funding for the implementation of the LTMS. Construction of additional solar energy projects will continue to increase the potential for cumulative impacts in the SEZ. Funding provided by right-of-way holders will be critical for helping the BLM to understand the extent of these impacts.

Funding from right-of-way holders is intended to be a one-time fee, due prior to the start of construction. Funds may be held and managed by a third party.

Funding requirements for right-of-way holders would be determined through the project permitting process and would be set at an appropriate level considering each project's anticipated impacts. For example, solar energy development generally impacts vegetation, so right-of-way holders would likely be required to provide funding for regional vegetation monitoring. Projects with the potential to contribute to other cumulative impacts, such as to air quality or sand transport, would contribute additional funding to cover a portion of the costs associated with monitoring those indicators.

Base funding requirements would be consistent with fees identified for similar monitoring efforts. For reference, the cost for long-term monitoring of mitigation locations was preliminarily estimated to be $5 per acre per year, in the solar regional mitigation strategy for the Dry Lake SEZ (BLM 2014). Assuming monitoring would continue over the life of a 30-year right-of-way, the base per acre fee would be $150 per acre ($5 per acre multiplied by 30 years).[1]

Because of the BLM's dependence on unpredictable appropriations from year to year and the uncertainty of the level of future development in the SEZ, the need to prioritize monitoring activities is critical. This document describes the monitoring objectives and associated monitoring indicators proposed for the Riverside East SEZ. However, funding may be inadequate to monitor all the indicators addressed in this document. Therefore, funding allocations will focus on the highest priority indicators first. The proposed list of prioritized monitoring indicators is provided in Section 2.5.

1.6 Planned Implementation

The implementation of the Riverside East LTMS includes the collection, analysis, and synthesis of monitoring data and the public reporting of the results. Data collection includes identifying and obtaining existing monitoring data as well new as data collection to be initiated under the LTMS. Current data collection relevant to each resource monitoring objective is described in Sections 4 through 6, along with proposed new data collection. The BLM will set priorities during project implementation and coordinate new data collection, which will initially focus on high priority monitoring objectives. See

[1] Factors which may be considered in adjusting the fee collected for monitoring include but are not limited to monitoring methodology and frequency, opportunities to utilize remote sensing, distance to the monitoring site, and travel costs (e.g., if overnight accommodations needed).

Section 2.5 for a discussion of how monitoring objectives were prioritized. High priority monitoring objectives include:

- Detect temporal changes of management significance in soil erosion/accretion relative to control areas. Indicators include visual indicators of erosion, AIM core indicators of soil aggregate stability, as well as soil texture, soil infiltration, and soil depth indicators;
- Detect temporal changes of management significance in PM10 and $PM_{2.5}$ within and near to the SEZ. Indicator would be ongoing and new PM monitoring;
- Detect temporal changes of management significance in groundwater surface elevations in monitoring wells as well as the spatial pattern and extent of these groundwater surface elevation changes on or near projects. Indicator would be groundwater surface elevation measurements at existing and new wells;
- Detect temporal changes of management significance in sand dune size, location, and sand transport relative to control areas as indicated by satellite imagery analysis;
- Detect temporal changes of management significance in total plant cover, intercanopy gaps, and woody plant height relative to control areas. Indicators include AIM core indicators of line-point intercept with plot-level species inventory, vegetation height, and canopy gap intercept, as well as remote sensing ;
- Detect temporal changes of management significance in rare and high-priority vegetation communities relative to control areas. Indicators include AIM core indicators of line-point intercept with plot-level species inventory, as well as remote sensing;
- Detect new introductions of invasive plant species relative to control areas. Indicator would be AIM core indicator of percent cover of non-native plant species.

The first step in new data collection will be for BLM to develop sampling strategies specific to each of these monitoring objectives. Proposed sampling designs and data collection methods for physical and ecological monitoring objectives are generally described in Section 4 and 5, respectively. The existing data need to be obtained, compiled, and analyzed. Additionally, the specific locations of new sampling and sampling methods have yet to be determined. The number of new sampling locations, sampling methods, and sampling frequency will be based on the desired level of statistical power necessary to detect a threshold level of change specific to that resource indicator. The threshold level of change will be one of management significance (i.e. outside the range of natural variation) as determined by BLM with input from stakeholders. The thresholds and sample size needed will be determined using existing data before initiating new data collection. However, preliminary sampling to better understand the natural variance in the resource indicators will likely be necessary to ascertain the appropriate sampling density.

New data collection will be conducted by the BLM, third party organizations (some funded by the BLM), and/or volunteers. For example, the BLM has funded the Great Basin Institute to collect AIM data at Riverside East SEZ and surrounding areas by for the past two years. All data collection will comply with NEPA requirements. The BLM, with assistance from third party organizations, will also identify and consolidate other regional data not specifically collected for the Riverside East LTMS, but that is applicable to addressing the monitoring objectives of the LTMS. This includes ongoing monitoring data from existing solar projects when this data is relevant to the LTMS regional monitoring objectives.

Data analysis will coordinated by the BLM with support from other organizations as needed. An initial status report based on existing data will be prepared to address what is known about baseline conditions, and identify additional needs for monitoring of new control and impact locations in order to adequately address priority monitoring objectives. Data synthesis and analysis will initially be conducted annually to determine if the data suggest solar development impacts to resources are currently occurring.

The results of LTMS monitoring will be made publicly available through periodic reports that will contain sections describing sampling sites, methods, and the status and trend of resources suggested by the data analysis. These reports, prepared annually or biennially, will be made available through the BLM Solar Energy Program website (http://blmsolar.anl.gov/) and/or the BLM California solar website (http://www.blm.gov/ca/st/en/prog/energy/solar.html). AIM data collected for the LTMS will be housed at the BLM National Operations Center. Repositories for non-AIM data will be publicized in the periodic reports referenced above.

Following the adaptive management guidelines described in Section 1.3, the BLM will periodically review the resource status and trends and their relationship to solar energy development in the Riverside East SEZ. The periodic LTMS reports will provide an opportunity for adaptive management in which monitoring results will be interpreted against the quantitative triggers that will be established for each monitoring objective. If the change in a monitoring indicator exceeds the trigger threshold, new or revised design features and/or management recommendations, or solar development requirements may be developed to return the resource to the desired state. If the causal link between the indicator change and solar development is uncertain, new indicators data collection and more spatially and temporally intensive data collection may be initiated to determine whether the observed resource change is related to solar energy development. Based on these results, the BLM may revise or implement new design features and management actions.

1.7 Overview of this Document

This document describes the process of developing a LTMS for the Riverside East SEZ. Included are discussions of the BLM Assessment, Inventory, and Monitoring Program (Section 2.1) and the development of the conceptual models, management questions, and management goals and monitoring objectives specific to resources at the Riverside East SEZ (Section 2.2). Public involvement and the incorporation of stakeholder comments into the monitoring plan are also described (Section 2.2.4). Section 2.4 describes feasible and cost-effective monitoring indicators and the overall sampling design that will be used to meet the monitoring objectives for physical, ecological, and sociocultural resources that will be monitored as part of the Riverside East LTMS. The elements of the monitoring plan are summarized in Section 2.5.

The cost-effective application of remote sensing to long-term monitoring is a key part of the AIM strategy and is discussed in Section 3. Sections 4, 5, and 6 contain detailed descriptions of physical, biological, and sociocultural monitoring indicators, respectively, including the rationale for monitoring the indicator and the relationship of the indicator to management questions, management goals, and monitoring objectives. Also described are existing monitoring and new proposed monitoring, sampling design, and data analysis related to the indicator.

1.8 Literature Cited

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2 MONITORING APPROACH

2.1 BLM Assessment, Inventory, and Monitoring Program

The BLM initiated the AIM Strategy to provide key information on BLM-administered resources and lands for decision makers. The AIM strategy guides the collection of quantitative data on the status, condition, trend, amount, location, and spatial pattern of resources on the nation's public lands. The AIM strategy identifies a specific set of core indicators relevant to the functioning of all ecosystems BLM manages, as well as indicator collection methods to ensure consistency of resource information across the United States. The AIM Strategy also emphasizes the importance of a statistically valid study design to obtain scientifically defensible information to track changes on public lands at multiple scales over time (Taylor et al. 2014).

AIM terrestrial core indicators include bare ground (% cover), the proportion of soil surface in large gaps between plant canopies (% cover), vegetation height (m), vegetation composition (% cover), and non-native invasive plant species (% cover) (Taylor et al. 2014). Several additional core indicators are currently being developed for aquatic habitats. These core AIM indicators have been identified in BLM planning documents as an important set of indicators to be monitored across BLM public lands. Each core indicator will be measured by using the field data collection methods specified in MacKinnon et al. (2011) and Herrick et al. (2015), in order to ensure spatial and temporal comparability of data collected across all BLM-administered lands. Resources or management questions not adequately addressed by AIM core indicators will be addressed by supplemental indicators developed specifically for potential solar development impacts.

The AIM Strategy provides a robust, responsive basis for building a monitoring and adaptive management strategy for the BLM Solar Energy Program (i.e., Solar LTMS). It provides a replicable, consistent framework for collecting monitoring data across solar program areas and for adaptively managing siting and permitting of solar energy projects and SEZs. Further, the AIM-based Solar LTMS will take advantage of and augment other AIM efforts under way, including Rapid Ecoregional Assessments, the national Landscape Monitoring Framework, and an array of local, management-driven monitoring efforts. The information derived from these coordinated, multiprogram efforts will provide an unprecedented understanding of the condition and trend of BLM-administered lands and support informed decision making across jurisdictional boundaries.

2.2 Development of the Long-Term Monitoring Strategy

The goal of the Riverside East SEZ LTMS is to develop and implement a monitoring program that addresses resource management questions over the long term. As identified in the AIM Strategy, the effort begins with collecting background information, including what is known about the ecosystem, critical management questions, and regulatory requirements. Conceptual models assist with this step by defining the current understanding of key ecosystem processes. Developing management goals, monitoring objectives, and ultimately monitoring indicators are also key steps in the AIM strategy. Each of these steps is described below.

2.2.1 Conceptual Models

The AIM Strategy utilizes conceptual models that describe the relationship between key ecosystem components, processes, and stressors. Generalized conceptual models were developed for the Mojave Desert and Sonoran Desert in support of the BLM Rapid Ecoregional Assessments (REAs) (Strittholt et al. 2012; Comer et al. 2013) (Figure 2-1). The conceptual model shows how the broad regional ecosystems (Montane Dry and Basin Dry Land Systems and Basin Dry and Basin Wet Systems) are influenced by natural drivers of change (e.g., elevation topography, weather, sediment processes) as well as by human drivers of change (e.g., grazing, fire regime, human development), which are ultimately determined by the Climate and Physiographic System and the Human System, respectively (Figure 2-1). These general models were adapted to the Riverside East SEZ and solar energy development as shown in Figure 2-2. The conceptual model for the Riverside East SEZ shows the interaction between five ecosystem components: atmospheric conditions, human elements, landscape elements, ecosystem components and processes, and disturbance from solar energy. Human elements encompass a wide variety of resources and issues present in the Riverside East SEZ. Examples include specially designated areas (e.g., Desert Wildlife Management Areas, Areas of Critical Environmental Concern), Native American concerns, and military uses. Wildlife, dominant vegetation communities, and special status species are examples of ecosystem components at the Riverside East SEZ. The model also shows the processes and interactions linking biological components, such as the role of vegetation in providing wildlife habitat and the role of wildlife in pollination and seed dispersal. Soil stabilization by vegetation and the influence of hydrology on plant production and distribution are examples of key biophysical interactions in the SEZ (Figure 2-2). These conceptual models depicting the resources present in the Riverside East SEZ, as well as how these resources interact with one another and human and natural ecosystem drivers, were important in formulating management questions.

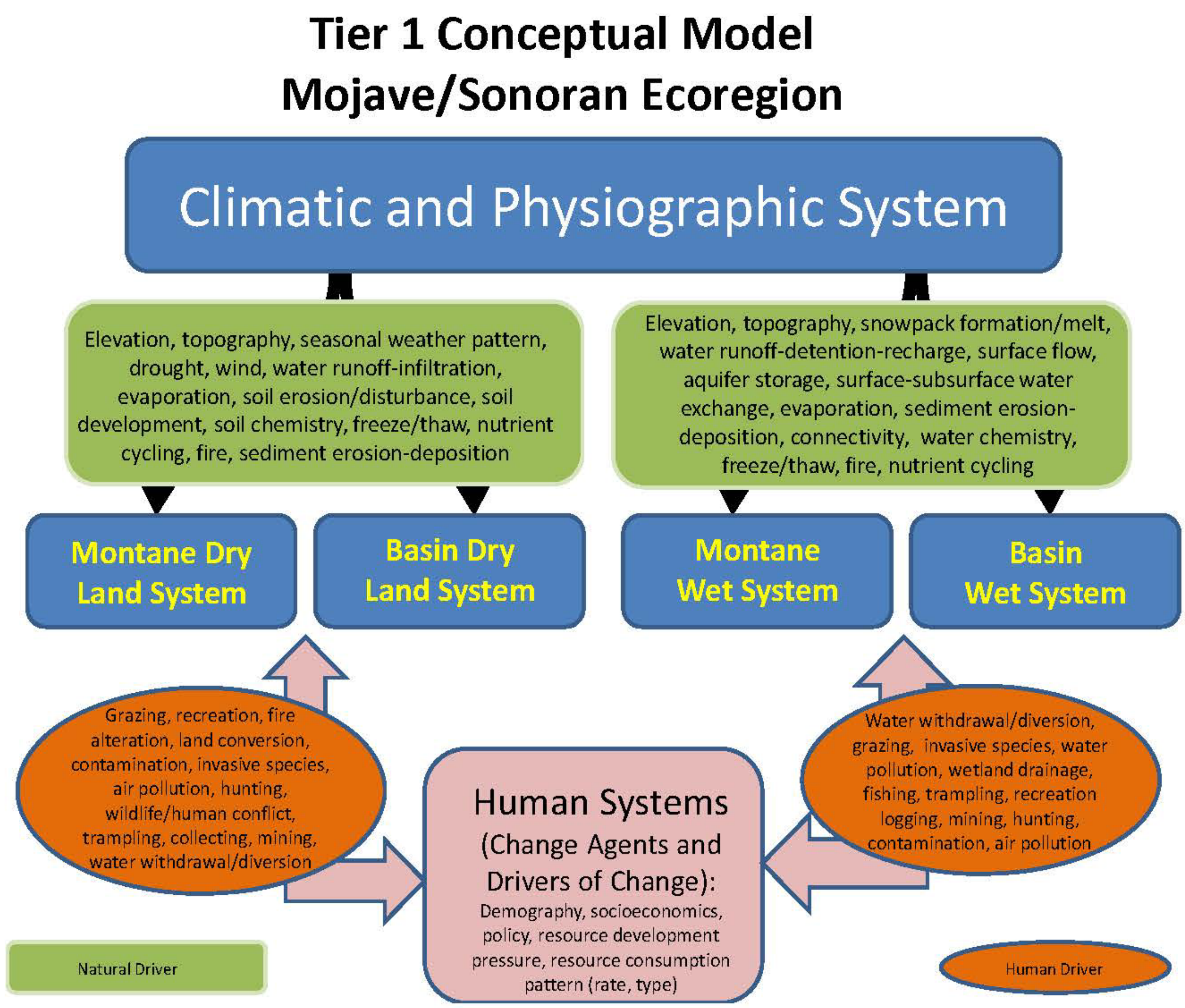
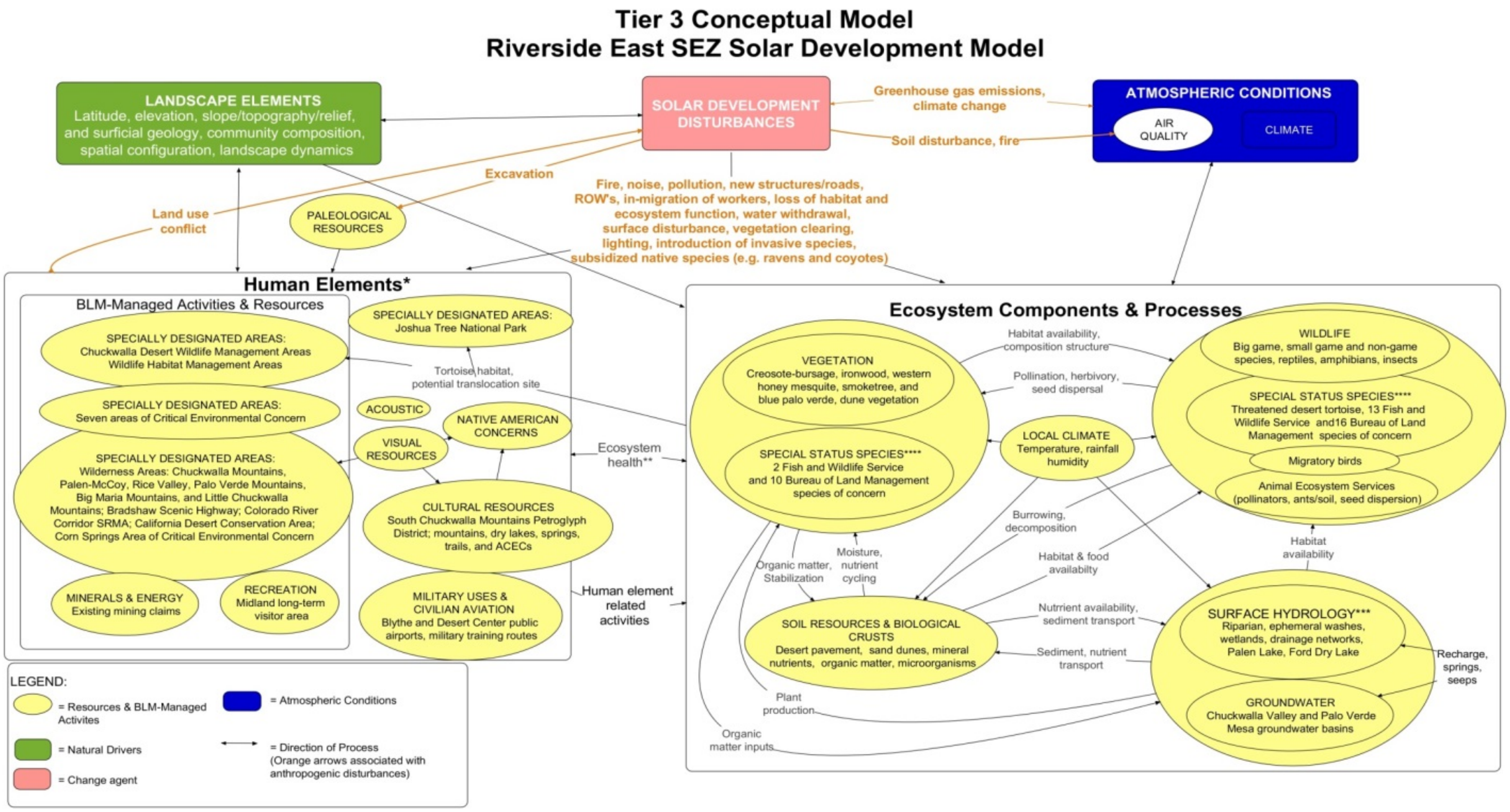


Figure 2-1 Conceptual Model of Ecosystem Components and Processes in the Sonoran-Mojave Ecoregion



* Human Elements includes the human concerns and related resources for which impact evaluation was included in the Solar PEIS. These are activities and resources with (or requiring) human engagement in one of the following ways: 1) requires active participation in management of a resource or activity (e.g., lands and realty, specially designated areas, transportation, mineral development, recreation, military uses); 2) addresses the perspective or perception of a resource (e.g., visual resources, acoustics, lands with wilderness characteristics, cultural); and/or 3) addresses human- specific values (e.g., cultural resources, Native American concerns, socioeconomics, environmental justice).
**Ecosystem health is referred to as the degree to which the integrity of the soil and the ecological processes of the ecosystem are sustained (BLM Handbook H-4180-1). Ecosystem health can influence Native American concerns, visual resources, specially designated areas, and recreation. Human elements can also influence ecosystem components (e.g.,recreation can compact soils, hunting can impact species, etc.).
***Unavoidable hydrologic impacts may occur due to changes in drainage and recharge patterns. Potential impacts to water availability will be mitigated on-site through the implementation of a net neutral use policy (water rights must be purchased).
****Special status plant and animal species can be found in an appended table.

Note: All the elements of Tier 2 carry over to Tier 3; however, space constraints limit the number of Human Elements that can fit within the present design.

Figure 2-2 Conceptual Model of Ecosystem Components and Processes in the Riverside East SEZ

2.2.2 Key Management Questions and Management Goals

An interdisciplinary team (IDT) consisting of local BLM resource specialists identified specific management questions and geographies of interest for the Riverside East SEZ LTMS. The management questions provide the basis for developing monitoring goals. The IDT developed management questions to address the issues relevant to landscape-level impact assessment of solar energy development as well as existing land management plan requirements (e.g., Northern and Eastern Colorado Desert Coordinated Management Plan [NECO]). For example, off-site soil erosion may result from soil disturbance and hydrologic modifications required for project site development. Consequently, one management question was, "How much soil erosion by wind and water is occurring before, during, and after construction?" Management goals were developed in response to each management question to define the desired resource conditions. For example, "minimize soil erosion impacts to desert pavement, dry lakes, sand dunes, fluvial and aeolian sand transport corridors, and sand source areas" would be a management goal that addresses the earlier management question related to soil erosion. Management questions and management goals for each resource are provided in Table 2-1.

Table 2-1 Management Questions and Management Goals for the Riverside East SEZ LTMS

Management Questions	Management Goals
Physical Resources–Soil	
• How much soil erosion by wind and water is occurring on-site and downslope before, during, and after solar facility construction? • Are on-site ground disturbances and facilities design and construction altering natural patterns and volumes of off-site soil erosion by wind or water?	• Minimize soil erosion impacts on desert pavement, dry lakes, sand dunes, and fluvial and aeolian sand transport corridors, and sand source areas. • Minimize soil erosion on- and off-site. • Control fugitive dust to minimize airborne particulates. • Protect essential blows and habitat and sand source for populations of Mojave fringe-toed lizard (a BLM sensitive species), including within the Palen and Ford dry lake/dune system
Physical Resources–Hydrology	
• Do solar facilities significantly alter off-site surface water flow? • Is solar-related groundwater withdrawal affecting surface water hydrology? • Is/are the groundwater basin(s) in overdraft? If so, to what degree?	• Maintain off-site surface water flow volumes and patterns in ephemeral, intermittent, and perennial water bodies within the watershed. • Minimize degree of divergence from the natural, pre-development balance of the groundwater supply (recharge/discharge) within the watershed • Maintain the hydrology of seeps and springs, groundwater-dependent streams, and wet playas within the watershed.
Physical Resources–Air Quality	
• Is solar development affecting regional air quality?	• Minimize solar-related changes in regional air quality.
Ecological Resources–Vegetation	
• What is the baseline status and trend of vegetation communities inside and surrounding the SEZ? • Are solar facility operations affecting vegetation communities in off-site areas? • Are solar facility operations affecting biological soil crusts? • Have changes in surface hydrology related to solar facility construction affected off-site vegetation alliances downslope of solar facilities and riparian vegetation communities, particularly desert dry wash woodlands? • Is solar-related water withdrawal affecting riparian habitats and ground water-dependent (phreatophytes) vegetation communities?	• Ensure facility operations do not promote the spread of non-native, invasive plant species. • Maintain vegetation communities, especially those that depend on groundwater (phreatophytes). • Maintain vegetation physiological functions. • Preserve vegetation communities that are rare. • Preserve important vegetation habitats for wildlife. • Maintain riparian vegetation cover. • Minimize impacts on biological soil crusts.

Table 2-1 (Cont.)

Management Questions	Management Goals
Ecological Resources–Wildlife	
• Are solar facilities affecting migration corridors for terrestrial species? • What is the impact of disease on kit fox populations subject to disturbance from large-scale renewable energy development?	• Minimize solar-related mortalities. • Ensure long-term habitat use and maintenance of habitat used by migratory birds. • Maintain suitable habitats and habitat connectivity.
Ecological Resources–Special Status Species	
• What is the condition of habitats for special status species in and near the SEZ before and after solar facility construction and operations? • What are the impacts on habitat connectivity between the Chuckwalla and Chemehuevi critical habitat units (CHUs), especially within the higher valued habitat on the west side of the Chuckwalla Valley? • Is solar development leading to an increase in the local abundance of tortoise predators (e.g., ravens and coyotes)?	• Ensure solar development does not impede the recovery of desert tortoise populations specified in the recovery plan. • Recover populations of the desert tortoise in the Chuckwalla and Chemehuevi critical habitat units by meeting the criteria for recovery as specified in the 2012 USFWS Desert Tortoise Recovery plan. • Mitigate effects on tortoise populations and habitat outside CHUs to provide connectivity between CHUs. • Reduce tortoise direct mortality resulting from interspecific (e.g., raven predation) and intraspecific (e.g., disease) conflicts that likely result from human-induced changes in ecosystem processes. • Ensure long-term viability of bighorn sheep populations and habitat. • Maintain bighorn sheep habitat connectivity within and between demes. • Maintain special status species population targets specified in land management plans.

Table 2-1 (Cont.)

Management Questions	Management Goals
Sociocultural Resources	
• Do site construction, operations, and increased site access and visitation negatively affect existing site uses, user experiences, cultural values, recreational value experience, or use? • Do site construction, operations, and increased site access and visitation negatively affect transportation? • Does cumulative solar development within the SEZ negatively affect visual values within and near the SEZ for daytime views, and if so, what are the nature and extent of the changes? • Do the visual impact levels predicted in the project EISs accurately reflect the impacts of the projects, whether or not required mitigation was in fact implemented, and whether or not it was effective where it was implemented? • Does solar development within the SEZ negatively affect night sky quality, and/or negatively affect nighttime views of the landscape within the SEZ? • Do site construction, operations, and increased site access and visitation negatively affect • Native American concerns? • How is solar development affecting the contextual integrity of cultural and paleontological sites?	• Avoid and/or minimize removal of cultural artifacts, fossil resources, and impacts on traditional use areas (e.g., lithic tool stone sources, vegetation resources for basket making, arrow making, medicinal plants, and so on). • Protect cultural resources from increased visitation and accesses. • Maintain baseline recreational opportunities and uses, and quality of experiences. • Maintain scenic quality consistent with inventoried VRI class value in order to preserve landscape/scenic values. • Minimize impacts of light on the night sky and on wildlife. • Minimize impacts, over time, on views from VSAs. • Ensure compliance with, and effectiveness of, visual impact mitigation for solar energy projects within the SEZ. • Minimize erosion to sacred areas and trails. • Protect cultural and paleontological resources from solar-related impacts from wind and water erosion. • Maintain integrity of cultural and paleontological resources.

2.2.3 Monitoring Objectives

To develop monitoring objectives, the IDT evaluated the management questions, regulatory requirements, and program needs, including land health fundamentals and standards, as well as key ecological elements as defined in the conceptual model. The IDT also considered the input of stakeholders. All monitoring indicators and objectives were formulated to be specific, measurable, achievable, relevant, and time sensitive (SMART) and derived from the ecosystem conceptual models and/or linked to specific management questions (Williams et al. 2009). For example, monitoring objectives need to indicate the desired amount of change (specific), level of confidence for the measured change (measurable), funding and capacity requirements (achievable), relationship to the management question (relevant), and time frame during which the measurement occurs to effectively inform management (time sensitive).

Given the variety of social, ecological, and physical resources the LTMS was designed to address, it is not possible to directly and comprehensively monitor all resources. The constraints of personnel -and long-term funding for carrying out the monitoring strategy may vary over time. Consequently, it was necessary to prioritize resource-monitoring objectives to identify those that address key resources that can feasibly be monitored. After the initial list of monitoring objectives for sociocultural, ecological, and physical resources were developed, the monitoring objectives were prioritized by using a modified method and criteria adapted from the National Park Service (Fancy et al. 2009). The method considered multiple criteria related to (1) the importance of the monitoring objective for decision-making and (2) the feasibility of monitoring the objective. The following are some examples of criteria used for prioritizing monitoring objectives:

- The monitoring objective addresses the appropriate scale (SEZ- or landscape-level, rather than individual project).
- Achieving the monitoring objective will produce results about indicators that BLM managers and the general public clearly understand and from which implications for adaptive management actions are apparent.
- The monitoring objective addresses a resource and/or impact that drives processes in the conceptual model of the system and/or is of high concern based on stakeholder input, BLM Resource Management Plans (e.g., NECO Plan), or analyses in the Solar Programmatic EIS.
- The monitoring objective addresses potential impacts specifically related to solar energy development.
- The monitoring objective provides an early warning if undesirable changes in the ecological system are affecting important resources.

- The monitoring objective addresses multiple management goals and/or questions.

Additional criteria were used to assess the feasibility of the monitoring objectives. Examples include the following:

- The monitoring objective can be achieved by using existing data sources.
- The monitoring objective can be achieved through cost-sharing partnerships with other agencies, universities, or private organizations to obtain data.
- Appropriate control sites are available to achieve the monitoring objective.
- Based on the indicator(s) and baseline data required to achieve the objective, the monitoring objective is realistic to achieve given the constraints of sample size, personnel, and time.
- The monitoring objective addresses a resource with a legal or policy requirement for monitoring.
- Achieving the monitoring objective will not require significant ancillary data collection or analysis to interpret the primary monitoring data.
- The monitoring objective can be achieved by using cost-effective methods, given the indicator (s) and baseline data required to achieve the objective.
- Well-documented, scientifically sound monitoring protocols already exist for the monitoring objective.
- The data collected to achieve the monitoring objective do not exhibit large, naturally occurring variability that would require significant sample size to achieve appropriate statistical power.

In addition, many critical resources in the Sonoran Desert and Colorado Desert are not well studied, and basic research studies are still necessary in order to formulate specific monitoring hypotheses. The time and expense of conducting basic research studies are beyond the scope of the LTMS. Therefore, monitoring objectives requiring basic research were not incorporated into the monitoring strategy. However, new data from non-LTMS studies will be incorporated into LTMS decision making as it becomes available.

2.2.4 DOE/BLM Public Outreach and Public Response to Monitoring Objectives

A draft list of monitoring objectives was presented at a Riverside East SEZ LTMS kickoff meeting held December 11–12, 2013. Based on stakeholder comments, the initial set of monitoring objectives was revised to accommodate stakeholder input. Examples of new monitoring objectives derived from stakeholder input include the following:

- Detect temporal changes of management significance in the amount or quality of habitat for migratory birds relative to control areas.
- Detect temporal changes in the visual character of the landscape including night sky.
- Detect temporal changes of management significance in sand dune size, location, and sand transport rates relative to control areas.
- Detect temporal changes of management significance in the abundance of indicator species relative to control areas.

A prioritized list of monitoring objectives, indicators for achieving monitoring objectives, and a monitoring strategy outline were presented to stakeholders in a second webinar held on May 28, 2014, at which time webinar participants were asked to provide input on the initial prioritization of monitoring objectives. Following the webinar, several resource impacts were given high priority based on stakeholder input including the following:

- Wildlife corridors for the desert tortoise, burro deer, desert bighorn sheep, Mojave fringe-toed lizard, and other BLM-listed sensitive species, as identified in the Desert Renewable Energy Conservation Plan (DRECP); and
- Invasive wildlife and their effects on special status species (e.g., desert tortoise predators).

Resource specific monitoring objectives for the Riverside East SEZ LTMS are provided in Table 2-2. Ultimately, the BLM will establish quantitative monitoring objectives that will specify the desired precision of statistical change detection for the monitoring indicators as well as the magnitude of change that is considered to be of management significance. An example of a quantitative monitoring objective would be “Detect a change in the cover of microphyll woodland in the Riverside East SEZ of ≥15%.” Changes in resources can be found to be statistically significant, but not have any management significance. Therefore, sample size will be calculated based on the number of samples required for the minimum detectable change deemed to have management significance. The ability to detect change in a resource-monitoring indicator is a function of the natural variability of the indicator and the number of samples that can be feasibly collected. Pilot sampling may show that the sample size necessary to detect some of these changes may be infeasible, in which case the minimum detectable change may have to be increased. These key pieces of information are currently uncertain for many resources of interest to the LTMS. Therefore, in general, quantitative change detection objectives cannot be established at this time. However, as baseline indicator data are obtained for the LTMS, information will become available to address these data gaps.

Table 2-2 Monitoring Objectives for the Riverside East SEZ Long-Term Monitoring Strategy

Physical Resources

2. Detect temporal changes of management significance in stream channel location and morphology relative to control areas[a]
3. Detect temporal changes of management significance in soil erosion/accretion relative to control areas..
4. Detect temporal changes of management significance in the cover and integrity of desert pavement relative to control areas.
5. Detect temporal changes of management significance in sand dune size, location, and sand transport relative to control areas...
6. Detect temporal changes of management significance in groundwater surface elevations in monitoring wells as well as the spatial pattern and extent of these groundwater surface elevation changes on or near projects.
7. Detect temporal changes of management significance in PM10 within the SEZ.

Biological Resources

8. Detect temporal changes of management significance in total plant cover, intercanopy gaps, and woody plant height relative to control areas.
9. Detect temporal changes of management significance in the cover of biological soil crust relative to control areas.
10. Detect temporal changes of management significance in rare and high-priority vegetation communities (i.e., microphyll woodland (*Parkinsonia florida—Olneya testota* Woodland Alliance); groundwater dependent vegetation) relative to control areas.
11. Detect new introductions of invasive plant species relative to control areas.
12. Detect temporal changes of management significance in the wildlife indicator species abundance relative to control areas.
13. Detect invasive wildlife species within the SEZ. The monitoring will focus on detecting changes in raven and coyote numbers relative to control areas.
14. Detect temporal changes of management significance in the abundance of the Mojave fringe-toed lizard relative to control areas.
15. Detect temporal changes of management significance in habitat quality and connectivity for desert tortoise, burro deer, and Mojave fringe-toed lizard relative to control areas.
16. Detect temporal changes of management significance in use of designated wildlife corridors within the SEZ by desert bighorn sheep and burro deer relative to control areas.

Sociocultural Resources

17. Detect temporal changes of management significance in permit requests and visitation for long-term visitor use areas.
18. Detect temporal changes of management significance in traffic within and near the SEZ.
19. Detect cumulative temporal changes in visual resource inventory scores within the SEZ
20. Detect temporal changes in the nature and amount of lighting from solar facilities directly visible from locations within the SEZ.
21. Detect temporal changes in the number of reported impacts on paleontological resources relative to control areas.
22. Detect temporal changes in the number of reported impacts on cultural resources and areas of native American concern relative to control areas.

[a] Sampling and data analysis will follow a Before-After Control-Impact (BACI) design, which is described in Section 2.3.2.

2.3 Monitoring Indicators, Methods, and Sampling Design

2.3.1 Monitoring Indicators

Monitoring indicators were identified to address each monitoring objective related to physical, ecological, and sociocultural resources. The AIM Strategy core and contingent indicators (Section 2.1) were used to address monitoring objectives when they were relevant. The AIM core indicators applicable to the ecological resource-monitoring objectives include intercanopy gaps, vegetation composition, non-native invasive plant species, and plant species of management concern (Toevs et al. 2011).

In addition to the AIM core indicators, multiple supplemental indicators were identified when the AIM core indicators alone were not adequate to address the monitoring objectives. The supplemental indicators were further refined based on the following criteria:

- Relation of a change agent to the indicator is unambiguous,
- Sensitivity to detection,
- Ability to maximize certainty,
- Minimization of cost, and
- Technical feasibility.

Monitoring indicators proposed for the Riverside East LTMS are provided in Table 2-3.

Table 2-3 Summary of Monitoring Indicators Proposed for the Riverside East SEZ

Physical Resource Indicators
• Soil aggregate stability, texture, infiltration; depth
• Groundwater elevation
• Stream channel depth, width, and location
• Particulate matter monitoring
• Desert pavement cover and integrity (remote sensing)
• Sand dune size, location and sand transport rates (remote sensing)
Biological Resource Indicators
• Cover of biological soil crusts (remote sensing)
• Vegetation cover (remote sensing)
• AIM core vegetation indicators
• Abundance and distribution of wildlife indicator species
• Raven and coyote abundance
• Special status species indicators

Table 2-3 (Cont.)

Sociocultural Resource Indicators
• Visual contrast at visually sensitive areas (VSAs)
• Nighttime illumination (night sky)
• Visual Resource Inventory (VRI) factors and VRI class
• Number of long-term and short-term passes requested;
• Number of visits and visitor days
• Traffic amount and distribution
• Number of reported impacts on cultural resources and areas of Native American concern
• Number of reported impacts on paleontological resources

2.3.2 Sampling Methods, Sampling Design, and Data Analysis

The AIM Strategy requires a statistically valid sampling design that defines the study area, relevant environmental strata within the study area, and the allocation of sampling points using a stratified random sampling design. The study area was defined as the Riverside East SEZ and additional areas that will serve as control sites.

The LTMS also adopts the BACI approach recommended by the DRECP Independent Science Advisors (2010). The BACI design requires that indicator data be collected both before development begins (to define baseline conditions) and after development occurs. The collection of baseline data that reflect the conditions of resources before construction and operation is necessary to detect long-term deviations from baseline conditions. The BACI approach also requires that resource indicator data be collected at both impact sites and multiple control sites (i.e., sites considered to be outside the area of potential effect but that otherwise have characteristics similar to those of impact sites). To accommodate a BACI design, three broad impact strata related solar development were identified:

- Solar buffer stratum (buffer),
- Nonbuffer SEZ stratum (SEZ), and
- Reference stratum (reference).

The solar buffer stratum consists of a 2-mi (3-km) buffer area around existing and potential solar developments based on the current project boundaries of BLM-authorized and -permitted projects (Figure 2-3). The buffer area is consistent with the area used for the pilot regional mitigation project for the Dry Lake SEZ in Nevada (BLM 2014) and is considered to be an area of indirect effects that is feasible to monitor. The non-buffer SEZ stratum represents the remainder of the SEZ where impacts are uncertain (outside solar development footprints and the 2-mi (3-km) buffer zones but still inside the SEZ).

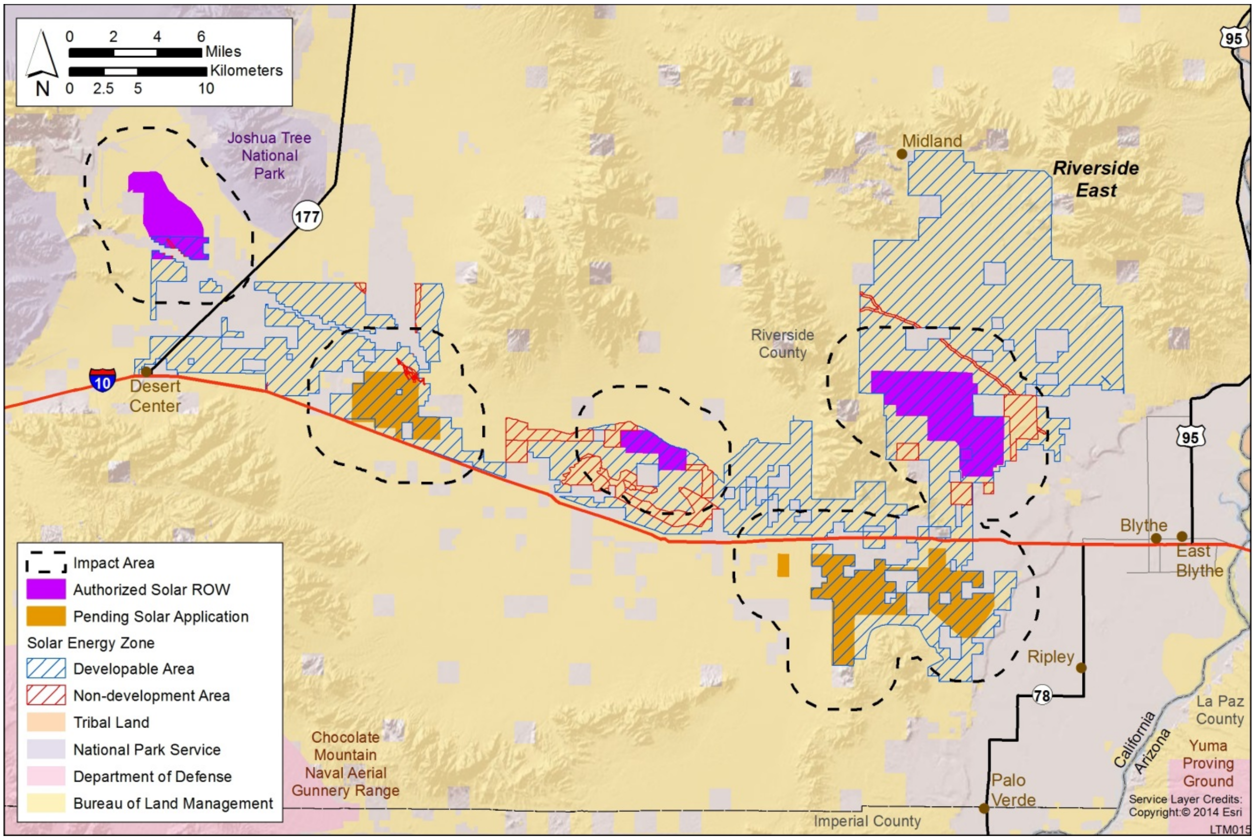


Figure 2-3 Authorized and Pending Solar Energy Projects within the Riverside East SEZ and a 2-mi (3-km) Buffer around these Projects That Will Serve as One of the Three Solar Development Impact Sampling Strata

This stratum is needed to detect the spatial extent of resource change and to account for solar development impacts that extend beyond the 2-mi (3-km) buffer. The reference stratum represents "control" sites that are not expected to be affected by solar development. Solar energy projects at the Riverside East SEZ are in various stages of development, ranging from pending approval by the BLM to currently operational. Because some solar facilities in the Riverside East SEZ are already under construction and/or operational, the BACI approach cannot be fully implemented for these facilities. However, BACI elements will be implemented to the extent achievable for this pilot LTMS and more fully for LTMSs for other SEZs.

The selection of appropriate control sites (also referred to as reference sites) is a critical aspect of a long-term monitoring program that uses the BACI approach (Underwood 1994). Control sites are important because simple comparisons of conditions before and after project development could be confounded by any temporal changes in the region (e.g., weather events, changes in climate patterns, precipitation patterns, fire, or other catastrophic events). In addition, many other factors can affect resources independent of a particular project (e.g., human activities, landscape context); these factors must be controlled for. Appropriate control sites can aid in interpreting monitoring data by allowing differentiation between development and environmental responses. The locations of control sites will be optimized to support more than one project where possible. Each project will likely require more than one control site in order to support analyses across a broad spectrum of natural and cultural resources. Control sites will not be required for long-term monitoring of some resources (e.g., visual resources) because impacts on these resources are considered to be driven primarily by project-specific and site-specific factors (i.e., they are less affected by other changes in the region).

Additional sampling stratification is necessary to examine solar development impacts on specific soil and vegetation communities of high interest or value. Monitoring locations can be stratified by ecological site descriptions (ESDs) developed by the National Resource Conservation Service (NRCS) (Taylor et al. 2014). These ESDs can be incorporated as biophysical substrata within the three broader strata related to solar impacts. However, ESD designations have not been completed for the Riverside East SEZ; therefore, vegetation alliance maps (Menke et al. 2013) were combined with landform layers to create biophysical sampling strata for use in pilot AIM monitoring for the Riverside East SEZ, which began in 2014. The biophysical strata used for AIM monitoring are described in detail in Section 5.2.4. The allocation of sampling plots will be proportionate to the area of each biophysical stratum.

There are multiple statistical approaches for analyzing BACI studies depending on the specifics of the experimental design (Underwood 1994; Benedetti-Cecchi, 2001; Stewart-Oaten and Bence 2001; Smith 2002; Terlizzi et al. 2005). For example, using a two factor analysis of variance (ANOVA) with location (buffer, SEZ, and reference) and time (before and after construction) as factors, a significant interaction between the location and time factors would be evidence of an impact from solar development (Underwood 1994). Impacts can also be identified by measuring the impact indicator (e.g., vegetation cover, number of non-native species) at reference and impact locations multiple times before and after the construction of solar energy facilities and then comparing the difference between the mean value of the impact indicator at the reference and impact sites before and after the construction and operation of the solar facility. A significant change in the difference between the two locations after construction would be indicative of a solar-related impact (Stewart-Oaten and Bence (2001). Statistical trend analysis can also be used for BACI designs with the goal of detecting significant change points in the monitoring data series (Torres et al. 2011). In this analysis, post-construction changes in data trends at the impact location, but not the reference location, would be evidence of solar development impacts. Detailed discussions of the design and statistical analysis of BACI studies can be found in Underwood (1994), Stewart-Oaten and Bence (2001), and Smith (2002). For indicators for which biophysical strata are incorporated into the sampling plan, the statistical analysis will also need to take into account the fact that the data were collected using stratified random sampling.

It is also critical that the Riverside East SEZ LTMS incorporate existing baseline and ongoing monitoring data. Although the collection of project-level baseline data will largely be the responsibility of developers, the BLM will take an active role in identifying and collecting priority baseline data for the SEZ and in developing consistent monitoring schema to reduce administrative and financial burdens to developers. Costs are also expected to be reduced in SEZs because of the ability to pool investments for monitoring and to coordinate with other federal, state, and local agencies in maximizing partnerships and data sharing. The BLM intends to coordinate the capture of monitoring data with partners and permittees through the deployment of the Solar LTMS across Solar PEIS program lands and appropriate control sites. For example, data from existing public and privately owned wells will be used to monitor groundwater elevation in the study area. Data from project-specific solar monitoring plans that were required for project permitting will also be incorporated into the LTMS for the Riverside East SEZ (note, however, that collection of project-level baseline data will largely be the responsibility of developers).

Although the goal of the LTMS is to detect changes in key resources within the Riverside East SEZ, the detection of change does not necessarily mean the change was due to solar development activities. For some resources, the monitoring objectives described in the Riverside East SEZ LTMS (See Table 2-2) will have a limited capacity to determine cause and effect, especially for ecological resources controlled by a complex set of physical, biological, and human drivers, including climate change. However, the detection of change in a resource’s status and trend will act as a trigger, prompting more detailed investigations specifically designed to determine causal factors. In this way, LTMS data will be an important contribution to adaptive management decision making (Section 1.3).

2.4 Monitoring Objectives Not Addressed in the LTMS

Several monitoring objectives suggested by stakeholders ultimately were not included in the LTMS. The reasons for not including these monitoring objectives varied by resource, but were primarily related to feasibility, cost-effectiveness, and expected spatial scale of the solar development impacts. One example is avian mortality related to the operation of solar facilities. There is significant stakeholder interest in this issue following reports of bird deaths near solar power towers. To comply with state and federal regulatory requirements (e.g., Migratory Bird Treaty Act, Endangered Species Act, and Bald and Golden Eagle Protection Act), monitoring protocols have been established at several existing solar facilities to systematically search the project facility and quantify mortality rates (Walston et al. 2015). These studies include methods to account for searcher efficiency, predation/scavenger biases in the calculation of a site-wide mortality rate, and background/natural mortality (H.T. Harvey & Associates 2015a, 2015b). In addition, mortality monitoring protocol standards are being developed by the U.S. Fish and Wildlife Service (USFWS) and the U.S. Geological Survey (USGS). The Riverside East LTMS does not include new bird mortality monitoring because these project-specific studies are already established. However, data from these studies will be reviewed as part of the Riverside East SEZ LTMS and used in adaptive management decision making. Resource impacts not included in the LTMS, as well as reasons for not including resources, are detailed in Table 2-4.

Table 2-4 Resource Changes Not Included in the Riverside East SEZ LTMS

Resource Change	Reason for Not Including in the Riverside East SEZ LTMS
• "Heat island" related to solar projects.	• Project-specific; significant impacts not anticipated given existing data
• The amount, location, type, or recreation uses around the facility.	• Recreational use of the Riverside SEZ is low.
• The reported recreational user experience around the facility.	• Recreational use of the Riverside SEZ is low.
• The income and employment of low-income and minority populations.	• Significant impacts not anticipated given existing data
• Human health (regional) including low-income and minority populations.	• Difficult to obtain data; will be monitored if dust-monitoring data trigger a need to monitor public health
• Noise levels within the SEZ.	• Existing monitoring data does not suggest noise related to solar development will be a regional issue.
• Glint/glare levels above visual impairment levels.	• Project-specific impact
• Cumulative impacts on military uses.	• Project-specific impact
• Bird mortality related to solar energy development operations.	• Project-specific studies already exist.
• Changes in plant pollination. plant litter, and seed dispersal	• Not feasible to monitor; vegetation impacts are covered by other monitoring objectives.
• Determine the position of solar developments in relation to migratory bird pathways.	• Research question •
• Change in carbon fluxes and sequestered carbon	• Project-specific; no well-documented way to monitor; requires basic research.

[a] Although a comprehensive litter-monitoring program will not be undertaken, ground cover, including litter, is monitored under AIM protocols.

2.5 Summary and Prioritization of the Monitoring Indicators Proposed for the Riverside East SEZ LTMS

Monitoring indicators and proposed sampling methods and sampling designs for each monitoring indicator are summarized in Table 2-5. AIM indicators will be monitored by using the methods specified in MacKinnon et al. (2011). The supplemental indicators will be monitored by using standard methods supported by the peer-reviewed literature (Belnap et al. 2008). A detailed description of sampling methods and sampling designs is provided in 4, 5, and 6 for physical, biological, and sociocultural resources, respectively..

As described in Section 1.5, prioritization of monitoring objectives and indicators is necessary because of the expense of long-term monitoring. Consequently, each indicator has been prioritized (Table 2-6). The highest priority monitoring objective indicators were related to potential physical and biological impacts, such as groundwater elevation, soil erosion, and AIM vegetation indicators. Lower priority indicators included traffic, long-term visitor area (LTVA) visitation, and visual resource impact indicators. Although it is the intention to monitor all indicators in Table 2-5, available funding will first be allocated to the highest priority resource indicators.

Table 2-5 Summary and Prioritization of Monitoring Indicators Used for the Riverside East SEZ

Indicator(s)	Method	Sampling Strata	Point Sampling versus RM	Data Analysis
Soil aggregate stability; texture, infiltration; depth	1. Data on soil aggregate stability, soil texture, soil depth, and soil infiltration will be collected once per year. 2. Qualitative visual observations of signs of erosion at each sampling plot with data sheets covering rills, gullies, pedestals, deposition and runoff, and water flow. 3. Photographs at each sampling site for visual signs of erosion.	Three solar impact strata (buffer, SEZ, and reference). Within the buffer strata, plots located down slope and downwind of solar development projects where wind- and water-related soil erosion is most likely to occur.	Point sampling within established plots	The number of rills can be quantified by manual counts using ground-based photographs. For each biophysical stratum, changes in the number of rills and the five soil indicators will be compared among impact strata (buffer, SEZ, and reference) and time (before and after solar facility construction) for evidence of an impact using a BACI statistical analysis.
Groundwater elevation	Well monitoring using electronic probe or programmable data-loggers	Data from existing wells (individual project; USGS National Water Information System [NWIS] wells); new wells may be needed but not initially called for because of high cost and because optimal locations will come into focus in the future.	Point sampling	Data evaluation should include graphs of water levels versus time at solar power plant monitoring wells, NWIS wells, and other wells within the SEZ; Anticipated drawdown may be evaluated through analytical or numerical flow models.
Stream channel depth, width, and location	Ground-based photography and archived photographs	Three solar impact strata (buffer, SEZ, and reference). Imagery will be obtained for randomly selected streams and washes downslope of existing or planned solar facilities within the (3-km) buffer zone. Further stratification may be used to target streams by erosion risk and channel size; reference streams.	Discreet photography locations	Changes in channel morphology metrics at solar impact and reference areas quantified from imagery and compared before and after solar development using a BACI statistical analysis

Table 2-5 (Cont.)

Indicator(s)	Method	Sampling Strata	Point Sampling versus RM	Data Analysis
Particulate matter monitoring	New climate stations	It is recommended that four monitors be set up at locations both upwind and downwind of the primary and secondary prevailing wind directions around the impact site; PM10 will be monitored at Joshua Tree National Park.	Point Sampling	Pre-construction monitoring data will be compared to dust concentrations and dispersion from solar facility activities; identify potential dust dispersion patterns.
Desert pavement cover and integrity	Quantify cover of desert pavement and degree of disturbance using remote sensing	Remotely sensed imagery will be used to map continuous cover and disturbance to desert pavement within each solar impact stratum (buffer, SEZ, and reference).	Continuous mapping using remote sensing	BACI; comparison of quantitative changes in desert pavement within buffer, SEZ, and reference impact strata before and after facility construction.
Dune location and sand transport rates	Quantify cover of dune cover, location, and movement	Dale Lake–Palen Dry Lake sand Corridor and the Palen Valley corridor, Palen-McCoy Valley through Chuckwalla Valley sand transport corridor. Bristol Trough sand path could serve as a potential reference site.	Continuous mapping using remote sensing	BACI; comparison of quantitative changes in sand dune cover location, and movement in buffer, SEZ, and reference impact strata before and after facility construction
Biological soil crust (BSC) cover	Quantify cover of biological soil crusts using remote sensing and image analysis	Remotely sensed imagery will be used to map continuous groundcover of BSCs within each solar impact stratum (buffer, SEZ, and reference).	Continuous mapping using remote sensing	BACI; comparison of quantitative changes in BSCs within buffer, SEZ, and reference impact strata before and after facility construction.
Vegetation cover	Quantify cover of vegetation, using remote sensing and image analysis	Remotely sensed imagery will be used to map continuous groundcover of vegetation within each solar impact stratum (buffer, SEZ, and reference).	Continuous mapping using remote sensing	BACI; comparison of quantitative changes in vegetation cover within buffer, SEZ, and reference impact strata before and after facility construction.
AIM core vegetation indicators	As specified in Herrick et al. (2015)	Biophysical strata and three solar impact strata (buffer, SEZ, and reference).	Random stratified plots sampling	BACI; comparison of quantitative changes in AIM core indicators in buffer, SEZ, and reference impact strata before and after facility construction.

Table 2-5 (Cont.)

Indicator(s)	Method	Sampling Strata	Point Sampling versus RM	Data Analysis
Abundance and distribution of wildlife indicator species.	Point count surveys and nesting surveys for abundance nest number, clutch size, hatching success, and fledging success (birds only) of black-tailed gnatcatcher loggerhead shrike, and verdin; methods for desert kit fox abundance not specified	Surveys should be confined to areas representing potential habitat for each wildlife indicator within each solar impact stratum (buffer, SEZ, and reference) to establish baseline. Post-construction surveys should be conducted annually (at minimum).	Point sampling within established plots	Spatial and temporal trends in relative abundance, nest numbers, clutch size, hatching success, and fledging success will be quantified at the three impact strata (buffer, SEZ, reference areas) and analyzed for evidence of solar development impacts using a BACI statistical framework.
Raven and coyote abundance	Methods for coyote abundance not specified; point count surveys for raven abundance	Surveys should be confined to areas representing potential habitat for coyote and ravens within each general solar impact monitoring stratum (buffer, SEZ, and reference). Additional monitoring locations will focus on detecting changes in raven and numbers in the Chuckwalla CHU.	Point sampling within established plots	Spatial and temporal trends in raven and coyote abundance will be analyzed within the three impact strata (buffer, SEZ, reference area) over time using a BACI statistical framework.
Special status species indicators	Monitoring habitat and habitat linkages for desert tortoise, Mojave fringe-toed lizard, burro deer, and bighorn sheep Direct species monitoring of burro deer, bighorn sheep, and Mojave fringe-toed lizard	Habitat and species monitoring should be conducted in potential habitat or movement corridors within each solar impact stratum buffer, SEZ, and reference).	RM and field monitoring of habitat; direct species monitoring will use transects and aerial surveys.	Habitat monitoring methods for the Riverside East SEZ LTMS include sand dunes and vegetation. Temporal trends in habitat monitoring indicators will be compared within each impact stratum (buffer, SEZ, and reference) using a BACI statistical framework. Spatial and temporal trends in relative abundance of the Mojave fringe-toed lizard, burro deer, and bighorn sheep will be quantified in their respective habitat and corridor areas located within the three impact strata (buffer, SEZ, and reference) and analyzed for evidence of solar development impacts using a BACI statistical framework.

Table 2-5 (Cont.)

Indicator(s)	Method	Sampling Strata	Point Sampling versus RM	Data Analysis
Visual contrast at VSAs	Field assessment, using the BLM Visual Contrast Rating (VCR) process at each key observation point (KOP) within a VSA.	KOPs within VSAs within the viewshed of the SEZ, as identified and assessed in the PEIS. The PEIS visual impact analysis did not include areas important to tribes, nor were VSAs selected with input from BLM staff or local stakeholders. These parties should be engaged to identify new VSAs and KOPs.	Point sampling	The VCR results and photographs for each KOP should be compared to the VCRs and simulations from the project EIS. Any significant differences should be documented, and similarly, discrepancies between the simulations in the project EIS and the photographs taken during the monitoring assessment should be documented. Visual impact mitigation monitoring involves analyzing the photographic and text-based record of the observed measures taken to mitigate visual impact associated with the various stages of development of a utility-scale solar energy facility.
Nighttime Illumination (night sky)	Estimation of limiting magnitude by star counts using Bortle scale or night sky meters; measuring brightness using charge-coupled device (CCD) images from an automated camera system	Establish a network of photo monitoring points within the SEZ. It may be possible to cover the entire SEZ with as few as six points.	Point sampling	Change in night sky over time
VRI factors and VRI class	VRI class determined from the VRI factor ratings using BLM VRI handbook	The VRI assessments should be conducted at the inventory observation points (IOPs) used for PEIS (2011). New IOPs may be established if the new solar facility or facilities are so far from existing IOPs that effects on scenic quality cannot be detected or assessed.	Point sampling	Using the 2011 inventory as a baseline, any changes over time to either the sensitivity or the scenic quality components, or the composite scores for the factors, or the overall VRI class recorded and discussed in a report prepared for the assessment.

Table 2-5 (Cont.)

Indicator(s)	Method	Sampling Strata	Point Sampling versus RM	Data Analysis
Number of requested and issued use permits for the LTVA	Midland LTVA data for the previous season should be collected after April 15 and prior to September 15 annually. Data currently collected by BLM.	Data should be collected for a Midland LTVA; the Mule Mountains LTVA can be used as a control site.	NA	Visitation data and permits issued will be calculated for the Midland LTVA and the reference site before and after solar development activities. Relative changes in permits and visitation at the two areas over time will be analyzed using a BACI statistical framework to determine whether any changes are related to solar development.
Traffic amount and distribution	Traffic counts by the California Department of Transportation; off-highway vehicle (OHV) traffic within the SEZ currently collected by the Palm Springs Field Office	Key intersections along I-10 and other major roads through and near the SEZ	NA	Calculate percentage change from previous year and percentage change from baseline year.
Number of reported impacts on cultural resources and areas of Native American concern	Site stewards supplied with monitoring forms; monitoring of vehicles, footprints, tire tracks, animal tracks, trash, spent ammunition, targets, fire pits/rings, camping; ground disturbance; incident reports from law enforcement officers, tribal representatives, and general public	Several project-specific cultural resource inventories and impact assessments in the SEZ have been completed; potential ongoing monitoring locations include NRHP/CRHP-listed sites, sites susceptible to a particular impact, highly visible, frequently used trails; areas of Native American concern include important trail systems, sacred sites and traditional use areas, as determined through consultation with tribal representatives; sample selection and size will be dependent on staff and volunteer resources available; control sites for cultural resources would be monitored in a similar fashion.	NA	Comparing baseline data against data collected from follow-up visits using photo documentation and a written record of impacts. Emphasis should be placed on changes in site condition due to increased visitation, fluctuations in water runoff patterns, aeolian sediment deposition or removal, or on land subsidence caused by increased groundwater use, as a result of solar development.

Table 2-5 (Cont.)

Indicator(s)	Method	Sampling Strata	Point Sampling versus RM	Data Analysis
Number of reported impacts on paleontological resources	BLM California should adopt a site steward program modeled on the BLM Utah Paleontological Site Stewardship Program; requires trained stewards to monitor their assigned locality four times a year.	Sites under the greatest threat of erosion, sites with the highest PYFC value, or sites that are frequently visited for recreation. Special consideration should be given to areas where known fossiliferous formations were surveyed.	NA	Data analysis would be similar to the methods used for cultural resources: comparing baseline data against data collected from follow-up visits using photo documentation and written record of impacts to determine new or potential future impacts.

Table 2-6 Summary and Prioritization of Monitoring Indicators Used for the Riverside East SEZ

Priority	Indicator (s)
Physical Resource Indicators	
High	Dune location and sand transport rates
High	Groundwater elevation
High	Particulate matter monitoring
High	Soil aggregate stability, texture, infiltration, depth
Medium	Desert pavement cover and disturbance
Medium	Stream channel depth, width, and location
Biological Resources Indicators	
High	AIM core vegetation indicators
Medium	Abundance and distribution of wildlife Indicator Species
Medium	Biological soil crusts
Medium	Raven and coyote abundance
Medium	Special Status Species Indicators
Medium	Vegetation cover (photography and remote sensing based monitoring)
Sociocultural Resources	
Medium	Number of reported Impacts on cultural resources and areas of Native American concern
Lower	Long-term and short-term passes issued; number of visits and visitor days
Lower	Nighttime illumination (night sky)
Lower	Paleontological resources impacts reported
Lower	Traffic amount and distribution
Lower	Visual Contrast at VSAs
Lower	VRI factors and VRI class

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3 THE ROLE OF REMOTE SENSING TECHNOLOGIES

The AIM Strategy emphasizes the need to incorporate remote sensing technologies into long-term monitoring programs, wherever feasible (Toevs et al. 2011). Remotely sensed data are collected with satellites, aircraft, and ground-based sensors. The resulting imagery is used to characterize resource targets such as vegetation based on how their physical and chemical properties reflect, absorb, and emit electromagnetic radiation.

Remotely sensed data offer some advantages over field-based data collection because remotely sensed data can be collected over large and remote areas that may be difficult, expensive, and time-consuming to characterize with traditional field methods. Because of the continuous spatial coverage provided, data derived from remotely sensed imagery also minimize sources of sampling bias inherent in field data collections such as sampling near roads and undersampling areas that are difficult to access.

3.3 Application of Remote Sensing to the LTMS

Remote sensing has been used to monitor multiple physical and ecological indicators including hydrology and geomorphology (Hughes et al. 2006; Yang et al. 1999), erosional processes (Pelletier et al. 2005), and land cover (Karl et al. 2012; Duniway 2012; Hulet et al. 2014). The AIM core indicators, such as canopy gaps (Karl, Duniway, and Schrader 2012), vegetation cover (Karl et al. 2014) and plant heights (Gillan et al. 2014), can also be monitored using remote sensing methods, which can supplement or reduce the field effort required to reliably detect environmental change. In addition to ecological and physical resources, remote sensing has application to cultural and paleontological resource monitoring (Lasaponara et al. 2010). Recently, remote sensing has been used to characterize multiple resources specifically at the Riverside East SEZ including ephemeral streams, vegetation, BSCs, desert pavement, and sand dunes (Potter and Li, 2014; Hamada et al. 2014). However, the results of these analyses have yet to be validated using field collected data.

3.4 Limitations and the Evolving Nature of Remote Sensing

Overall, the existing literature suggests remote sensing methods can provide data on key ecological, physical, and cultural indicators that are included in the Riverside East SEZ LTMS. However, some limitations are also evident. For example, certain cover types are difficult to analyze for temporal changes because they are not spectrally distinct or require high-resolution imagery that may not be available. Also, differences in atmospheric conditions and sun angle between images may reduce the accuracy of resource quantification in images collected in separate years. Continuing validation of image-processing algorithms is needed to assess their robustness to detecting resource change in a series of images collected over time.

Thus there are uncertainties inherent in the application of remote sensing to long-term monitoring and methods for quantifying certain resource indicators using remote sensing are still in a state of development. Despite the promising utility of remote sensing, its use does not eliminate the need for field-based measurements. In fact, the effective use of remote sensing requires rigorous calibration and validation that uses field-based data. To reliably detect and identify features and quantify parameters, it is likely that a combination of approaches is needed to provide comprehensive and meaningful information for long-term environmental monitoring (Hamada et al. 2011). See Appendix A for a detailed discussion of past and potential future applications of remote sensing to resource monitoring at the Riverside East SEZ.

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4 PHYSICAL RESOURCES INDICATORS

Monitoring indicators are measures that characterize the biological, chemical, or physical attributes of an ecosystem. Sections 4 and 5 describe the monitoring indicators used to achieve monitoring objectives related to physical and ecological resources, respectively. Indicators of physical impacts proposed for the Riverside East SEZ LTMS address the erosion of soil and surface water features following solar facility construction, disturbance of sand dunes and desert pavement, and groundwater drawdown related to solar energy operations. For each section, the rationale for monitoring the indicator is described, as well as how the monitoring indicator relates to the management questions, management goals, indicators, and monitoring objectives discussed in Section 2. Past and ongoing data collection related to the monitoring indicator is described along with the proposed data collection and analysis plan for the indicator that will be used for the LTMS.

4.1 Groundwater Elevation

4.1.1 Rationale for Monitoring the Indicators

In the arid Southwestern United States, water demand is a particular concern. Total water demands among solar technologies differ significantly, with concentrating solar power (CSP) using more water than photovoltaic (PV). Although many solar facilities will utilize PV technology, several solar facility permit applications submitted to the BLM are for the more water-intensive dry-cooled CSP technology (http://blmsolar.anl.gov/documents/docs/Pending_applications_list.pdf). Groundwater pumping for solar facility operations will obtain water from some combination of direct basin recharge, mountain front recharge, aquifer storage, leakage from ephemeral channel flow, and possibly induced recharge from rivers. In an arid location such as the Chuckwalla Basin, the dominant source will be aquifer storage, because recharge is generally low and no river is within the basin. Additional water use could be problematic for the basins like the Chuckwalla that may already be in overdraft (DRECP, 2014). Thus, groundwater elevation is a key monitoring indicator that will provide decision makers with needed data to evaluate whether groundwater overdraft is occurring.

The calculated water level in a well reflects the hydraulic head of the screened section of the well. Water level is an important parameter in groundwater monitoring because it indicates changes in the amount of stored groundwater. The water level will fluctuate over time according to stresses on the aquifer system such as increased or decreased recharge over a time interval and groundwater withdrawals. The response of the head at an observation point (e.g., monitoring well) to pumping at an extraction well will be a function of the pumping rate, the aquifer properties, the distance between the wells, and the amount of time since pumping began. This time interval is a critical factor in evaluating the impact from individual projects and for a large overall basin, because significant negative impact may be observed at key locations because of an expanding composite cone of depression even after pumping has ceased (Bredehoeft and Durbin 2009; Bredehoeft 2011). Key monitoring locations may include other groundwater users, surface water bodies receiving groundwater inflow, or other discharge locations in the basin. Intensive groundwater use may, therefore, have a long-term adverse effect on other groundwater users and ecological entities in the basin (Figure 4-1). In the Chuckwalla Basin, lowering of the water table could result in impacts on the hydrology of the Palen Lake playa.

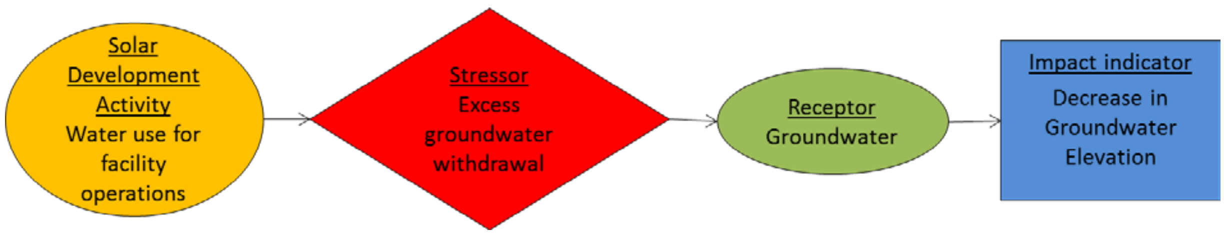


Figure 4-1 Conceptual Model Illustrating Potential Impacts on Groundwater Resulting from Solar Development Activities and the Impact Indicators used for the Riverside East SEZ LTMS

4.1.2 Related Management Questions, Management Goals, and Monitoring Objectives Addressed by the Indicator

Monitoring the groundwater elevation will address the management questions, management goals, and monitoring objectives in Table 4-1.

Table 4-1 Management Questions, Management Goals, and Monitoring Objectives Addressed by Monitoring Groundwater Elevation

Management Questions
- Is/are the groundwater basin(s) in overdraft? If so, to what degree?

Management Goals
- Minimize divergence from the natural, pre-development balance of the groundwater supply (recharge/discharge) within the watershed.
- Maintain the hydrology of seeps and springs, groundwater dependent streams, and playas within the watershed.

Monitoring Objectives
- Detect temporal changes of management significance in groundwater surface elevations in monitoring wells as well as the spatial pattern and extent of these groundwater surface elevation changes on or near projects.

4.1.3 Spatial and Temporal Considerations for Monitoring the Indicator

The Riverside East SEZ is located within two groundwater basins: Chuckwalla Valley and Palo Verde Mesa. Groundwater-level monitoring should occur at two spatial scales to inform decision makers of the short- and long-term effects over near- and far-field areas of the basins. Within and adjacent to the Riverside East solar energy projects, water level and well pumping data should be collected, compiled, and annually assessed in terms of local impacts. In addition, water level data collected across the Chuckwalla and Palo Verde Mesa basins by the USGS or other entities should be compiled and assessed annually to monitor for basin-wide changes.

The frequency of data collection at solar energy plants (closest wells within project rights-of-way plus nearby wells within the SEZ) should be quarterly. Manual measurements and any continuous data from probes should be transferred to BLM at regular intervals.

4.1.4 Existing Data Sources and New Indicator Data Collection Recommended for the Riverside East SEZ LTMS

Groundwater elevation is determined at a monitoring well by measuring the depth to water (DTW) from a known elevation (usually the top of the well casing or the elevation of the ground at the well) and subtracting this distance from the elevation (with respect to sea level) of the reference point. To ensure accuracy, this method needs to account for land subsidence because subsidence would affect the elevation of the ground. The DTW is usually measured by manually lowering an electronic probe down the well for a single occasional measurement. A more informative method would be to use programmable, data-logging probes (transducers) that would provide an essentially continuous DTW record.

Installing new wells is expensive. Therefore, the LTMS will use existing groundwater-monitoring wells as much as possible. Eight authorized or pending solar energy projects occur across the Riverside East SEZ. New solar developments typically need to install two to three monitoring wells on-site and to collect data from off-site private wells if permission is obtained from well owners (Noel Ludwig, BLM hydrologist, pers. com. 2015). Data are supposed to be sent to the BLM field office. No centralized oversight of this data collection currently exists. Baseline conditions must be established prior to the onset of high-volume pumping (or impacts caused by that pumping) in order to determine the change caused by the pumping. Years of baseline data would indicate the typical range of fluctuations of water levels due to changes in basin recharge.

Unconfirmed estimates of production and monitoring wells at project areas throughout the basin include Desert Sunlight (2 production, 8 monitoring), Genesis (4 production, 10 monitoring), Colorado River Substation (1 serving both purposes), Redbluff Substation (1 serving both purposes), and Blythe (1 production, 1 monitoring). Other clusters of wells include the Kaiser mining production and monitoring well field (10) in the western Chuckwalla Valley and the prison compound (9) in the central Chuckwalla Valley.

The McCoy solar development has seven wells (AECOM 2015). Three are on-site, and four are off-site and downgradient including USGS Well 334202114434001 at T5S R22E Section 31, and the Gila Farm Well at T6S R22E, Section 17. Monitoring of the on-site wells began in 2014. Five of the wells are outfitted with pressure transducers that translate changes in water pressure into changes in water level.

Monitoring data for groundwater levels in the study area are available through the USGS NWIS (USGS 2015). A search of the overall Chuckwalla and Palo Verde Mesa vicinity using online NWIS tools yielded several dozen wells within the SEZ and numerous other wells outside the SEZ, especially in the Palo Verde Valley agricultural area east of the SEZ (Figure 4-2). Of the wells in the Chuckwalla and Palo Verde Mesa, well depth information is available in the NWIS database for about half the wells. Most of the wells had at least one water level measurement in the database; however, about half of the wells with a measurement had only one, two, or three measurements. The dates represented by the data at various wells extend over a wide range of many decades. The condition of most of the wells in NWIS is unknown; it is possible that many of them are unusable due to collapse.

Only two wells in the search were found to be included in Groundwater Watch, an online USGS measurement program for management of real-time data; neither of them is within the SEZ. Well 333939114411501 is located on the edge of the Palo Verde Mesa adjacent to the Palo Verde Valley (Figure 4-3). The well is 252.2 ft deep; land surface elevation is 399.6 ft NGVD29. Its data include five manual measurements from 1968 to 1992, 52 manual measurements from 2000 to 2011, and daily (provisional) data from March 2012 to May 2014 (Figure 4-4). Its overall water level data indicate a large decrease in water level from 1968 to 1984, a large increase from 1984 to 2000, and fairly steady levels from 2000 to present, including a slight rise since about 2005.

Well 333214114535501 is located less than a mile south of the Chuckwalla State Prison (Figure 4-3). The well is 830.0 ft deep; land surface elevation is 505.6 ft NGVD29. Its data include one measurement in 1982, one in 1992, 60 manual measurements from 2000 to 2012, and daily (provisional) data from May 2012 to May 2014 (Figure 4-5). The data suggest a large increase in water level from 1982 to 1991, decreasing water levels from 1991 to 2006, and steady to increasing water levels from 2006 to 2015.

The data from both of these wells are useful because they are some of the basin's more long-term monitoring points, and they illustrate the short-term fluctuations observable with continuous monitoring.

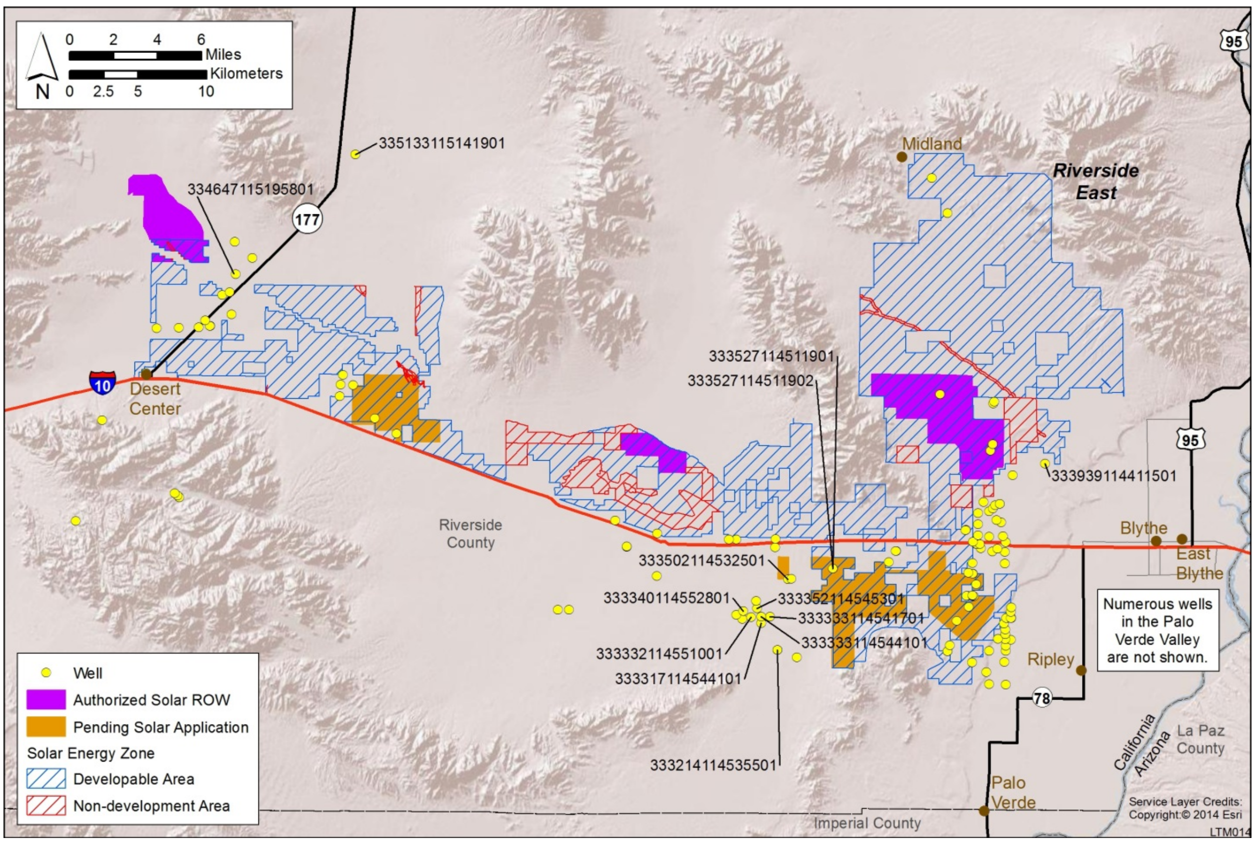
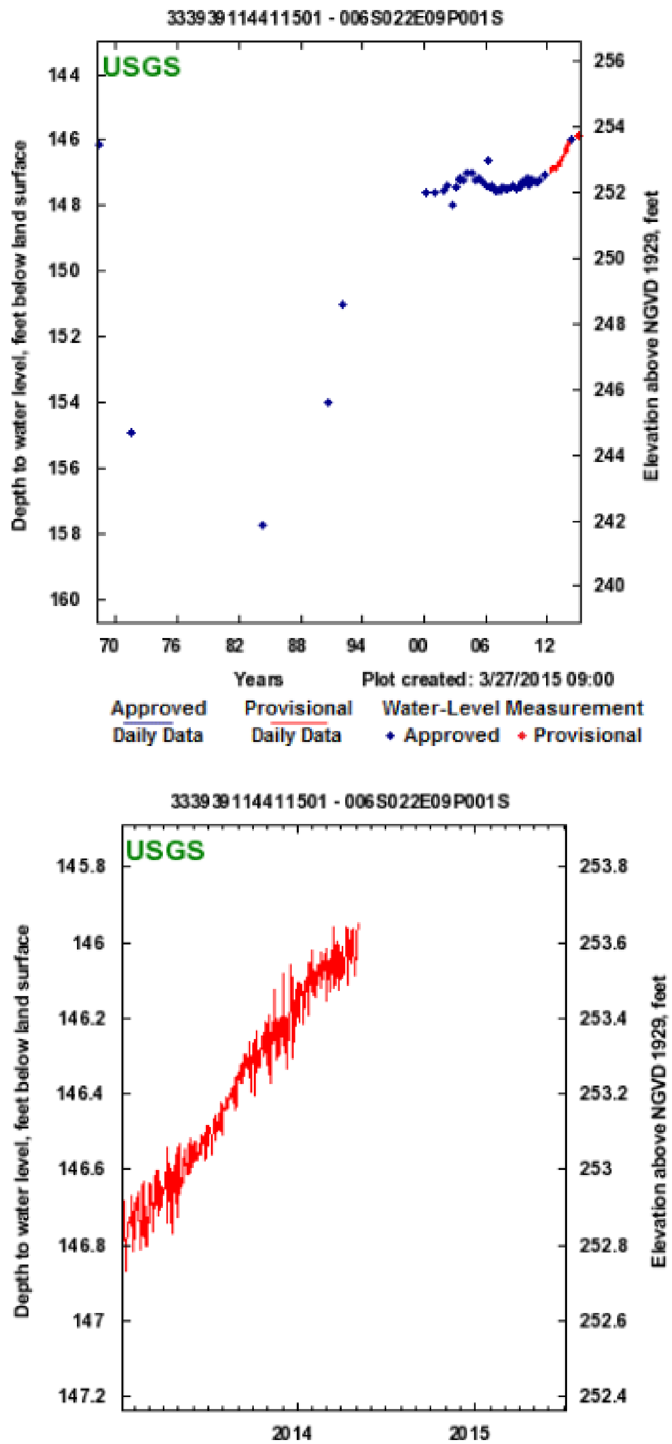


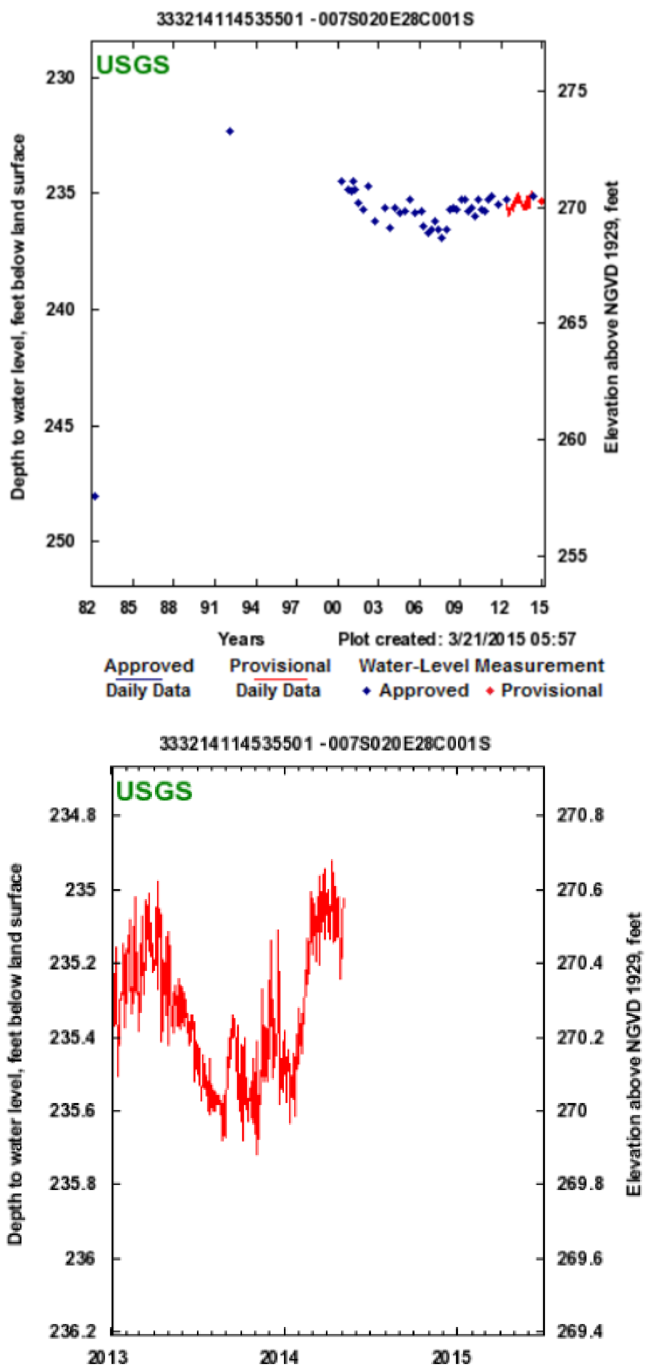
Figure 4-2 USGS NWIS Wells in Chuckwalla and Palo Verde Mesa Basins and Vicinity, and Outlines of the Riverside East SEZ and Authorized and Existing Solar Power Plants within that SEZ. Numbered and unnumbered wells are shown.



A.

B.

Figure 4-3 A. USGS Groundwater Watch Data for Well 333939114411501 (continuous data shown in red). B. Detailed view of recent continuous data. (Source: USGS 2015)



A.

B.

Figure 4-4 A. USGS Groundwater Watch Data for Well 333214114535501 (continuous data shown in red). B. Detailed view of recent continuous data. (Source: USGS 2015)

Most of the USGS NWIS wells described above are considered “inactive” (i.e. not currently collecting data) in the NWIS database. Only the two wells in the Groundwater Watch program, 333214114535501 and 333939114411501, are considered “active.”

The USGS recently installed new monitoring wells for the BLM in the Chuckwalla Valley (USGS 2013). The CWV1 multiple monitoring well site is in the eastern Chuckwalla Valley near the Palo Verde Mesa. The three wells at this site have depths of 230, 505, and 993 ft, and each has two water level measurements in NWIS. These wells are marked as inactive in NWIS. They are being monitored by the BLM using sensors; however, two of the three sensors had failed prior to April 2015, so data collection is incomplete. These wells will become active in the NWIS database and regularly monitored by the USGS starting early in fiscal year 2016.

Several other sources of water level data were considered. The Metropolitan Water District of Southern California (2015) did not have monitoring wells in the Chuckwalla area. A study on the Chuckwalla Valley Groundwater Basin by Lawrence Berkeley National Laboratory and Pennsylvania State University is under way, but this study does not include collection of monitoring data. A groundwater modeling study by Argonne National Laboratory (Greer et al. 2013) investigated potential future drawdown but did not involve new monitoring wells. The California Statewide Groundwater Elevation Monitoring (CASGEM) program (2015) has data for five wells in the Chuckwalla Valley, but all of their data are duplicated in NWIS. Numerous CASGEM wells are in the Palo Verde Valley and Palo Verde Mesa. The CASGEM well depths there are confidential. Presumably, the well data are duplicated in NWIS, and most of them are expected to be shallow wells associated with the agricultural activities. New wells may be desired based on prior years’ results; however, they are not called for because of high cost and because optimal locations will be determined in the future.

Recordkeeping for water level data at individual solar power plants, NWIS wells, or elsewhere within the SEZ should include a description of the well name, date, time, well location, NWIS well number (if applicable), reference elevation (top of well casing or ground surface elevation), and the depth to water measurement. Data logged in the field should be transferred carefully to computer spreadsheets and maintained throughout the study.

4.1.5 Data Analysis and Summary of Monitoring Strategy

Analysis of the data should take into account available baseline data (e.g., relevant NWIS well data), the pumping schedule of production wells, manual and/or continuous data from solar power plant monitoring wells, and data from control points (private wells or NWIS wells away from solar developments). The NWIS data provide the best source of baseline conditions, though the data from a particular well may be limited to a very small number of measurements, and the data may range from recent to decades old. The available data near a project site therefore need to be evaluated appropriately to provide an understanding of baseline trends and fluctuations. These control points would indicate overall changes in the basin due to long-term changes in recharge and pumping by various basin users. Data evaluation should include graphs of water levels versus time using available data from solar power plant monitoring wells, NWIS wells, and other wells within the SEZ; mapping of water levels for particular snapshots in time; and mapping of drawdown relative to the water levels of a starting date for particular snapshots in time. Regional groundwater models, such as the one being developed by Pennsylvania State University would also be used in analyzing monitoring data.

The groundwater elevation monitoring program developed for the Chuckwalla and Palo Verde Mesa (if basin-wide) or for focused evaluation of a development or cluster of developments must be adaptable to new information identified during early stages of monitoring. The monitoring strategy should be revised appropriately to respond to new questions. These changes could include more or less frequent measurements at wells, additions or deletions to the wells composing the monitoring well network, installation of new wells at key locations, and adding or dropping the use of data-logging probes.

The LTMS will use the best available groundwater model in interpreting the monitoring data. Anticipated drawdown may be evaluated through careful hydrogeologic evaluation by an investigator with sufficient expertise using analytical modeling (e.g., Appendix O of BLM and DOE 2012), or use of an online set of numerical flow model files (Greer et al. 2013). Groundwater modeling could be performed with the pumping data and any local aquifer testing results from SEZ wells and hydrostratigraphic data (from solar project or substation well drilling) to improve model calibration and predicted long-term drawdown. The groundwater elevation monitoring plan for the Riverside East SEZ LTMS is summarized in Table 4-2.

Table 4-2 Summary of Monitoring Indicators and Monitoring Plan Proposed to Monitor Groundwater Elevation.

Indicator (s)	Method	Sampling Strata	Data Analysis
Groundwater elevation	Well monitoring using electronic probe or programmable data-loggers	Data from existing wells (individual project; USGS NWIS wells); new wells may be needed but not initially called for because	Data evaluation should include graphs of water levels versus time at solar power plant monitoring wells, NWIS wells,

Indicator (s)	Method	Sampling Strata	Data Analysis
		of high cost and because optimal locations will come into focus in the future.	and other wells within the SEZ; anticipated drawdown may be evaluated through analytical or numerical flow models.

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4.2 Erosion and Surface Disturbance Indicators

4.2.1 Rationale for Monitoring the Indicators

Section 4.2 describes monitoring indicators of erosion and surface disturbance related to solar development. These disturbances can result from changes in surface hydrology, soil compaction, soil-disturbing activities, and vegetation clearing, especially during the construction phase. The Riverside East SEZ LTMS includes indicators of soil and ephemeral stream erosion, as well as disturbance to desert pavement. A description of the potential erosional effects of solar energy development follows.

4.2.1.1 Soil Erosion

Following soil disturbance and vegetation clearing, exposed soils are more susceptible to both wind and water erosion (Figure 4-5). Wind erosion is a natural process in which the shearing force of wind is the dominant eroding agent, detaching soil particles from the ground surface and often causing significant soil loss across much of the exposed area. Soil erosion by wind is especially strong if organic matter is low in the soil and vegetation (the source of organic matter) does not shelter soil from the shearing force of wind. Wind erosion and deposition and their effects, such as dust clouds and storms and aeolian landforms (yardangs and sand dunes), are important processes in desert environments. Effects are readily visible in alluvial valleys such as those in the Riverside East SEZ. Construction-related activities, such as vegetation clearing, excavating, stockpiling soils, and truck and equipment traffic on unpaved roads and surfaces, can significantly increase the susceptibility of desert soils to wind erosion (Figure 4-5). Because soil particulate aerosolization and deposition are usually widespread in desert environments, these processes can have a significant impact on air quality, water quality, vegetation, and wildlife.

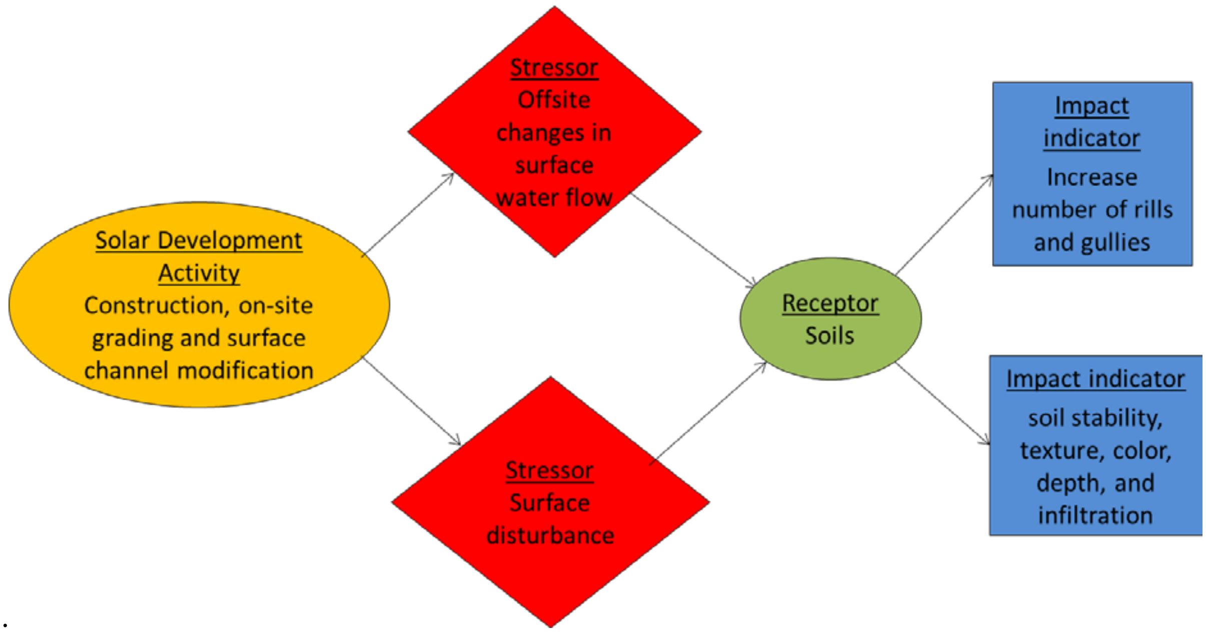

Figure 4-5 Conceptual Model Showing Solar Development Impact Indicators for Soil Erosion

Soil quality is an important element of ecological health and integrity. The redistribution and loss of soil resources by wind and water can result in the reduction of soil fertility and productivity and cause degradation of air and water quality over time. For these reasons, soil stability and related soil properties (described below) will be monitored to determine whether solar development within the Riverside East SEZ is increasing soil erosion in the region.

4.2.1.2 Disturbance to Desert Pavement

Desert pavement has been identified by stakeholders as a resource of particular concern. Desert pavements are highly stable and consist of dense surface cobble that protects the fine sediments beneath from wind and water erosion (Wood et al. 2005). Desert pavements also modify landscape runoff patterns by reducing soil infiltration (Wood et al. 2005). Desert pavements constitute a significant proportion of land cover at the Riverside East SEZ (Potter and Li 2014), making them vulnerable to loss due to soil-disturbing activities, such as facility construction and the placement of pipelines and transmission lines. In addition, the increased vehicle and foot traffic associated with solar facility operations could disturb desert pavements, significantly reducing their soil stabilization functions (Belnap et al. 2008) (Figure 4-6). Unless avoidance measures are taken, loss of desert pavement will continue from ongoing development in the desert, including utility-scale solar development. Consequently, all action alternatives in the DRECP will require limits on the percentage of desert pavement that can be disturbed within a solar project right-of-way (ROW).

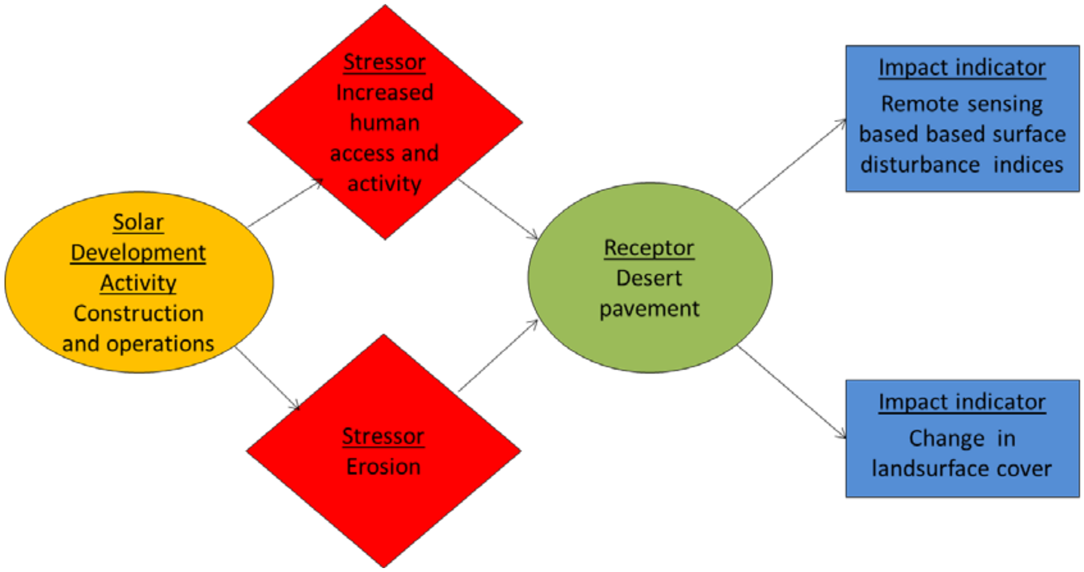

Figure 4-6 Conceptual Model Illustrating Potential Impacts on Desert Pavement Resulting from Solar Development Activities and the Impact Indicators Used for the Riverside East SEZ LTMS.

As described in Section 3, remote sensing is an effective tool for monitoring changes in desert pavement (Beratan and Anderson 1998; Potter and Li 2014; Hamada and Rollins 2015). Therefore, the LTMS will include the use of remote sensing to map the continuous cover of desert pavement within the Riverside East SEZ.

4.2.1.3 Dust

Soil disturbance and vegetation clearing can also increase regulated particulate matter in the atmosphere. Currently, the air pollutants of greatest concern in Riverside County are ozone (O_3) and PM (particulate matter, PM_{10} and $PM_{2.5}$). Typically, O_3 is a regional issue and low-level emissions of ozone precursors from solar facilities do not significantly increase ozone levels at and downwind of the SEZ. Because the solar facilities are located in arid or semi-arid environments, which are persistently subjected to high levels of natural and manmade fugitive dust, the key air pollutant related to solar development is PM, which will be monitored as part of the Riverside East LTMS.

The particulate matter (PM) is a complex mixture of extremely small particles and liquid droplets, such as dust, fly ash, soot, smoke, aerosols, fumes, mists, and condensing vapors that can be suspended in the air for extended periods of time. The composition and size of these airborne particles and droplets vary. Particles collected in two size cuts, PM_{10} and $PM_{2.5}$, are widely monitored. The $PM_{2.5}$ particles size cut represents the mass of aerosols less than or equal to 2.5 μm in aerodynamic diameter, and PM_{10} represents particles with sizes less than or equal to 10 μm in aerodynamic diameter. Coarse particles, or the subset of PM_{10} that is larger than 2.5 μm but smaller than or equal to 10 μm ($PM_{10–2.5}$), are not transported over the long distance because they are too large to be sustained in the airstreams and readily removed from the atmosphere. On the other hand, fine particles ($PM_{2.5}$), which are smaller than or equal to 2.5 μm and the subset of PM_{10}, can remain airborne for a long period and travel hundreds of miles borne by winds. In general, most of the mass in the larger particles fraction in the atmosphere is from mineral dust. Dust has important climatic effects through its influence on solar and terrestrial radiation and the radiative and physical properties of clouds.

PM sources, associated with solar facility development, include soil disturbances, unpaved road traffic in and around the SEZ, and wind-blown dust during both construction and operational phases (Figure 4-7). Combustion-related activities during solar facility development could also generate PM emissions. However, solar facilities within the SEZ would be constructed in a relatively flat terrain, and thus large-scale earth-moving activities, which could generate the highest combustion-related emissions during construction, would not be required (i.e., only minimal site preparation activities). In addition, PV solar facilities do not burn fossil fuel to generate electricity, and thus combustion-related emissions are much smaller than those from any other power stations or industrial facilities. Consequently, direct PM sources from combustion would be minor.

PM can cause health effects and environmental effects, which include visibility impairments, environmental damage, and aesthetic damage (EPA 2015a). Health effects include premature death in people with heart or lung disease, aggravated asthma, decreased lung function, and increased respiratory symptoms, such as coughing or difficult breathing. The groups most susceptible to health effects from PM are the elderly, people with heart and/or lung disease, and children/infants. Review of scientific literature about the issues and impacts of PM on human health and the environment are presented in detail by the US EPA (2004, 2009). PM can reduce visibility (haze) in parts of the United States, including many national parks and wilderness areas, where the visibility is an important value. The State of California Air Resources Board has a standard for visibility-reducing particles, which can be found at http://www.arb.ca.gov/research/aaqs/aaqs2.pdf.

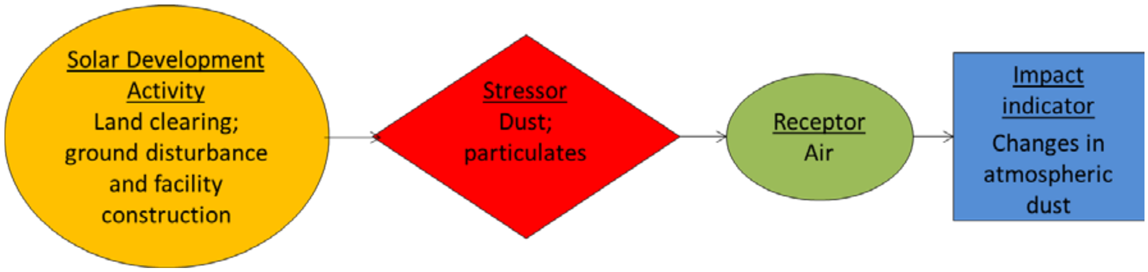

Figure 4-7 Conceptual Model Showing Solar Development Impact Indicators for Dust

4.2.1.4 Stream Erosion

Water erosion is a natural process in which water is the dominant eroding agent. The degree of water-induced erosion is generally determined by the amount and intensity of rainfall, but is also affected by the cohesiveness of the soil as a function of soil texture and organic content, its infiltration capacity, vegetation cover, gradient and length of slope (USDA 2004), and channel geomorphology. In desert environments, rainfall is infrequent but typically intense, causing sudden runoff. Desert soils disturbed by solar development are more likely to be susceptible erosion, especially during these periods of heavy rainfall (Figure 4-8). Increased surface runoff caused by soil compaction also increases the likelihood of soil erosion

There are no perennial streams within the Riverside East SEZ. However, a number of ephemeral streams cross the area, the largest being those associated with McCoy Wash, which drains the eastern slope of the McCoy Mountains and flows to the southeast across the eastern portion of the SEZ. Although large channels were avoided in designating developable areas in the Riverside East SEZ, small, ephemeral streams are ubiquitous in the Desert Southwest and cannot feasibly be avoided entirely. The construction of utility-scale solar facilities will entail grading or otherwise disturbing the project site and removing or redirecting ephemeral channels to shunt water flow away from facility infrastructure. These on-site modifications to surface hydrology could affect stream channels downstream of the project site (Figure 4-6). Potential impacts include increases in off-site flow volume, resulting in erosion-related changes in channel morphology.

Monitoring ephemeral channels presents unique challenges because runoff events are infrequent and stream flow is episodic. For these reasons, remote sensing and repeat ground-based photography, rather than direct monitoring of stream flow, are the most effective ways to assess changes in surface hydrology and stream erosion over time (Belnap et al. 2008). For the Riverside East LTMS, morphological indicators, including channel depth (m), channel width (m), and channel location, should be monitored in order to determine whether solar energy development contributes to the erosion of surface water features.

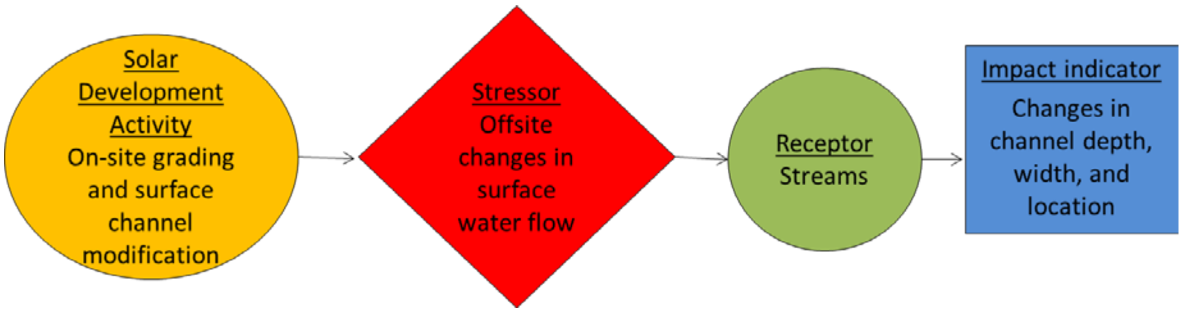

Figure 4-8 Conceptual Model Showing Solar Development Impact Indicators for Stream Erosion

4.2.1.5 Relevant Policy

Relevant BLM policy documents with respect to soil quality include the following:

- The BLM *Land Use Planning Handbook*, H-1601-1, 2005, and Amendments
- California Desert Conservation Area Plan, 1980, and Amendments
- BLM Manual 1734, Rangeland Interagency Ecological Site Manual, and BLM Handbook 1734-1, Interagency Ecological Site Handbook for Rangelands
- BLM Manual 5000, *Forest Management*, and BLM Handbook 5000-1, *Forest Management*
- BLM Manual 5711, *Site Preparation*
- BLM Information Memoranda 2014-112, Policy for Solar and Wind Energy Inspection and Enforcement
- Bureau of Land Management (BLM) Instruction Memorandums (IM) related to air quality issues (BLM 2009, 2012, 2014).

4.2.2 Related Management Questions, Management Goals, and Monitoring Objectives Addressed by the Indicator

Monitoring soil erosion indicators, stream channel morphology, PM, and disturbance to desert pavement will address the management questions, management goals, and monitoring objectives listed in Table 4-3.

Table 4-3 Management Questions, Management Goals and Monitoring Objectives Addressed by the Soil Erosion Indicators

Management Questions
- How does land-clearing for project site development change the relative land cover types within the SEZ?
- How much soil erosion by wind and water is occurring on-site, downwind, and downslope before, during, and after solar facility construction?
- Are on-site ground disturbances and facility design and construction altering natural patterns and volumes of off-site soil erosion by wind or water?
- Do solar facilities significantly alter off-site surface water hydrology?
- Is solar development affecting regional air quality?

Management Goals
- Minimize soil erosion impacts on wash banks, desert pavement, dry lakes, sand dunes, and fluvial and aeolian sand transport corridors, and sand source areas.
- Minimize soil erosion on- and off-site.
- Minimize impacts on desert pavement.
- Minimize solar-related effects on air quality.
- Control fugitive dust to minimize airborne particulates.

Monitoring Objectives
- Detect temporal changes of management significance in soil erosion/accretion relative to control areas.
- Detect temporal changes of management significance in stream channel location and morphology relative to control areas.
- Detect temporal changes of management significance in PM_{10} within the SEZ.
- Detect temporal changes of management significance in the cover and integrity of desert pavement relative to control areas.

4.2.3 Soil Aggregate Stability, Texture, Infiltration, and Depth

Soil erosion can be monitored by using indicators obtained from remote sensing and field surveys. The clearest indicator of soil erosion is the formation of rills and gullies following significant rainfall. Such changes have long been detected by using aerial and ground-based photography (King et al. 2005) and should be monitored as part of the Riverside East SEZ LTMS. Additional field-based indicators of soil erosion proposed for the Riverside East SEZ LTMS are listed in Table 4-4. The following four indicators represent key soil characteristics that are sensitive to changes in the environment created by solar development and are relatively easy to observe and measure in the field.

4.2.3.1 Key Soil Characteristics Sensitive to Environmental Changes

4.2.3.1.1 Soil Aggregate Stability

Soil aggregates are clumps of soil particles that are bound more strongly together than to other surrounding soil particles (USDA 2014). Aggregate stability is an AIM contingent indicator and provides information on the stage of soil structural development and the ability of soil to resist disintegration when subjected to the forces of erosion (wind and water). It is a composite measure of the properties of healthy soil function including soil texture, organic matter, and biological activity (Table 4-4). Soil aggregate stability is critical for infiltration and root growth (USDA 2014) because it creates pore spaces in soils that transport water and oxygen to root systems. Soils with higher aggregate stability resist the blowing forces of wind and disaggregate less during rainstorms (USDA 2008a; Herrick et al. 2015).

4.2.3.1.2 Soil Texture

Soil texture is an indicator of the particle size distribution of soil, that is, its proportion (percent by weight) of sand, silt, and clay (USDA 2014). The U.S. Department of Agriculture (USDA) uses soil texture in its soil classification scheme, and texture class is typically one of the first (and most basic) soil parameters measured when a soil is characterized. Soil texture provides information on parent material and weathering. Spatial differences in soil texture horizontally reflect differences in parent material mineral weathering and erosional processes, and vertically reflect movement of fine particles, dispersions of salts, loss of minerals, or secondary formation of minerals and noncrystalline substances (USDA 2014) and development of water-impermeable soil layers.

Soil texture influences the degree of water infiltration and permeability, and aggregate stability. Together these features determine erodibility of a soil. For example, soils with a high proportion of clay inherently have small pore spaces that restrict the movement of water throughout the soil profile, thereby increasing runoff. Soils with low clay content are less cohesive and thus more susceptible to erosion by water and wind. Soils with high content of coarse sand are not cohesive and allow for high water infiltration and rapid drainage. Coarsely textured soils seldom become airborne in windy conditions but may roll or saltate (jump) across the soil surface, and when carried by surface or stream flows, these coarse particles are the first to fall out of suspension as the speed of water flow slows.

Table 4-4 Soil Erosion Indicators Proposed for the Riverside East SEZ LTMS

Soil Erosion Indicator	What the Indicator Measures
Soil aggregate stability	Degree of soil development, integrity of soil aggregates, resistance to erosion
Soil texture	Proportion of sand, silt, and clay
Infiltration	Rate (velocity) at which water enters soil
Soil depth to rock	Soil loss or deposition

4.2.3.1.3 Soil Infiltration

Soil infiltration is an indicator of the soil's ability to permit the downward movement of water into and through the soil profile (USDA 2008b). Compacted soils have less pore space and, therefore, lower infiltration rates. Other factors, such as low organic matter content and poor aggregate stability, also increase the likelihood that compaction will occur. When the rate of water supplied exceeds the soil's infiltration capacity, water moves downslope as runoff (on sloping lands) or ponds on the surface of level land. Erosion will take place where runoff occurs on sparsely vegetated or bare soil, resulting in decreased soil productivity, off-site sedimentation of water bodies, and reduced water quality. Ponding and soil saturation increase the erodibility of soils by decreasing soil strength and structure (USDA 2008b).

4.2.3.1.4 Soil Depth

Measurements of soil depth to a rock layer provide an indirect indication of soil erosion trends over time. This parameter has limited application in rocky areas like desert pavement.

4.2.3.2 Spatial and Temporal Considerations for Monitoring the Indicator

Soil sampling should be focused in areas most affected by solar development activities, that is, areas identified to be at risk of erosion or degradation. Because of the spatial variability of soils, the selection of reference locations must take into account parent material, soil texture, and landscape position to ensure that similar soils are being compared. Areas of recent disturbance, such as new roads, should be avoided or noted. Unlike observation or measurements, soil sampling is destructive data collection, so samples should not be collected from the same location more than once.

Some soil properties vary with the daily, seasonal, or annual cycles of air temperature and precipitation, while others (e.g., organic matter content and soil texture) are relatively stable. For this reason, the timing and frequency of sampling should be consistent and documented to characterize trends over short and long time intervals. Major weather events, such as storm events or flash floods, should also be noted. Observations of surface features, such as rills, should be made at regular intervals following a major storm event, and the time interval between the event and the observation should be noted.

4.2.3.3 Existing Data Sources

Data on soil aggregate stability, soil depth, and soil texture and water flow patterns, rills, and pedestals were collected during the initial characterization of the sites monitored for the pilot AIM data collection in the Riverside East SEZ (2014–present) and the Westwide Landscape Monitoring Framework (WLMF). Data on two of the indicators—soil aggregate stability and characterization of water flow patterns, rills, pedestals—continue to be collected annually within the Riverside East SEZ since May 2014. The Riverside East SEZ LTMS should incorporate this ongoing data collection following the sampling locations and sampling stratification currently employed for the AIM pilot sampling effort and WLMF (Great Basin Institute 2014; Herrick et al. 2015).

Several additional sources of spatial data characterizing soil types within the Riverside East SEZ are available from the California Department of Conservation (2010) and the National Resource Conservation Service (http://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateId=CA) and the STATSGO2 dataset (https://catalog.data.gov/dataset/u-s-general-soil-map-statsgo2-for-the-united-states-of-america), also available from the NRCS. In addition, the soil stability layer in the Sonoran Rapid Ecological Assessment (Strittholt et al. 2012) provides low- spatial resolution maps that could be used to direct sampling to those areas most vulnerable to erosion.

4.2.3.4 New Indicator Data Collection Recommended for the Riverside East SEZ LTMS

4.2.3.4.1 Criteria and Methods for Sample Stratification

Sampling locations will conform to the sampling plan currently used for the Riverside East SEZ AIM monitoring pilot project (Great Basin Institute 2014). To conform to a BACI design, three solar impact strata (buffer, SEZ, and reference) are incorporated into the sampling design (Section 2.3.2). Existing AIM sampling may need to be supplemented with new soil sampling locations to ensure that all solar impact strata are adequately sampled. Within the buffer strata, samples should be collected in areas downslope and downwind of solar development projects where wind- and water-related soil erosion is most likely to occur. See Section 2.3.2 for the rationale and description of the solar impact strata.

4.2.3.4.2 Sampling Methods

Soil aggregate stability and plot observation data characterizing water flow patterns, rills, and pedestals (Herrick et al. 2015) are currently collected at plots in the Riverside East SEZ once per year as part of ongoing AIM sampling (Great Basin Institute 2014). Soil aggregate stability is also measured at 4-m intervals along the vegetation-monitoring transects using the methods of Herrick et al. (2015). AIM data collection methods also specify the qualitative observations of signs of erosion at each sampling plot and include filling out observational data sheets covering rills, gullies, pedestals, deposition and runoff, and water flow patterns (Herrick et al. 2015). Photographs are taken at each sampling site. These observations and photographs can be used to detect visual indicators of erosion (King et al. 2005). As described in Herrick et al. (2015), field conditions that affect soil characterization, such as rainfall, new soil disturbance should also be recorded. The number of rills can be quantified by manual counts in the series of ground-based photographs of the study sites (Belnap et al. 2008).

Soil infiltration, soil texture, and soil depth are not currently being monitored in the SEZ. However, if determined to be feasible and necessary, monitoring of these properties can be done by using field-based measurements in conjunction with ongoing AIM monitoring at the Riverside East SEZ. Table 4-5 summarizes the methods to be used for assessing and monitoring soil indicators.

Table 4-5 Field and Laboratory Methods for Assessing and Monitoring Soil Indicators

Soil Property	Method Description	Source
Soil aggregate stability	Field test measures aggregate stability when exposed to wetting	USDA (2009); Herrick et al. (2015); *Soil Quality Test Kit Guide*, Section I, Chapter 8 (USDA 1999)
Soil texture	Field analysis	Soil Survey Field and Laboratory Methods Manual (USDA 2014)
Infiltration	Field (in situ) test	*Soil Quality Test Kit Guide*, Section I, Chapter 3 (USDA 1999)
Soil depth	Soil probe (field)	Belnap et al. (2008)
Visual indicators of erosion (e.g., rills, gullies, and pedestals)	Plot observation data sheets	Herrick et al. (2015);

4.2.4 Stream Morphology

4.2.4.1 Spatial and Temporal Considerations for Monitoring the Indicator

Channel network patterns and erosion indicators can be characterized by using several image types (Vrieling 2006), such as scanned aerial photography (Yang et al. 1999) and high- to moderate-resolution (2- to 30-m) multispectral imagery (Bryant and Gilvear 1999; Yang et al. 1999). Surface water features in the Riverside East SEZ range from large intermittent streams with incised channels to broad, shallow, poorly defined alluvial fans. Therefore, the number of stream channels delineated by using remotely sensed imagery will vary significantly with the resolution of the imagery and methods used for image analysis. For example, using 15-cm resolution aerial imagery with a series of widely used processing techniques, Hamada and O'Connor (2012) found a 500% greater number of channels in the Riverside East SEZ study area compared to the National Hydrology Dataset (NHD), which uses lower resolution USGS topographic maps. Thus, the appropriate spatial resolution of the imagery depends on the size and characteristics of the channel being monitored.

The morphology of desert streams and washes can be significantly altered following large floods (Levick et al. 2008), and smaller channels and washes are repeatedly reworked during the rainy season. Thus, rainfall patterns provide guidance for determining the timing and frequency of data collection for monitoring stream channel morphology. Annual precipitation in the region of the Riverside East SEZ is less than 15 cm and highly seasonal (Hereford et al. 2006). Rainfall is greatest during the cooler months (October to April); the warmer months (May through September) have the lowest rainfall but the highest intensity rain events, typically associated with monsoonal weather patterns (Hereford et al. 2006).

4.2.4.2 Existing Data Sources

There are several sources of data for surface water features in the Riverside East SEZ. In addition to maps of surface water features available from the USGS NHD, stream survey data have also been collected for individual solar energy projects as part of solar project streambed alteration agreements with the California Department of Fish and Wildlife (Table 4-6). Under these agreements, developers are required to delineate "waters of the state" in order to determine jurisdictional waters.

Also available are high-resolution stream mapping and field survey data of the McCoy Wash portion of the SEZ, which were generated by Argonne National Laboratory (Argonne) (Hamada et al.

2014) (Table 4-6). In addition, current and historical visual imagery of desert washes in the SEZ can be obtained from free or low-cost satellite imagery (e.g., Landsat TM, SPOT).

Table 4-6 Baseline and Existing Surface Hydrology Data Collected at the Riverside East SEZ

1. Ephemeral stream channel survey data (collected March 2015), high-resolution imagery and channel maps (November 2012 and January 2014) in the eastern portion of the SEZ (Hamada et al. 2014)
2. Historical imagery (Landsat, NAIP)
3. Project-specific jurisdictional waters maps (e.g., TetraTech EC Inc. 2010)
4. USGS NHD

4.2.4.3 New Indicator Data Collection Recommended for the Riverside East SEZ LTMS

4.2.4.3.1 Criteria and Methods for Sample Stratification

Imagery should be obtained for randomly selected streams and washes downslope of existing or planned solar facilities within the 2-mi (3-km) buffer zone (Section 2.3.2). Further stratification may be used to target streams by erosion risk and channel size. Streams and washes of similar physical (e.g., size) and environmental (e.g., slope) characteristics but not potentially affected by solar development should be selected as reference streams.

4.2.4.3.2 Image Collection Methods

The appropriate image resolution needed to detect significant changes in stream morphology depends on the size of the streams and washes and the magnitude of the change in morphology. Commonly used Landsat imagery is typically 30-m resolution and may be useful for monitoring general changes in alluvial fans. Higher resolution imagery will be required to monitor morphological changes to small and medium-sized channels (Gilvear et al. 1999).

Repeated, ground-based (oblique) photography, using archived photographs or digital cameras, can also be employed to document land change over time (Belnap et al. 2008). Successful use of this technique requires highly consistent camera positioning and environmental conditions (lighting, shallows, and vegetation condition) across image collection dates. To meet the rigorous requirements, accurate camera positioning (latitude, longitude, and elevation) should be documented by using GPS devices, and camera settings (shutter speed, f-stop, and film type), and the viewing geometry (camera height, azimuth, and tilt) should be recorded in details.

The type of imagery and the frequency of image collection and analysis will be determined upon further evaluation of the surface water features in the SEZ. Imagery acquired annually before and after the rainy season (fall to spring) and after summer monsoons would be most useful in monitoring erosional changes in stream morphology over time (Gilvear et al. 1999).

4.2.4.4 Image Analysis

Changes in channel location, channel depth (m), and channel width (m), should be quantified by using established methods for quantifying channel erosion using imagery (Micheli and Kirchner 2002; Buckingham and Whitney 2007). Briefly, active channels and adjacent areas should be digitized, and changes in channel morphology should be quantified across the time series of images in the impact and reference areas. The image-based quantification of channel morphology should be field-validated. If ground-based photography is used for channel monitoring, the digital quantification of changes in stream morphology would likely be accomplished manually (Belnap et al. 2008). Alternatively, visual changes in stream morphology can be qualitatively evaluated.

4.2.5 Particulate Matter Monitoring

4.2.5.1 Spatial and Temporal Considerations for Monitoring the Indicator

PM concentration levels should be monitored around the SEZ along with the collection of meteorological parameters. These data will be used to identify PM increases around the SEZ associated with solar facility development and to assess the effectiveness of dust mitigation measures. In addition, air dispersion modeling can be performed by using meteorological data and activity levels within the SEZ to formulate the best mitigation plans in terms of effectiveness and costs.

The spatial scale for monitoring PM is around the SEZ where sensitive receptors such as human residences, crops, vegetation, or other ecosystems are located. Data on this indicator should be collected and archived on an hourly basis, if possible, along with data on meteorological parameters and detailed activity levels. No seasonal constraints on data collection for this indicator exist. Severe weather events (e.g., dust storms, flash floods) and changes in surface features should be noted.

4.2.5.2 Existing Data Sources

Currently, PM data are routinely collected by state, local, tribal, and other governmental agencies and are available at the U.S. Environmental Protection Agency (EPA) *AirData* web site (EPA 2015b) or the California Air Resources Board (ARB) *Air Quality and Emissions* web site (ARB 2015). However, monitoring sites in these databases are relatively far away from the Riverside East SEZ, and meteorological patterns differ greatly because of surrounding complex terrain features. Consequently, these data may not be representative of activities related to solar energy facilities within the SEZ.

Other sources of monitoring data include a BLM-operated climate station east of Wiley's Well and a National Park Service weather station at Pinto Well (Table 4-7 and Figure 4-9). Finally, several ongoing solar projects within the SEZ currently collect PM data. The project-specific monitoring data should be incorporated into the LTMS as they become available.

Table 4-7 Baseline and Existing PM Data Being Collected at the Riverside East SEZ

1.	Air quality data being collected at the Desert Sunlight and Genesis solar energy projects ($PM_{2.5}$ and PM_{10})
2.	BLM-operated climate station east of Wiley's Well
3.	National Park Service weather station in Pinto Wells
4.	Air-monitoring stations in Blythe
5.	On-site dust monitoring at the Genesis, McCoy, and Desert Sunlight solar energy projects.

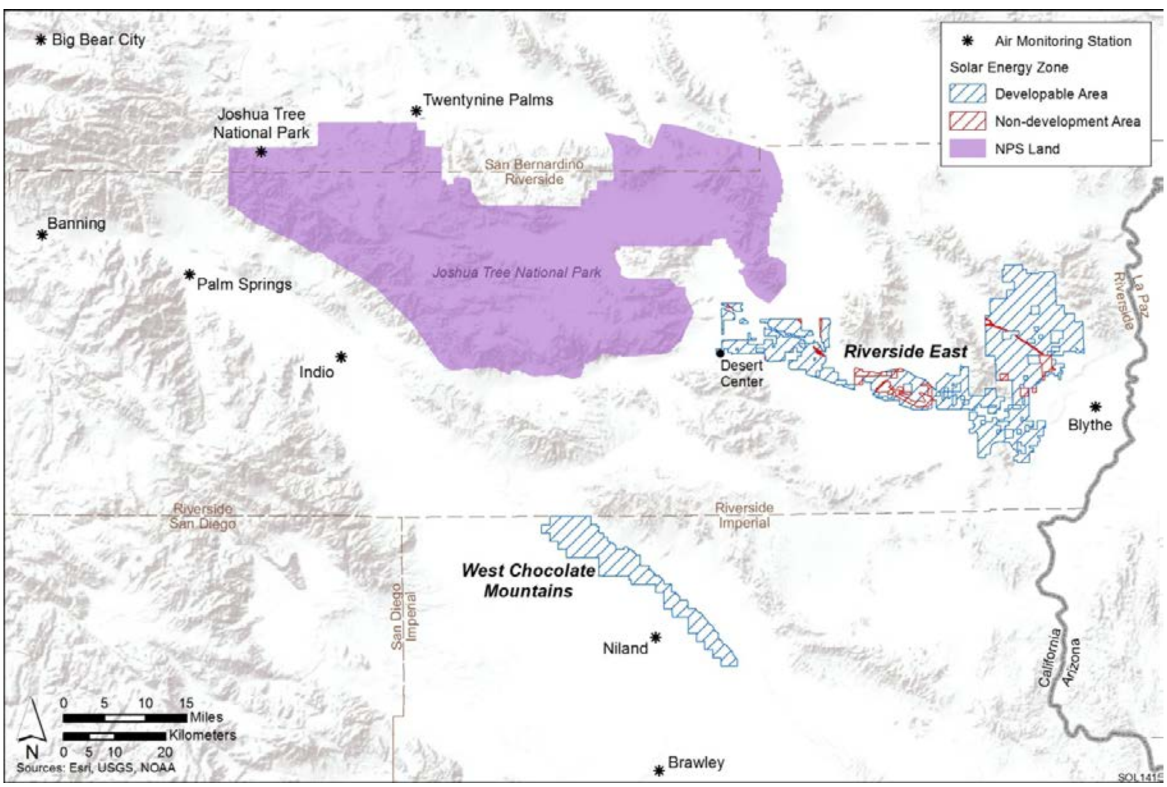

Figure 4-9 Locations of Air-Monitoring Stations in the Vicinity of the Riverside East SEZ

4.2.5.3 New Indicator Data Collection Recommended for the Riverside East SEZ LTMS

Future PM monitoring for the LTMS should occur at locations representative of the proposed solar facility. Because of the size of the Riverside East SEZ, PM data monitoring along with meteorological data collection are warranted. An air-quality-monitoring program should be established in accordance with all federal, state, and local standards and ordinances. The purpose of a program for air quality monitoring is to measure dust concentrations and dispersion generated from solar facility activities and identify potential dust dispersion patterns.

4.2.5.3.1 Sampling Methods

To establish accurate baseline information, pre-construction monitoring would be needed, at the least, for a continuous six-month period, and preferably for a full calendar year. The specific requirements for air quality monitoring will be determined by project- and site-specific factors. The number and placement of sampling locations will be affected by various factors, such as the frequency distribution of the wind direction and the distance to nearby sensitive receptors (e.g., residences, schools, nursing homes, biota, and wildlife habitat of concern) around the SEZ.

To the extent possible, during the construction phase PM samples should be collected at the same locations and times as those used to collect background measurements or as those used during the pre-construction phase. It is recommended that four monitors be set up at locations that are both upwind and downwind of the primary and secondary prevailing wind directions around the impact site, as determined from pre-construction meteorological data measurements. RAWS (Remote Automated Weather System) data from the Desert Resources Institute Western Regional Climate Center (http://www.raws.dri.edu/wraws/azF.html) can produce wind roses which would give the primary and secondary wind directions. The closest stations are at Cibola (Arizona) and Rice Valley (California). In addition, the nearest Class I area, Joshua Tree National Park, is about 1.8 mi (2.9 km) from the nearest SEZ boundary. PM10 is already monitored at the National Park. Additional monitoring sites would be advantageous at the east end of the Park closest to the SEZ. All other Class I areas are located beyond 62 mi (100 km) of the Riverside East SEZ. PM concentrations attributable to a solar facility can be estimated by subtracting those at an upwind monitor from those at a downwind monitor on an hourly basis.

Key references for PM-monitoring procedures are 40 Code of Federal Regulations (CFR) Part 50, Appendix L for $PM_{2.5}$ and 40 CFR Part 50, Appendix J for PM_{10} (http://www.ecfr.gov/cgi-bin/text-idx?SID=60f9ec118fba5ff4c59e939e86309551&mc=true&node=pt40.2.50&rgn=div5). Note that these are both for use of manual methods, which are the reference methods. Several PM continuous monitoring methods are listed in EPA-approved reference and equivalent methods (EPA 2014).

4.2.5.3.2 Meteorological Data Collection

Meteorological data that should be collected to support the interpretation of PM-monitoring data include wind speed and direction, stability parameters (e.g., wind fluctuation data or solar radiation/vertical temperature difference data), air temperature, relative humidity, barometric pressure, and precipitation on an hourly basis. To obtain data representative of a specific location, sensors should be sited so that they are not artificially influenced by surrounding materials and/or obstructions (e.g., concrete, buildings, and forests) and thus minimize or eliminate the effects of manmade or geographical obstructions. In particular, sensors should be located as far as practicable from cultivated land to reduce contamination by dust and dirt. Proper siting of meteorological sensors may be difficult depending on the location, but every effort should be made to meet these requirements, thus ensuring that the collected data are representative of local conditions. Siting criteria for meteorological towers and sensors appropriate for the SEZ are established by the EPA (2000) and OFCM (2005).

4.2.6 Desert Pavement

4.2.6.1 Spatial and Temporal Considerations for Monitoring the Indicator

Desert pavement and desert varnish often form large, stable, and spatially homogeneous areas that are relatively easy to distinguish using remotely sensed imagery. No specific temporal or spatial considerations have been identified for monitoring this indicator.

4.2.6.2 Existing Data Sources

Baseline monitoring data that could potentially be used to quantify the cover of desert pavement in the SEZ are shown in Table 4-8. Researchers at the National Aeronautics and Space Administration (NASA) Ames Research Center and the California State University Monterey Bay have mapped desert pavement in the Riverside East SEZ in support of DRECP (Potter and Li 2014). However, the mapping results have yet to be field-verified. In addition, mapping by Argonne National Laboratory in McCoy Wash area of the SEZ (using 15-cm resolution aerial imagery) can be used to quantify the baseline cover of desert pavement (Figure 4-10). Image-processing algorithms for desert pavement for the Argonne dataset are also in the process of validation. Systematic ground-truthing is necessary to validate the image analysis algorithms and resulting land-cover mapping conducted by Hamada et al. (2014) and Potter and Li (2014) for the Riverside East SEZ. The validation results will feed back into refinements to the current maps. Validating these cover maps, as well as maps generated by any alternative algorithms developed in the future, is necessary before remote-sensing-based monitoring is applied to the Riverside East SEZ LTMS. This task represents a significant and time-consuming up-front effort.

Table 4-8 Baseline Data Collection That Can Be Used to Assess the Cover of Desert Pavement

1. High-resolution desert pavement mapping for the McCoy Wash area (2012 and 2014) collected by Argonne (Hamada and O'Conner 2012; Hamada 2014)
2. Mapping of desert pavement by NASA Ames and Monterey Bay (Potter and Li 2014)
3. Historical aerial and satellite imagery (Landsat, National Agricultural Imagery Program [NAIP])

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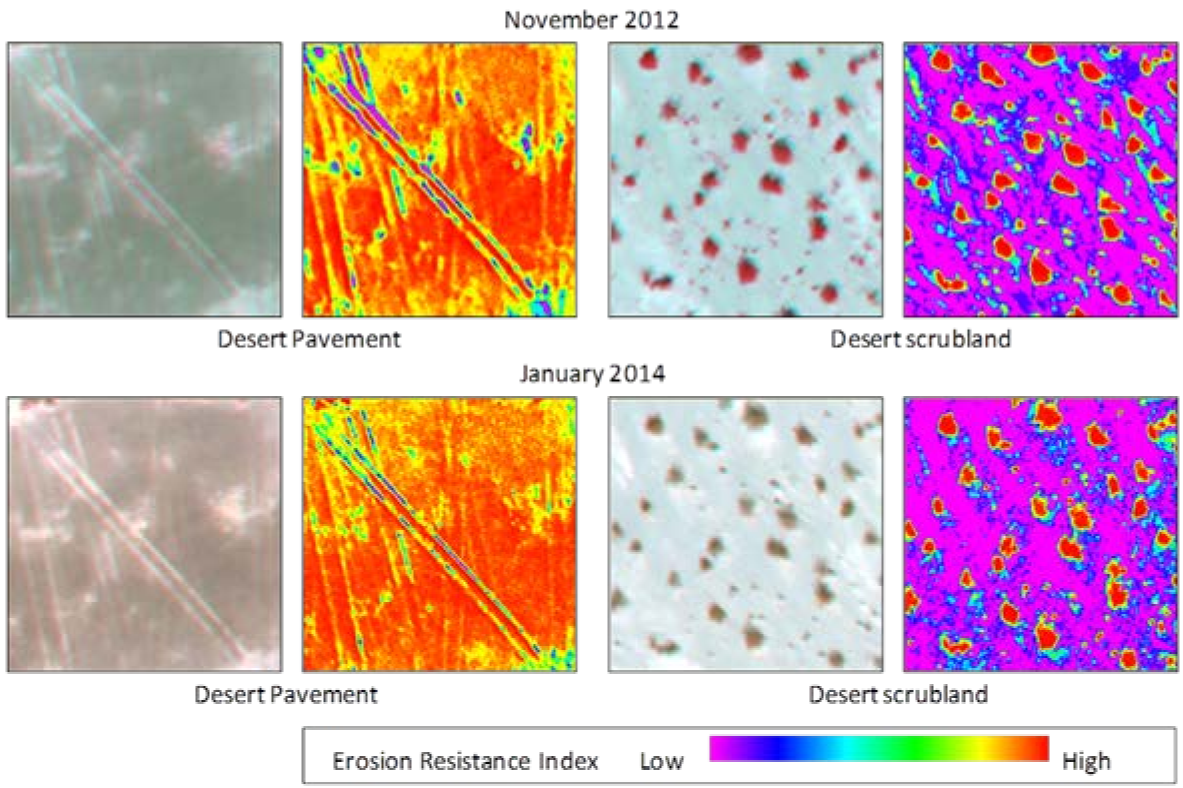

Figure 4-10 Very High Spatial Resolution (VHSR) Images Taken November 2012 and January 2014 in the McCoy Wash Region of the Riverside East SEZ. The erosion resistance index can distinguish desert pavement containing naturally degraded areas and mechanically disturbed features from recreational activities (left).

4.2.6.3 New Indicator Data Collection Recommended for the Riverside East SEZ LTMS

4.2.6.3.1 Criteria and Methods for Sample Stratification

Adherence to a BACI design requires collecting indicator data in areas potentially affected by solar energy development and reference areas subject to similar environmental forcings but outside the area of impacts from solar energy development. Therefore, remotely sensed imagery will be used to map continuous groundcover of desert pavement within each of the three solar impact strata (buffer, SEZ, and reference).

4.2.6.3.2 Image Collection

Imagery collected over time for long-term monitoring should be obtained from a similar time of the year and day to reduce variation in environmental and phenological conditions to ensure that the target–background relationship is fairly constant.

4.2.6.4 Image Analysis

Baseline cover of desert pavement should first be estimated in the three impact strata (buffer, SEZ, and reference) by using existing pre-construction imagery where available. Methods for image analysis applicable to each of desert pavement are referenced in the discussion below. Further investigation is needed to determine the most appropriate image types and image analysis techniques considering the environmental conditions and the available imagery (historic and current) specific to the Riverside East SEZ. See Section 3.4 for a discussion of the uncertainties, limitations, and evolving nature of remote sensing as applied to long-term monitoring.

Cover of desert pavement can be quantified by using methods similar to Potter and Li (2014). As with vegetation, the results of the image analysis must be validated using field-collected data, and validation will be used to refine the image analysis. In addition to quantifying cover, the Erosion Resistance Index (ERI) developed at Argonne National Laboratory can potentially be used to quantify disturbances to desert pavement resulting from human activity (Hamada et al. 2014) (Figure 4-10).

4.2.7 Data Analysis and Summary of Erosion Indicator Data

Each of the erosion and surface disturbance indicators discussed in the preceding sections should be compared among locations (buffer, SEZ, and reference) and time (before and after solar facility construction) for evidence of an impact by using a BACI statistical analysis (Section 2.3.2). PM concentrations attributable to the solar facility can be estimated by subtracting those at an upwind monitor from those at a downwind monitor to assess PM changes related to solar facilities.

The erosion indicators, sampling method and design, and data analysis are summarized in Table 4-9.

Table 4-9 Summary of Monitoring Indicators and Monitoring Plan Proposed to Monitor Surface Erosion and Disturbance

Indicator (s)	Method	Sampling Strata	Data Analysis
Soil aggregate stability; texture, infiltration; depth	1. Data on soil aggregate stability, soil texture, soil depth, and soil infiltration will be collected once per year. 2. Qualitative visual observations of signs of erosion at each sampling plot with data sheets covering rills, gullies, pedestals, deposition and runoff, and water flow will be made. 3. Photographs will be taken at each sampling site.	Three solar impact strata (buffer, SEZ, and reference). Within the buffer stratum, plots located downslope and downwind of solar development projects where wind and water related soil erosion is most likely to occur.	The number of rills can be quantified by manual counts using ground-based photographs. For each of the biophysical strata, changes in the number of rills and the five soil indicators will be compared among impact strata (buffer, SEZ, and reference) and time (before and after solar facility construction) for evidence of an impact using a BACI statistical analysis.
Stream channel depth, width, and location	Ground-based photography and archived photographs	Three solar impact strata (buffer, SEZ, and reference). Imagery will be obtained for randomly selected streams and washes located downslope of existing or planned solar facilities within the 2-mi (3-km) buffer zone. Further stratification may be used to target streams by erosion risk and channel size; reference streams.	Changes in channel morphology metrics at solar impact and reference areas quantified from imagery and compared before and after solar development using a BACI statistical analysis.
PM monitoring	New climate stations	It is recommended that four monitors be set up at locations both upwind and downwind of the primary and secondary prevailing wind directions around the impact site; PM_{10} will be monitored at the east end of Joshua Tree National Park closest to the SEZ.	Pre-construction monitoring data will be compared to dust concentrations and dispersion from solar facility activities; potential dust dispersion patterns will be identified.
Desert pavement cover and integrity	Quantify cover of desert pavement and degree of disturbance using remote sensing	Remotely sensed imagery will be used to map continuous cover and disturbance to desert pavement within each of the three solar impact strata (buffer, SEZ, and reference).	BACI; comparison of quantitative changes in desert pavement within buffer, SEZ, and reference impact strata before and after facility construction.

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4.3 Dune Location and Sand Transport Rates

4.3.1 Rationale for Monitoring the Indicator

Sand dunes are unique and ecologically important habitats that support specialized plant and animal species. Sand dunes within the Riverside East SEZ have been divided into zones based on their relative stability or mobility (Lancaster et al. 2013). Active dunes are less vegetated and have migrating sand deposits transported primarily by wind (Lancaster et al. 2013). Within the Riverside East SEZ, the main sand transport corridor is through the Clark Pass, which supplies the Ford-Palen Dune system, the primary dune system in the SEZ (Muhs et al. 2003; Lancaster et al. 2013).

Given the large footprint of utility-scale solar energy projects in the SEZ, there is the potential for direct or indirect impacts on sand dune habitat and sand transport corridors (Figure 4-11). Solar facility infrastructure that extends into sand transport corridors would physically block the movement of sand. Indirectly, solar infrastructure could redirect or reduce wind speed and subsequently alter or reduce aeolian sand transport. Muhs et al. (2003) describe the dune fields in southeastern California as sediment-limited and dependent on rainfall and fluvial transport for new sediment supply. Therefore, surface flow modification on the solar project site could reduce the supply of sand available for dune aggradation. Monitoring dune location and migration rates will provide data on whether these processes change over time and whether any changes are related to solar energy development in the SEZ.

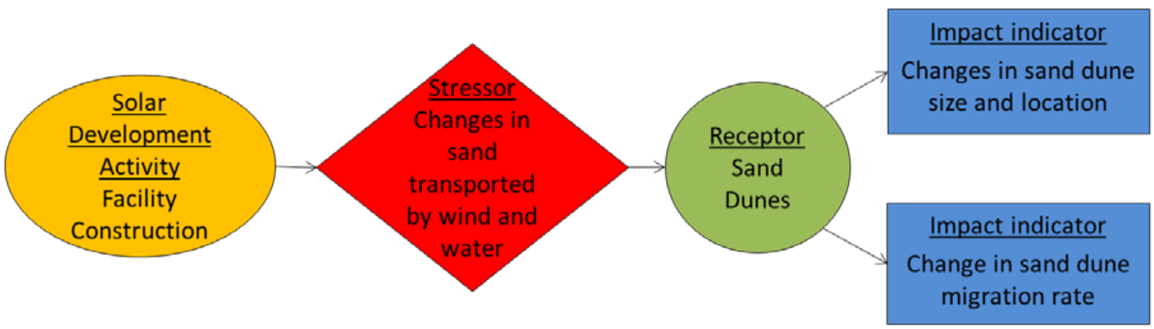

Figure 4-11 Conceptual Model Illustrating Potential Impacts on Sand Dunes Resulting from Solar Development Activities and the Impact Indicators Used for the Riverside East SEZ LTMS

BLM policies for preserving, protecting, and maintaining ecological resources are laid out in the following documents:

- BLM *Land Use Planning Handbook*, H-1601-1, 2005, and Amendments
- California Desert Conservation Area Plan, 1999, and Amendments
- BLM Manual 1734, Rangeland Interagency Ecological Site Manual, and BLM Handbook 1734-1, Interagency Ecological Site Handbook for Rangelands
- BLM Manual 5711, *Site Preparation*
- BLM Information Memoranda 2014-112, Policy for Solar and Wind Energy Inspection and Enforcement

4.3.2 Related Management Questions, Management Goals, and Monitoring Objectives Addressed by the Indicator

Monitoring dune location and migration rate will address the management questions, management goals, and monitoring objectives listed in Table 4-10.

Table 4-10 Management Questions, Management Goals and Monitoring Objectives Addressed by Monitoring Sand Dune Movement and Sand Transport Rates

Management Questions

- Are on-site ground disturbances and facilities design and construction altering natural patterns and volumes of off-site soil erosion by wind or water?

Management Goals

- Minimize soil erosion impacts on desert pavement, dry lakes, sand dunes, and fluvial and aeolian sand transport corridors, and sand source areas.

Monitoring Objectives

- Detect temporal changes of management significance in sand dune size, location, and sand transport relative to control areas.

4.3.3 Spatial and Temporal Considerations for Monitoring the Indicator

The spatial extent of the primary sand transport corridors include the Dale Lake–Palen Dry Lake sand corridor and the Palen Valley corridor, both of which flow southeast into the Chuckwalla Valley and the Palen-McCoy Valley through which sand moves south into the Chuckwalla Valley (Muhs et al. 2003) (Figure 4-12). Sand from these three sources mix and is transported eastward through the Chuckwalla Valley sand transport corridor. Thus, the sand field is large and continuous and therefore can be mapped with lower resolution imagery (>30 m) (Mohamed and Verstraeten 2012). The active dune fields occupy only a portion of the corridor. The rest is either vegetated or playa and includes both stabilized dunes and areas with no visible sand-related topography. An important spatiotemporal consideration for monitoring sand dunes is the rate of sand transport. Lancaster et al. (2013) estimated a mean sand transport rate of 2.5 m^3 per meter per year in the area of the Palen solar energy project, while Collison et al. (2011) estimated a mean sand transport rate of 2.1 m^3 per meter per year at the eastern edge of the Chuckwalla Valley. With such a small annual migration distance, imagery with higher spatial resolution (<5 m) may be required to quantify annual migration of the leading edge of the active dune field.

An important temporal consideration for monitoring sand transport is seasonal wind patterns. Lancaster et al. (2013) determined that the strongest winds, and sand transport potential, occur during the spring. Consequently, it may be best to obtain imagery after the spring months. Because sand dunes create shadows that can make feature delineation difficult, Potter and Li (2014) examined Landsat data throughout the year to determine the optimal month for image collection. They concluded that images collected in July and August have the most suitable sun elevation and sun azimuth for accurately detecting dunes. Images also should be collected at the same time of day. Image collection is typically recommended around noon for most applications. However, dune detection may benefit from having shadow in the scene to differentiate dune features from sand in level areas, so mid-day may not be the best time of the day for the image collection. Research should be conducted to determine the optimal time of day for image collection.

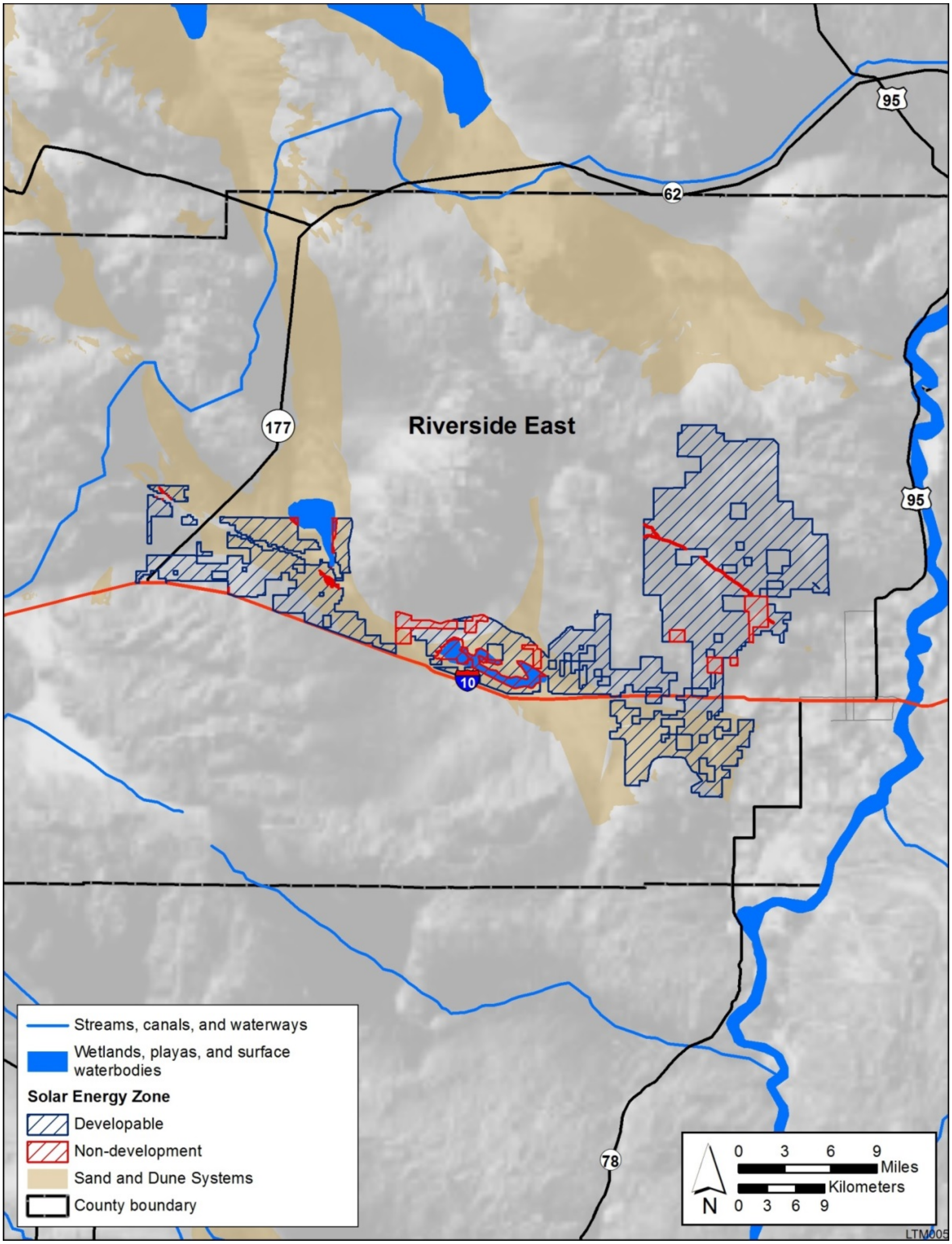

Figure 4-12 Sand Dunes and Sand Transport Systems on and in the Vicinity of the Riverside East SEZ (Source: DRECP EIS [DRECP 2014])

4.3.4 Existing Data Sources

There have been several reviews of the primary dune systems and sand transport corridors in the Riverside East SEZ, including studies conducted for the DRECP and individual solar energy projects (Muhs et al. 2003; Collison et al. 2011; Lancaster et al. 2013). There are also several imagery sources available for addressing sand transport rates in the SEZ (Table 4-11). For example, Potter and Li (2014) were able to quantify the migration of Palen Dune between 1984 and 2011; they found that Palen Dunes expanded 47% during the past three decades. Although the dune mapping conducted by Potter and Li has yet to be field-validated, several studies using similar image-processing analyses have shown remote sensing techniques can accurately map sand dunes (Mohamed and Verstraeten 2012). In addition, the California Department of Fish and Wildlife has contracted with the California Department of Mines and Geology to produce higher resolution mapping of sand transport corridors within the Riverside East SEZ.

Table 4-11 Baseline and Ongoing Data Collection That Can Be Used to Assess Sand Dunes Location and Migration Rate in the Riverside East SEZ

1. Baseline NASA Ames and Monterey Bay mapping for sand dunes (Potter and Li 2014)
2. Publicly available aerial and satellite imagery
3. Ongoing studies of sand transport corridors within the Riverside East SEZ funded by the California Department of Fish and Wildlife
4. Dune Systems and Sand Transport corridors mapped in DRECP
5. California Geological Survey 2014 aeolian mapping for the Riverside East SEZ

4.3.5 New Indicator Data Collection Recommended for the Riverside East SEZ LTMS

4.3.5.1 Criteria and Methods for Sample Stratification

To conform to a BACI design, it is necessary to sample areas potentially affected by solar energy development as well as reference areas (Section 2.3.2). For the Riverside East SEZ, the Chuckwalla Ford-Palen dune field is the only dune habitat potentially affected by solar development. An active dune corridor system not influenced by solar energy development should be selected as a reference area. Bristol Trough sand path is also a northwest-to-southeast trending corridor through which sand moves from Bristol playa to the Cadiz and Danby dune fields (Muhs et al. 2003) and could serve as a potential reference site.

4.3.5.2 Image Collection

Image collection will focus on the Dale Lake-Palen Dry Lake sand Corridor, the Palen Valley corridor, the Chuckwalla Valley sand transport corridor, and the Ford-Palen dune field. Sand dunes and sand transport rates can be monitored by using aerial or satellite imagery, as appropriate, following the methods of Mohamed and Verstraeten (2012) as applied to the Riverside East SEZ by Potter and Li (2014). Sand dune size, location, and annual movement rate should be determined annually with imagery from approximately the same date and time of day to ensure consistent sun angle at the time image of collection. The satellite imagery analysis can be supplemented with field data measurements of sand transport.

4.3.6 Image Analysis and Summary of Monitoring Strategy

Image analysis methods applicable to sand dunes are referenced in the following discussion. Further investigation may be needed to determine the most appropriate image analysis techniques for the environmental conditions and the available imagery (historic and current) specific to the Riverside East SEZ. See Section 3.4 for a discussion of the uncertainties, limitations, and evolving nature of remote sensing as applied to long-term monitoring.

Dune area and sand transport can be determined from imagery by using automated image-processing methods such as red-green-blue (RGB) clustering (Mohamed and Verstraeten, 2012; Hugenholtz et al., 2012; Hermas et al. 2012). Potter and Li (2014) describe methods for applying these algorithms to sand dunes in the Mojave and Sonoran Deserts. Dune movement rate can be calculated by determining the change in the leading edge of the dune over the time series of images. If field validation suggests that automated image analysis does not sufficiently delineate dune location, area, and movement, then sand dunes can be manually digitized based on visual interpretation of the imagery, as described in Redsteer et al. (2011).

Changes in dune size and location should be quantified over time (before and after solar facility construction) and compared to changes at the reference location using a BACI statistical framework (Section 2.3.2). A summary of the proposed sand dune indicators, sampling method and design, and data analysis is provided in Table 4-12.

Table 4-12 Summary of Monitoring Indicators and Monitoring Plan Proposed to Monitor Sand Dunes

Indicator (s)	Method	Sampling Strata	Data Analysis
Dune location and Sand Transport rates	Quantify cover of dune cover, location, and movement	Dale Lake–Palen Dry Lake sand corridor and the Palen Valley corridor, Palen-McCoy Valley through Chuckwalla Valley sand transport corridor. Bristol Trough sand path could serve as a potential reference site.	BACI; comparison of quantitative changes in sand dune cover location, and movement in buffer, SEZ, and reference impact strata before and after facility construction.

4.3.7 Literature Cited

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5 BIOLOGICAL INDICATORS

5.1 Biological soil crusts

5.1.1 Rationale for Monitoring the Indicators

Five solar energy development sites have been permitted at or adjacent to the Riverside East SEZ, and three other project applications are under review (Table 1-1). Given the spatial extent of land-clearing and grading for project site development, there is the potential for significant changes in natural land cover within the SEZ. BSCs have been identified by stakeholders as resources of particular concern.

The LTMS includes indicators of impacts on BSCs (Figure 5-1). BSCs are soil surface communities primarily comprised of cyanobacteria, mosses, and lichens and are widely distributed in the desert environments. Like desert pavement, biological crusts are recognized as an important influence on surface water runoff (Viles 2008; Bowker et al., 2008) and soil biogeochemistry (Bowker et al. 2008) and on reducing aeolian sand transport in arid systems (Sankey and Draut 2014). Once disturbed, many types of biological crusts can take years to recover (Viles 2008). BSCs make up a significant proportion of land cover at the Riverside East SEZ (Potter and Li 2014), making them vulnerable to loss due to soil-disturbing activities, such as facility construction and the placement of pipelines and transmission lines. In addition, the increased vehicle and foot traffic associated with solar facility operations could disturb BSCs, significantly reducing their soil stabilization functions (Belnap et al. 2001) (Figure 5-1). Unless avoidance measures are taken, loss of these cover types will continue from ongoing development in the desert, including utility-scale solar development. Consequently, all action alternatives in the DRECP will require limits on the percentage of BSCs that can be disturbed within a solar project ROW.

As described in Section 3, remote sensing is an effective tool for monitoring changes in BSCs (Chen et al. 2005; Ustin et al. (2009). Therefore, the LTMS will include the use of remote sensing to map the continuous cover of BSCs within the Riverside East SEZ.

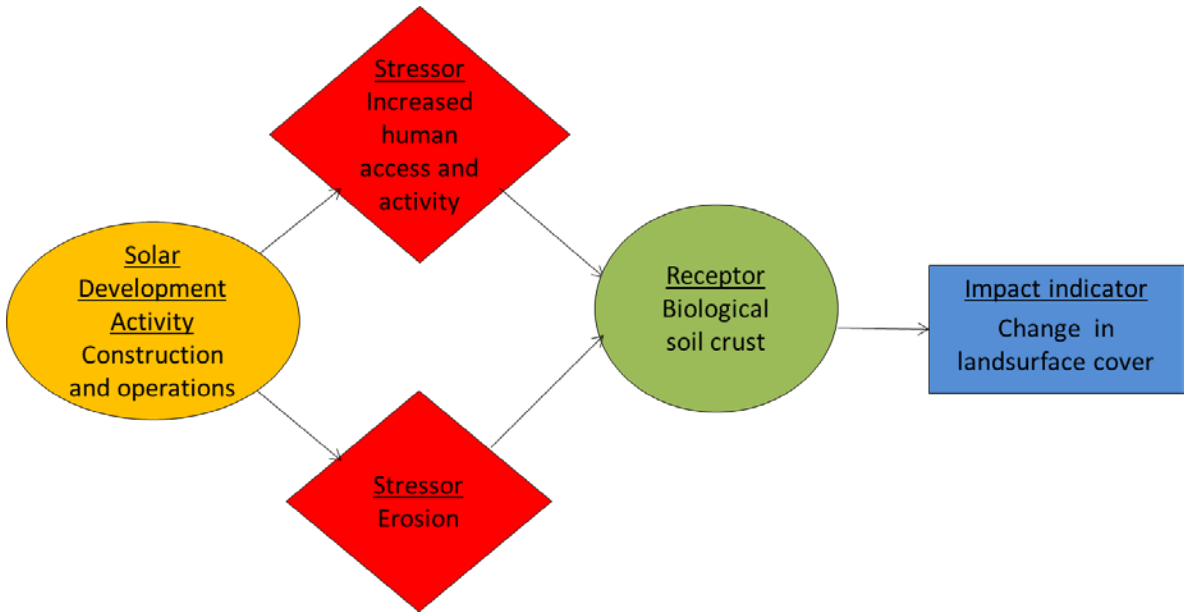

Figure 5-1 Conceptual Model Illustrating Potential Impacts on Desert Pavement and BSCs Resulting from Solar Development Activities and the Impact Indicators used for the Riverside East SEZ LTMS

BLM policies for preserving, protecting, and maintaining ecological resources are laid out in the following documents:

- BLM Handbook H-1601-1, *Land Use Planning*, , 2005, and Amendments
- California Desert Conservation Area Plan, 1999, and Amendments
- BLM Manual1734, Rangeland Interagency Ecological Site Manual, and BLM Handbook 1734-1, Interagency Ecological Site Handbook for Rangelands
- BLM Manual 5000, *Forest Management*, and BLM Handbook 5000-1, *Forest Management*
- BLM Manual 5711, *Site Preparation*
- BLM Handbook 1740-2, Integrated Vegetation Management
- BLM Information Memoranda 2014-112, Policy for Solar and Wind Energy Inspection and Enforcement

5.1.2 Related Management Questions, Management Goals, and Monitoring Objectives Addressed by the Indicator

Monitoring BSCs within the SEZ will address the management question, management goal, and monitoring objective listed in Table 5-1.

Table 5-1 Management Question, Management Goal, and Monitoring Objective Addressed by Monitoring BSCs

Management Question
- How does land-clearing for project site development change the relative land cover types within the SEZ?
- Are solar facility operations affecting biological crusts?

Management Goal
- Minimize impacts on biological soil crusts from solar energy development.

Monitoring Objective
- Detect temporal changes of management significance in BSC relative to control areas..

5.1.3 Spatial and Temporal Considerations for Monitoring the Indicator

A variety of spatial considerations exists in monitoring BSCs. BSCs are common in the Riverside East SEZ, and their spatial distribution is determined by a number of factors including vegetation cover, soil composition, and soil moisture (Belnap et al. 2001). Several studies have used relatively low resolution (30–90 m) imagery (Landsat, ASTER) to map the spatial cover of BSCs (Karneli 1997; Chen et al., 2005; Rozenstein and Karnieli 2015). However, the accuracy of BSC cover mapping can vary with the density and cover of the BSCs (Potter and Li 2014). BSCs are most biologically active during cooler months of the year if the soil surface is moist (Belnap et al. 2001).

5.1.4 Existing Data Sources

Baseline monitoring data that could potentially be used to quantify the relative cover of BSC in the SEZ are shown in Table 5-2. Researchers at NASA Ames Research Center and the California State University Monterey Bay have mapped BSCs in the Riverside East SEZ in support of DRECP (Potter and Li, 2014). However, the mapping results have yet to be field-verified. In addition, mapping by Argonne in McCoy Wash area of the SEZ (using 15-cm resolution aerial imagery) can be used to quantify the baseline fractional cover of BSCs (Hamada et al. 2014). Systematic ground-truthing is necessary to validate the image analysis algorithms and resulting land-cover mapping conducted by Hamada et al. (2014) and Potter and Li (2014) for the Riverside East SEZ, and the validation results will feed back into refinements to the current maps. Validating these cover maps, as well as maps generated by any alternative algorithms developed in the future, is necessary before remote-sensing-based monitoring is applied to the Riverside East SEZ LTMS. This task represents a significant and time-consuming up-front effort.

Table 5-2 Baseline Data Collection That Can Be Used to Assess the Cover of BSCs

1. Mapping of BSC by NASA Ames and California State University at Monterey Bay (Potter and Li 2014)
2. Historical aerial and satellite imagery (Landsat, NAIP)

5.1.5 New Indicator Data Collection Recommended for the Riverside East SEZ LTMS

5.1.5.1 Criteria and Methods for Sample Stratification

Adherence to a BACI design requires collecting indicator data in areas potentially affected by solar energy development and reference areas subject to similar environmental forcings but outside the area of impacts from solar energy development. See Section 2.3.2 for the rationale and description of the stratification plan for the Riverside East SEZ LTMS. Therefore, remotely sensed imagery will be used to map continuous ground cover of BSCs within each of the three solar impact strata (buffer, SEZ, and reference).

5.1.5.2 Image Collection

Imagery collected over time for long-term monitoring should be obtained from a similar time of the year and day to reduce variation in environmental conditions and ensure that the target-background relationship is fairly constant. BSC imagery should be collected during the wet season (winter to spring) when BSCs are most biologically active (Belnap et al. 2001). The frequency of image collection may be increased in order to collect imagery before, during, and after the construction of individual solar energy facilities.

5.1.6 Image Analysis and Summary of Monitoring Strategy

Baseline fractional cover of BSCs should first be estimated in the three impact strata (buffer, SEZ, and reference) using existing pre-construction imagery where available. Change in the area and fractional cover of the BSC will be compared among locations (buffer, SEZ, and reference) and time (before and solar facility construction) for evidence of an impact using a BACI design statistical analysis framework (Section 2.4.2).

Methods for image analysis applicable to BSCs are referenced in the following discussion. Further investigation is needed to determine the most appropriate image types and image analysis techniques for the environmental conditions and the available imagery (historic and current) specific to the Riverside East SEZ. See Section 3.4 for a discussion of the uncertainties, limitations, and evolving nature of remote sensing as applied to long-term monitoring.

Although several metrics exist for mapping BSCs, they will likely be the most difficult of the land cover indicators to accurately characterize. BSC cover has been quantified using the BSCI following the methods of Chen et al. (2005) and Potter and Li (2014). However, BSCs in the Riverside East SEZ are dominated by cyanobacteria as well as lichens (Belnap et al. 2001). Consequently, the crust index (CI), which was developed for cyanobacterial BSCs (Karnieli 1997), may provide more accurate BSC cover estimates. The proposed monitoring plan for BSCs is summarized in Table 5-3.

Table 5-3 Summary of Monitoring Indicators and Monitoring Plan Proposed to Monitor Biological Soil Crusts

Indicator (s)	Method	Sampling Strata	Data Analysis
BSC cover	Quantify cover of BSCs using remote sensing and image analysis	Remotely sensed imagery will be used to map continuous groundcover of BSCs within each of the three solar impact strata (buffer, SEZ, and reference).	BACI; comparison of quantitative changes in BSCs within buffer, SEZ, and reference impact strata before and after facility construction

5.1.7 Literature Cited

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5.2 Vegetation Indicators

5.2.1 Rationale for Monitoring the Indicators

Five solar energy development sites have been permitted at or adjacent to the Riverside East SEZ and three other project applications are under review (Table 1-1). Given the spatial extent of land-clearing and grading for project site development, there is the potential for significant changes in vegetation cover. The multiple functions of vegetation in desert ecosystems are well documented and include food (Krueper 1993; Levick et al. 2008), shelter for wildlife (Stamp and Ohmart 1979; Brode and Bury 1984); and soil stability (Micheli and Kirchner 2002). Vegetation is also an excellent monitoring endpoint because of the sensitivity of plants to local hydrologic conditions.

The construction of utility-scale solar energy facilities would significantly increase human access and presence via newly constructed access roads and transmission lines. Many of these areas are remote and have experienced little prior encroachment from human activities. More human activity could increase physical disturbance, dust, and introduce non-native species, all of which could adversely affect native plant communities (Figure 5-2a).

In arid environments, the distribution, density, and species composition of vascular plant communities are largely determined by the availability of groundwater and surface water (reviewed in Levick et al. 2008). Groundwater withdrawal is another primary concern associated with solar energy development that has the potential to affect plant communities (Figure 5-2b). Consequently, a reduction in groundwater elevation due to water withdrawal for solar facility operations could result in impacts on phreatophytic vegetation (Patten et al. 2008). Similarly, off-site changes in the quantity, timing, and duration of surface flow could alter riparian vegetation cover, species composition, and canopy structure (Levick et al. 2008; Stromberg et al. 2010). In the southwestern United States, a number of impacts on plant communities have been documented as resulting from excessive groundwater use. Frequently observed changes in vegetation following groundwater depletions include the loss of phreatophytic plants, a reduction in riparian tree density, and a shift to xeric plant species (Zektser et al. 2005; Webb and Leake 2006; Patten et al., 2008). Similarly, groundwater drawdown can decrease the salt concentration in soils, resulting in a decrease in halophytic plants (Patten *et al.*, 2008).

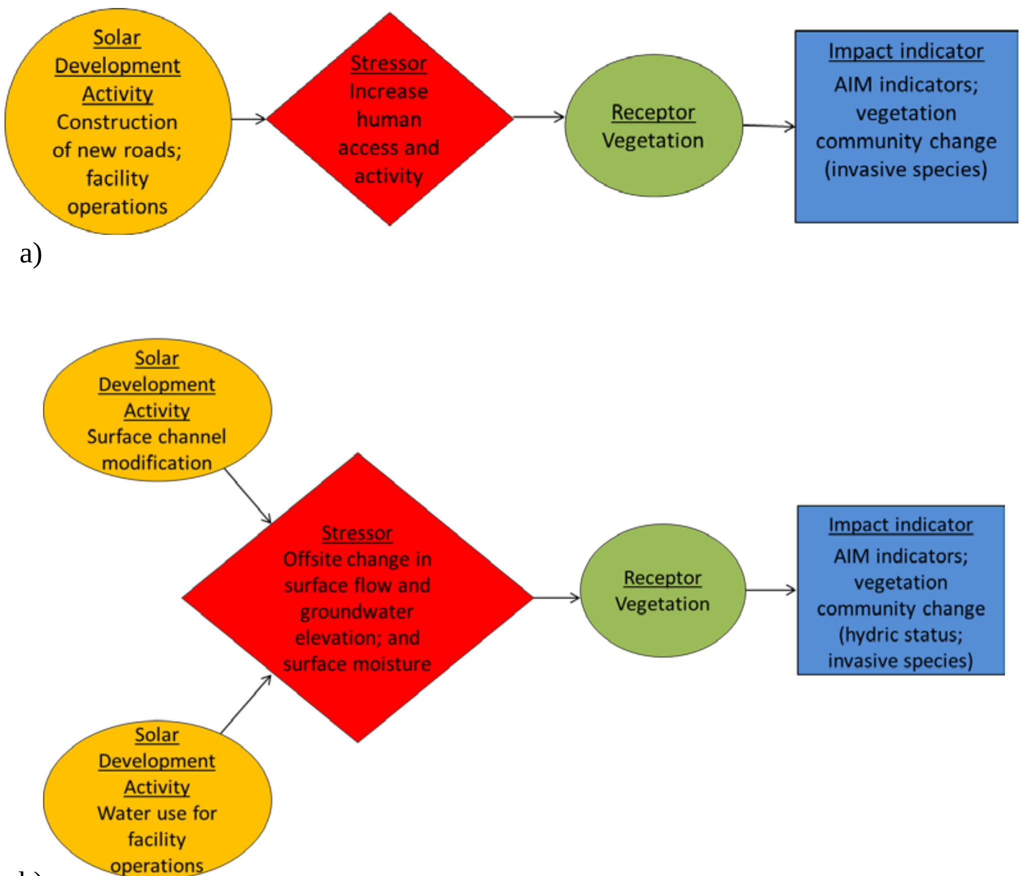

Figure 5-2 Conceptual Model Illustrating Potential Impacts on Vegetation Resulting from Solar Development Activities Including (a) Increased Human Access (b) Hydrology, and the Impact Indicators Used for the Riverside East SEZ LTMS

Changes in soil moisture, flood intensity, and surface flow frequency and duration following solar energy development can also alter the composition of vegetation because of species-specific sensitivity to hydrologic conditions (Stromberg et al. 2006; Stromberg, Lite. and Dixon 2010) (Figure 5-3). For example, if off-site riparian areas experience reduced surface flow conditions, plant communities can shift to more xeric or more mesic species and riparian herbaceous cover can be reduced (Smith et al. 1998; Stromberg et al. 2006, Stromberg , Lite. and Dixon 2010). These changes could also result in a detectable change in the physical structure (e.g., vegetation cover, life form, and canopy height) of the riparian community (Stromberg , Lite. and Dixon 2010). In addition, reduced flow frequency can allow the establishment of invasive species, such as *Tamarix ramosissima* (Cleaverly et al. 1997; Smith et al. 1998; Stromberg , Lite. and Dixon 2010). Hydrologic regime is also an important influence on plant species diversity (Katz et al. 2011).

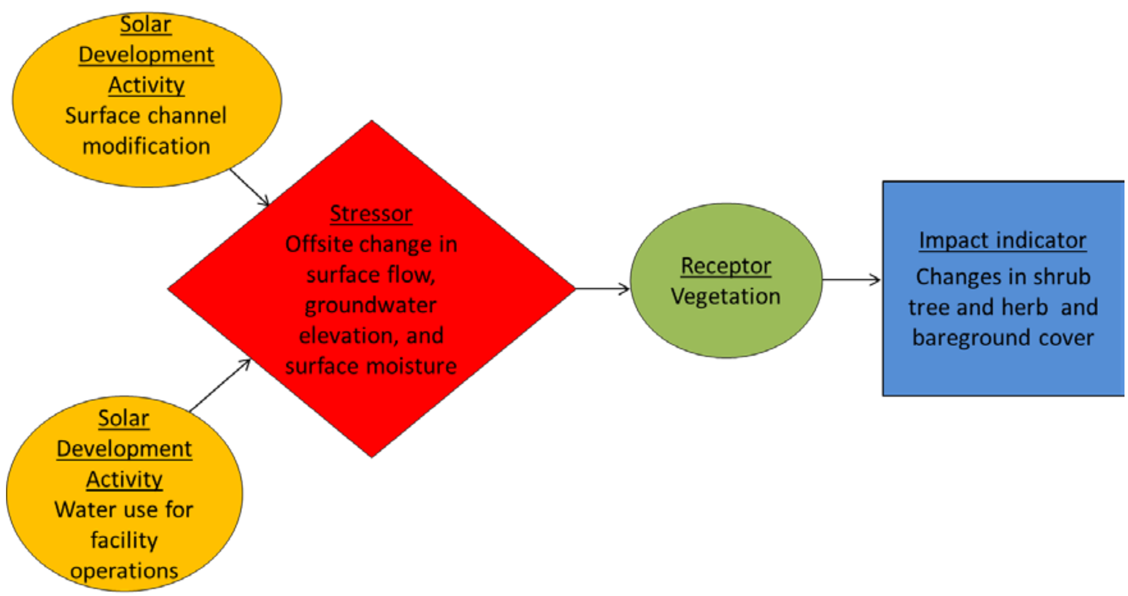

Figure 5-3 Conceptual Model Illustrating Potential Impacts on Vegetation Resulting from Solar Development Activities and the Impact Indicators Used for the Riverside East SEZ LTMS

To assess the potential impacts on vegetation communities from solar energy development, vegetation cover and AIM vegetation indicators will be monitored as part of the Riverside East SEZ LTMS. Monitoring methods and the sampling plan for vegetation cover and AIM indicators are discussed in Section 5.2.3 and Section 5.2.4, respectively.

BLM policies for preserving, protecting, and maintaining ecological resources, including vegetation, are laid out in the following documents:

- BLM Handbook H-1601-1, *Land Use Planning*, 2005, and Amendments
- California Desert Conservation Area Plan, 1999, and Amendments
- BLM Manual1734, Rangeland Interagency Ecological Site Manual, and BLM Handbook 1734-1, Interagency Ecological Site Handbook for Rangelands
- BLM Manual 5000, *Forest Management*, and BLM Handbook 5000-1, *Forest Management*
- BLM Manual 5711, *Site Preparation*
- BLM Handbook 1740-2, Integrated Vegetation Management Handbook
- BLM Information Memoranda 2014-112, Policy for Solar and Wind Energy Inspection and Enforcement

5.2.2 Related Management Questions, Management Goals, and Monitoring Objectives Addressed by the Indicator

Monitoring vegetation cover within the SEZ will address the management questions, management goals, and monitoring objectives listed in Table 5-4.

Table 5-4 Management Questions, Management Goals, and Monitoring Objectives Addressed by Monitoring Vegetation Cover

Management Questions

- What is the baseline status and trend of vegetation communities inside and surrounding the SEZ?
- Are solar facility operations affecting vegetation communities in off-site areas?
- Have changes in surface hydrology related to solar facility construction affected off-site vegetation alliances downslope of solar facilities and riparian vegetation communities, particularly desert dry wash woodlands?
- Is solar-related water withdrawal affecting riparian habitats and groundwater dependent (phreatophytes) vegetation communities?
- How does land-clearing for project site development change the relative land cover types within the SEZ?

Management Goals

- Maintain vegetation communities, especially those that depend on groundwater (phreatophytes).
- Ensure facility operations do not promote the spread of invasive plant species.
- Preserve vegetation communities that are rare or have rare species.
- Preserve vegetation communities that have high species richness.
- Preserve important vegetation habitats for wildlife.
- Maintain riparian vegetation cover.

Table 5-4 (Cont.)

Monitoring Objectives
• Detect temporal changes of management significance in total plant cover, intercanopy gaps, and woody plant height relative to control areas.
• Detect temporal changes of management significance in rare and high-priority vegetation communities relative to control areas.
• Detect new introductions of invasive plant species relative to control areas.

5.2.3 Remote-Sensing-Based Estimates of Vegetation Cover

5.2.3.1 Spatial and Temporal Considerations for Monitoring the Indicator

A variety of spatial considerations exists in monitoring vegetation cover using remote sensing. Vegetation in the Riverside East SEZ is principally sparsely distributed shrub lands, although tree and shrub cover can be high along desert washes. At local or regional scales, vegetation cover has been quantified using moderate- to low-resolution imagery like Landsat and SPOT (Xie et al. 2008). However, in desert environments, the accuracy of these vegetation cover estimates can be limited due to the low density of vegetation. Higher resolution imagery is typically needed to detect individual plant canopies. Frank and Tweddale (2006) found that imagery with <1-m spatial resolution was necessary to accurately estimate shrub cover in the Mojave Desert. Similarly, Hamada et al. (2014) used 15-cm resolution images to map individual shrub and tree canopies in the East Riverside SEZ, and the optimal resolution for mapping these canopies are being investigated.

Vegetation imagery should be obtained when vegetation is most easily distinguished from background soil and during particular stages of plant phenology (e.g., flowering, peak greenness, and senescence) that depend on environmental conditions (e.g., precedent precipitation and temperature), so that the target-background relationship is optimal and fairly constant. Therefore, the optimal time for image collections may be sometime shortly after the rainy season when precipitation is negligible but plant “greenness” is still high. In other cases, it would be optimal to take imagery after a dry winter. Imagery taken in periods of prolonged dryness may be less optimal because perennial plant leaves senesce during extended periods of no rainfall (Wallace and Thomas 2008). The Riverside East SEZ falls primarily within the Sonoran desert, but portions also fall within the Mojave Desert. In the Mojave Desert, annual and perennial plant growth primarily occurs in the spring following the autumn to winter rainy season (Beatley 1974; Wallace and Thomas 2008). In the Sonoran Desert there are two distinct rainy seasons, a summer monsoon season with strong thunderstorms and a winter rainy season characterized by widespread, lower intensity rainfall (Gray and Stuart 1981; Reynolds et al. 2004).

5.2.3.2 Existing Data Sources

Baseline monitoring data that could potentially be used to quantify the relative cover of vegetation in the SEZ are shown in Table 5-5. Mapping by Argonne in the McCoy Wash area of the SEZ (using 15-cm resolution aerial imagery) can be used to quantify the baseline fractional cover of trees, shrub, and bare ground (Figures 5-4 and 5-5). Image-processing algorithms for vegetation and desert pavement for the Argonne dataset are also in being validated. Systematic ground-truthing is necessary to validate the image analysis algorithms and resulting land-cover mapping conducted by Hamada et al. (2014) and Potter and Li (2014) for the Riverside East SEZ, and the validation results will feed back into refinements to the current maps. Validating these cover maps, as well as maps generated by any alternative algorithms developed in the future, is necessary before remote-sensing-based monitoring can be applied to the Riverside East SEZ LTMS. This task represents a significant and time-consuming up-front effort.

Table 5-5 Baseline Data Collection That Can Be Used to Assess Vegetation Cover

1.	High-resolution vegetation mapping for the McCoy Wash area (2012 and 2014) collected by Argonne (Hamada et al. 2013, 2014)
2.	Historical aerial and satellite imagery (Landsat, NAIP)
3.	California Vegetation Alliance maps
4.	WorldView imagery available to BLM

5.2.3.3 New Indicator Data Collection Recommended for the Riverside East SEZ LTMS

5.2.3.3.1 Criteria and Methods for Sample Stratification

Adherence to a BACI design requires collecting indicator data in areas potentially affected by solar energy development and reference areas subject to similar environmental forcings but outside the area of impacts from solar energy development. See Section 2.3.2 for the rationale and description of the stratification plan for the Riverside East SEZ LTMS. Remotely sensed imagery will be used to map continuous groundcover of vegetation within each of the three solar impact strata (buffer, SEZ, and reference). For example, WorldView imagery, which is available for download by BLM, can be used to monitor cover changes over large areas in high priority vegetation communities like microphyll woodlands. WorldView is 0.3-2 m resolution which should be suitable for measuring canopy area manually or by an algorithm developed and verified at some point in the future

5.2.3.3.1 Image Collection

Imagery collected over time for long-term monitoring should be obtained from a similar time of the year and day to reduce variation in environmental conditions and ensure that the target–background relationship is fairly constant. Imagery for vegetation cover should be obtained in from early May to early summer after the rainy season and spring growing season depending on environmental conditions.

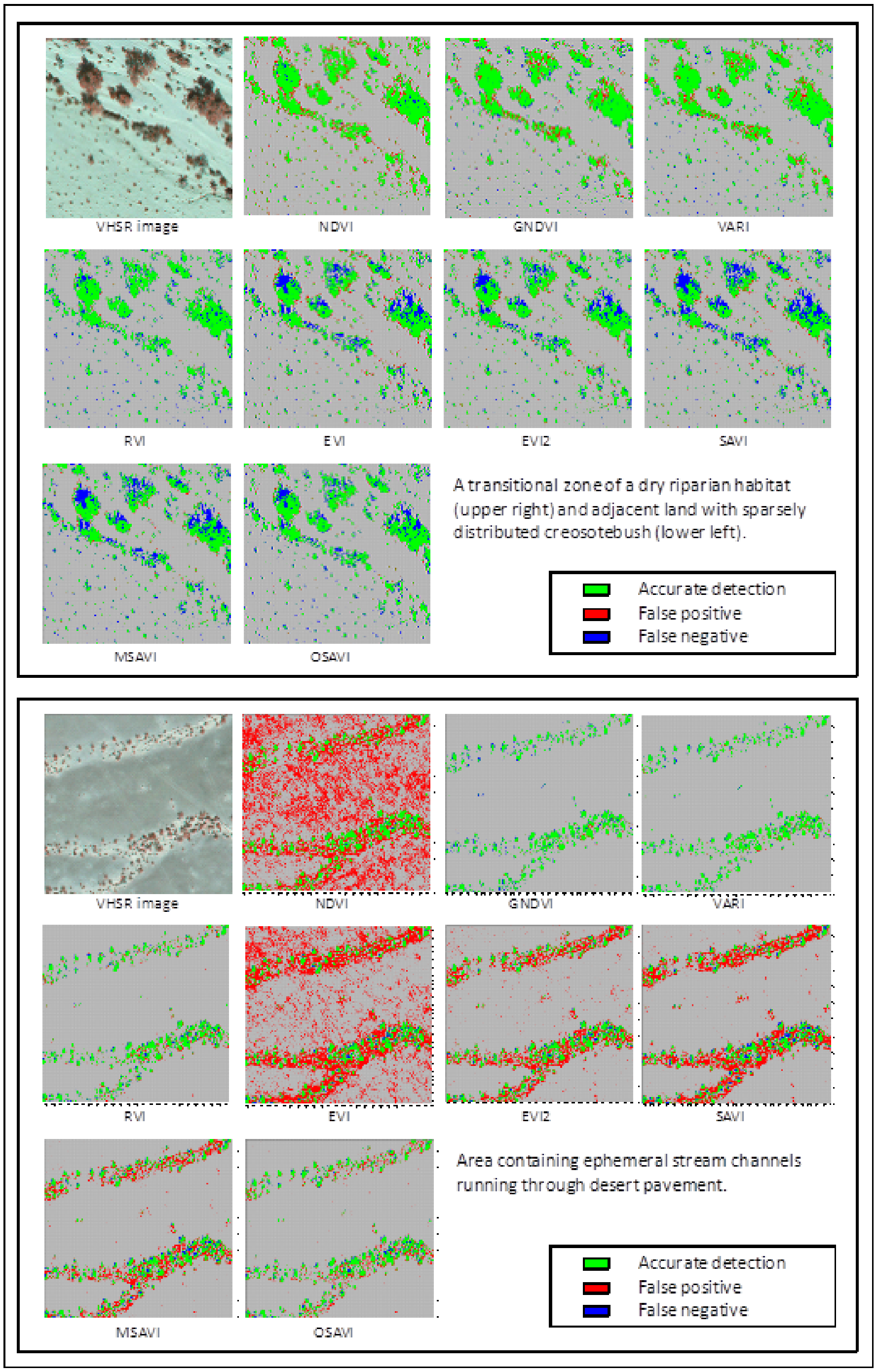

Figure 5-4 Vegetation Maps Derived Using Multiple Spectral Vegetation Indices from 15-cm Resolution Aerial Imagery Collected in January 2014. The area shows a portion of downstream riparian (top) and upstream ephemeral channel (bottom). VHSR = very high spatial resolution; NDVI = normalized difference vegetation index; GNDV = green NDVI; RVI = ratio vegetation index; GRRVI = green-red ratio vegetation index; EVI = enhanced vegetation index; SAVI = soil-

adjusted vegetation index; MSAVI = modified soil-adjusted vegetation index; and OSAVI = optimized soil adjusted vegetation index.

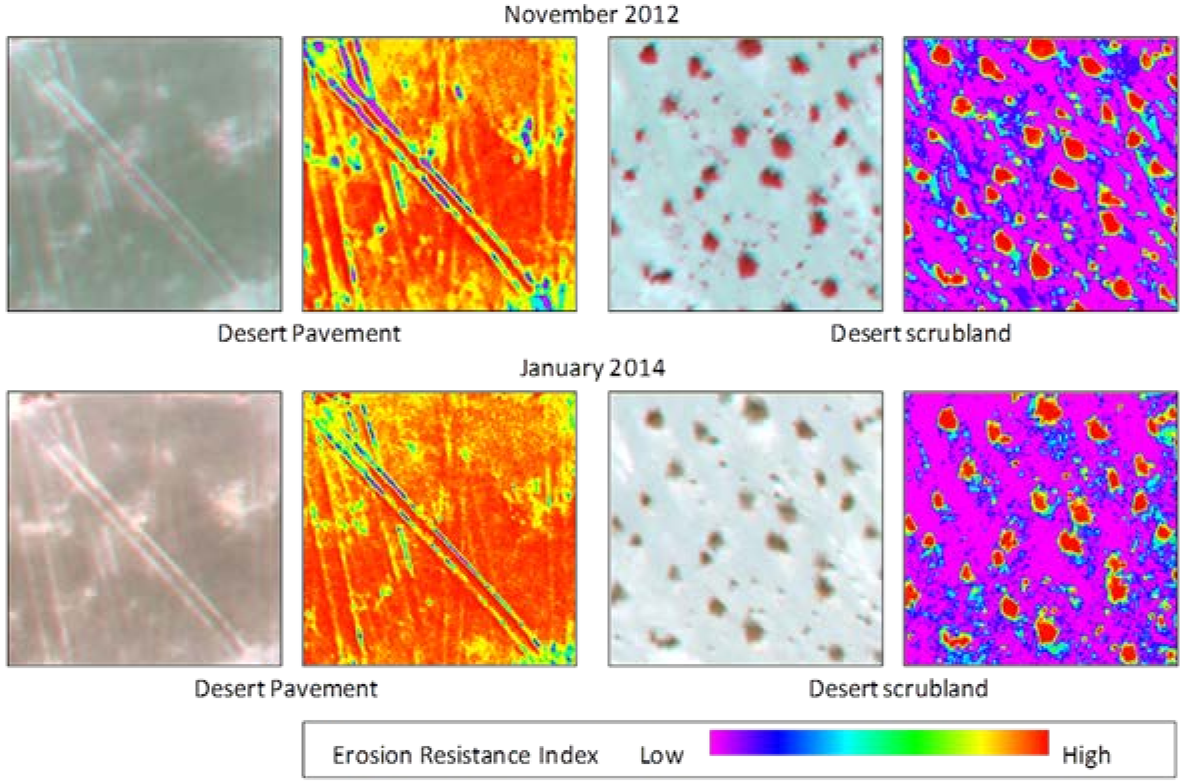

Figure 5-5 VHSR Images Taken November 2012 and January 2014 in the McCoy Wash Region of the Riverside East SEZ, showing a portion of a large ephemeral wash containing scattered scrub growth typical of the study area (right).

5.2.4 AIM Core Vegetation Indicators

This section describes the field-based AIM core vegetation indicator monitoring proposed for the Riverside East SEZ LTMS. Appendix A contains a detailed discussion of the studies by the USDA Jornada using remote sensing to specifically monitor AIM core indicators (Karl, Duniway, and Schrader 2012; Karl et al. 2012; Duniway et al. 2012). The USDA Jornada has conducted multiple studies using high-resolution aerial imagery (~3cm) to quantify vegetation cover and canopy gap distance along transects within specific monitoring plots. The potential changes in community characteristics just described can be monitored over time following solar facility construction using AIM core vegetation indicators (Toevs et al. 2011). AIM core indicators include bare ground (% cover), the proportion of soil surface in large intercanopy gaps (% cover), vegetation height (m), vegetation composition, plant species of management concern, and non-native invasive plant species (% cover). Species richness and diversity, fractional cover of live (versus dead or residual) vegetation (as opposed to dead or residual plant materials) can also be derived from AIM monitoring data. The AIM core vegetation indicators have been identified in BLM planning documents (Taylor et al. 2014) as key monitoring endpoints to be monitored across BLM public land.

5.2.4.1 Spatial Scale for the Indicator and Temporal Scale of the Indicator

The spatial scale over which the AIM vegetation indicators will be monitored includes the SEZ and areas outside the SEZ that can serve as reference locations. Within the SEZ, the proximity to solar development sites is likely to be the most important spatial sampling consideration for detecting changes in AIM core vegetation indicators. Other spatial considerations for monitoring plant communities include local hydrology, elevation, and soil characteristics, which determine the distribution of specific vegetation communities that are of interest (i.e., microphyll woodland). See Section 5.3.4.3 for a description of the sampling stratification design for the Riverside East SEZ LTMS that accounts for spatial variation in biophysical variables and solar development impacts.

The distribution of dominant desert plant communities (i.e., creosotebush scrublands) is generally stable from year to year. However, in riparian areas, year-to-year changes in hydrology can significantly alter plant diversity, density, and composition over time (Smith et al. 1998; Patten et al. 2008; Stromberg et al. 2010). Given this spatiotemporal variability, annual sampling is needed to detect long-term changes in AIM core vegetation indicators.

5.2.4.2 Existing Data Sources

Baseline data relevant to AIM vegetation indicator monitoring include the vegetation alliance maps prepared by Menke et al. (2013) in support of the DRECP and ongoing AIM indicator monitoring at the Riverside East SEZ, which began in the summer of 2014 (Table 5-6) (Great Basin Institute 2014). The vegetation alliance maps consist of vegetation polygons mapped at >1 acre, which is much lower resolution than the plot-level vegetation data collected as part of AIM. However, the vegetation alliance data provide continuous vegetation cover mapping that can be used to target monitoring to areas containing high-value plant communities (e.g., riparian vegetation, microphyll woodland). AIM indicators are currently being collected within the Riverside East SEZ and surrounding region as a pilot effort for this LTMS and the WLMF (Taylor et al. 2014; Great Basin Institute 2014).

Table 5-6 Baseline and Ongoing Data Collection That Can Be Used to Assess AIM Core Vegetation Indicators in the Riverside East SEZ

1.	California Vegetation Alliance maps
2.	Ongoing AIM core vegetation indicator data collection in the Riverside East SEZ (2014 to the present) and the WLMF

5.2.4.3 New Indicator Data Collection Recommended for the Riverside East SEZ LTMS

5.2.4.3.1 Criteria and Methods for Sample Stratification

To conform to a BACI design, it is necessary to collect indicator data in areas potentially affected by solar energy development and reference areas subject to similar environmental forcings but outside the area of solar impacts. See Section 2.3.2 for the rationale and description of the solar impact stratification plan. The SEZ will be classified by three broad solar impact strata:

1. Two-mile buffer areas around existing and potential solar developments (based on BLM authorized and permitted projects)
2. The remainder of the SEZ where impacts are uncertain (outside solar development areas and buffer zones)
3. Reference (control) areas outside the SEZ that are not expected to be affected by solar development.

The sampling design for the Riverside East SEZ LTMS should incorporate AIM sampling locations and sampling stratification currently employed for the AIM pilot sampling effort and the WLMF. These sampling locations are allocated across biophysical sampling strata to ensure the sampling of a wide range of types of land. For AIM pilot sampling, vegetation alliance maps (Menke et al. 2013) were combined with landform layers to create the biophysical sampling strata (Great Basin Institute 2014) (Table 5-7). Mountainous areas should be excluded from sampling because of the relative inaccessibility of these locations and because solar facilities are located on lands with minimal slope. A map of the biophysical strata at the Riverside East SEZ is shown in Figure 5-6. A map of AIM plots that are currently sampled in the region of the Riverside East SEZ is provided in Figure 5-7.

Baseline characterization of AIM core vegetation indicators should be conducted first by sampling the biophysical strata in Table 5-7 within each of the three solar development impact strata. Then other locations should be added to ensure the sampling of all solar impact strata and the sampling of ecologically significant vegetation alliances, riparian vegetation, groundwater-dependent vegetation (*Larrea tridentata*). Specific sampling locations should be selected by using a spatially balanced probabilistic approach to ensure sampling locations are proportionate to the area of each stratum (Stevens and Olsen 2004; Kincaid 2012). Following baseline characterization, AIM core indicators should be monitored annually.

Rare plants present in the SEZ, such as Wislizenia refracta, should also be targeted for sampling. W. refracta communities were discovered winthin the Riverside East SEZ by the CNPS during their vegetation community mapping effort (Menke et al., 2013). Targeted monitoring would involve groundtruth the CNPS mapping and establishing line-intercept monitoring transects to monitoring changes in the community over time..

Table 5-7 Biophysical Strata Used for Sampling Stratification at the Riverside East SEZ. Biophysical strata are a combination of California vegetation alliance level vegetation maps and Northern and Eastern Colorado Desert Coordinated Management Plan (NECO) landform layer.

Vegetation–Landforms Biophysical Strata	Acres	Plant Communities
Alkali desert scrub	6,800	*Allenrolfea occidentalis; Suaeda moquinii*
Creosote scrub	25,662	*Larrea tridentata; Larrea tridentata - Ambrosia dumosa; Larrea tridentata - Encelia farinose*
Fd, creosote scrub	84,815	
F, creosote scrub	23,4429	
P, creosote scrub	16,980	
Desert wash	10,212	*Acacia greggii; Parkinsonia florida - Olneya tesota; Hyptis emoryi; Prosopis glandulosa*
F, desert wash	48,325	
Fd, desert wash	15,152	
Other (r,s,m; barren, desert riparian, desert scrub)	14,2041	Landform not specified

Abbreviations: f = sandy fans; fd= dissected fans, fans, highly dissected fans, and pediments; p = sandy plains, undifferentiated plains; r = river washes; s = crescentic dunes, dry playas, longitudinal dunes, undifferentiated dunes; m = hills, mountains.

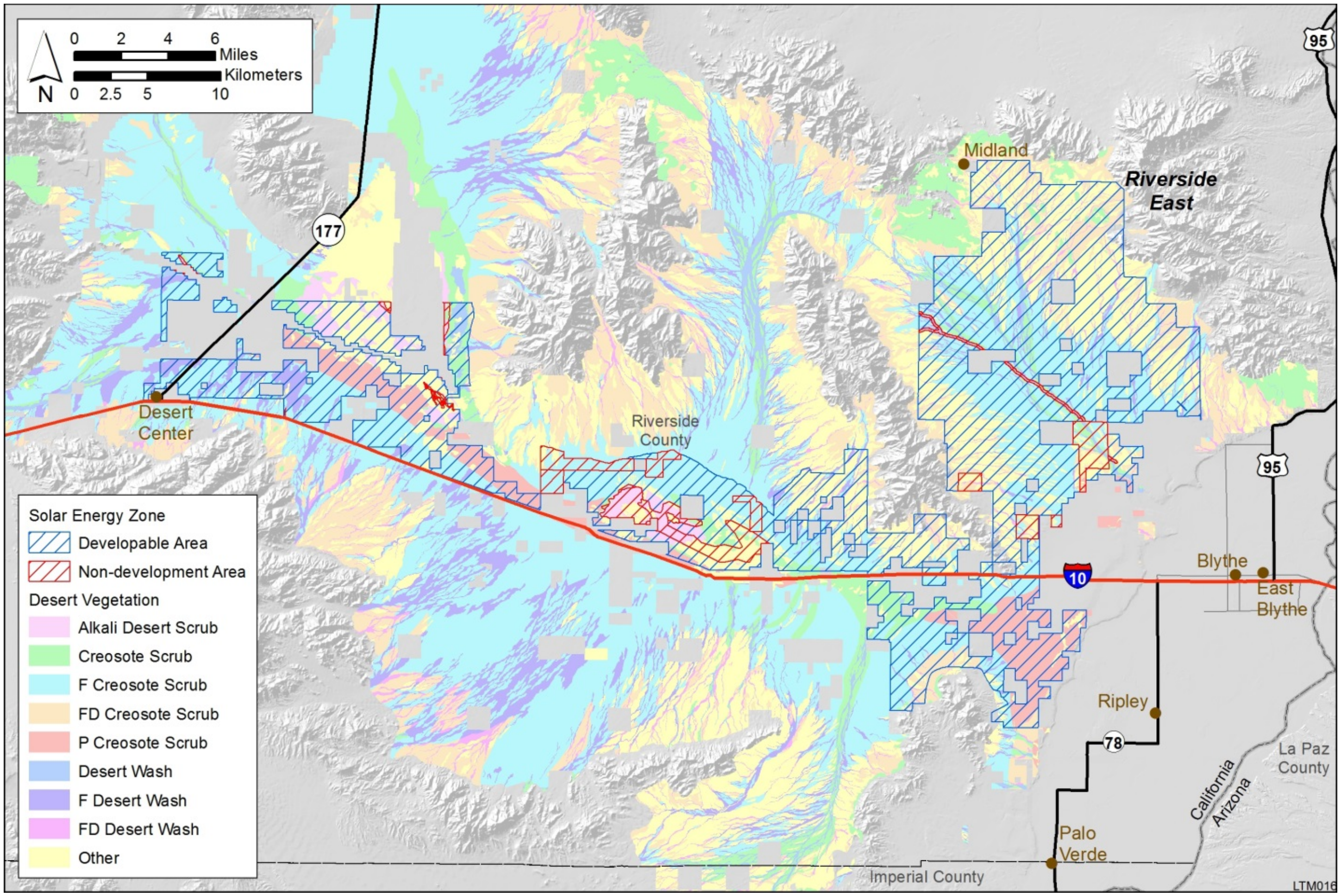

Figure 5-6 Location of Biophysical Strata Used for Sampling Stratification at the Riverside East SEZ. Vegetation strata are based on California vegetation alliance level vegetation maps and Northern and Eastern Colorado Desert Coordinated Management Plan (NECO) landform layer.

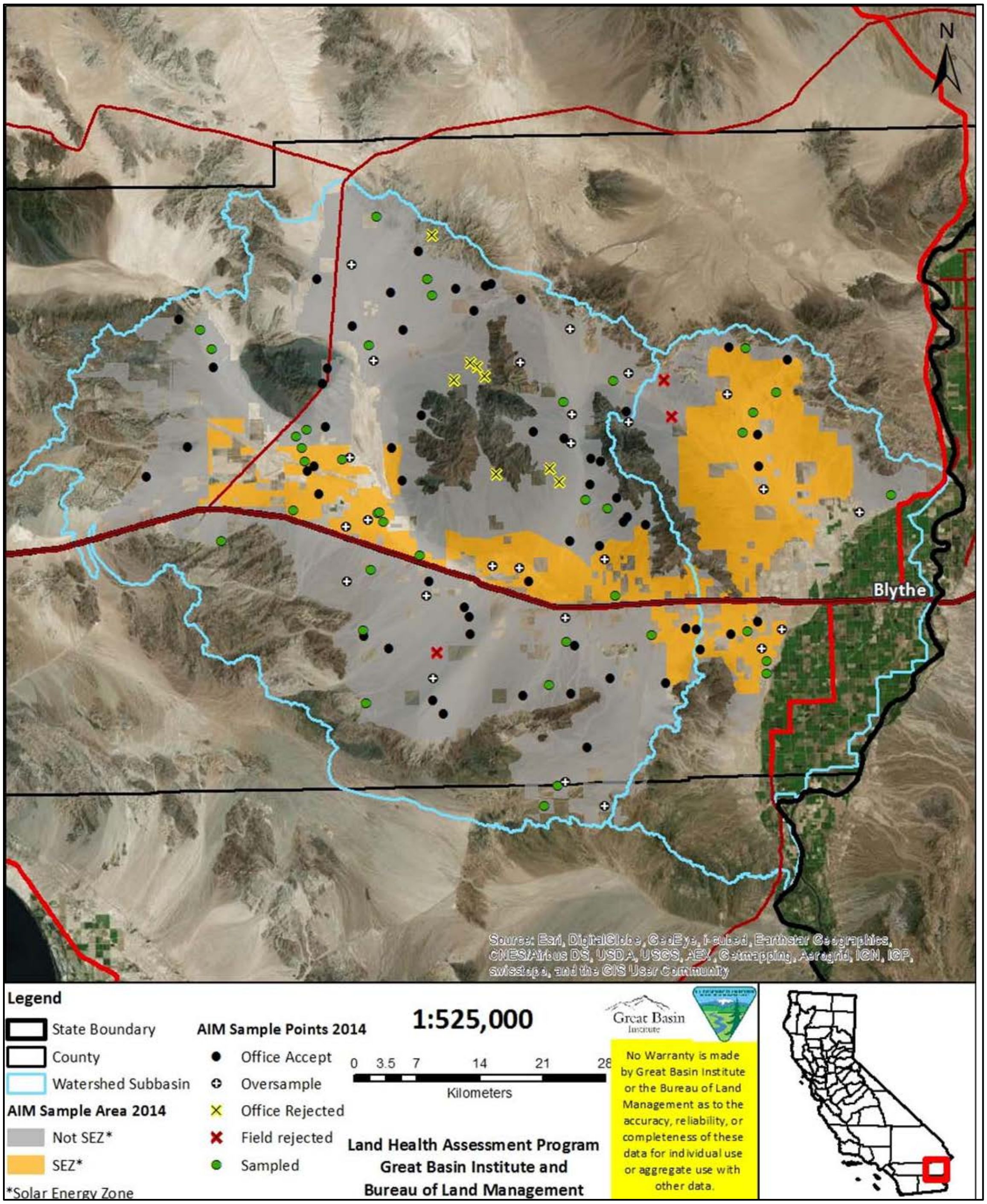

Figure 5-7 AIM Sampling Plots Generated, Sampled, and Rejected in the Riverside East SEZ in 2014 (Source: Great Basin Institute 2014)

5.2.4.3.2 Sampling Methods

AIM core vegetation indicator sampling methods are specified in Toevs et al. (2011) and described in detail in Herrick et al. (2015). Bare ground cover, total plant cover, intercanopy gaps, and plant height can be monitored at transects by using the line-point intercept (LPI) method described in MacKinnon et al. (2011) (Table 5-8). In addition, a plot-level inventory of plant species should be conducted (MacKinnon et al. 2011). Data collection should be conducted annually and should be undertaken shortly after the growing season ends in late spring (Wallace and Thomas 2008).

Table 5-8 Recommended Methods and Measurements for AIM Core and Contingent Vegetation Indicators (reproduced from MacKinnon et al. 2011)

Method	Indicators (s)	Description
Line-point intercept with plot-level species inventory	• Bare ground • Vegetation composition • Non-native invasive species • Plant species of management concern	The LPI method is a rapid and accurate method for quantifying cover of vegetation and bare ground. Because LPI can underestimate cover of uncommon species, this method is supplemented with searches of a 150-ft (45.7-m) diameter standard plot for at least 15 minutes and until new species detections are more than 2 minutes apart. When LPI is performed within tree cover, a modified pin method (e.g., a pivot-table laser or extendable pin) will be used to capture overstory cover.
Vegetation height measurement	• Vegetation height	Measure height of tallest leaf or stem of woody and herbaceous vegetation (living or dead) within a 6-in. (15-cm) radius recorded for points along a transect. If vegetation is taller than 10 ft, a standard tape and clinometer method should be used to estimate vegetation height.
Canopy gap intercept	• Proportion of soil surface in large intercanopy gaps	Canopy gap intercept measures the proportion of a line covered by large gaps between plant canopies and is an important indicator of the potential for erosion. Use 1-ft (30-cm) minimum gaps.

5.2.5 Data Analysis and Summary of Monitoring Approach

5.2.5.1 Vegetation Cover Estimates Using Remote Sensing

Methods for image analysis applicable to vegetation cover are referenced in the following discussion. Further investigation is needed to determine the most appropriate image types and image analysis techniques for the environmental conditions and the available imagery (historic and current) specific to the Riverside East SEZ. See Section 3.4 for a discussion of the uncertainties, limitations, and evolving nature of remote sensing as applied to long-term monitoring.

Continuous vegetation area and cover in each impact stratum can be estimated by using one of many vegetation metrics that are correlated with the amount of green vegetation (Elmore et al. 2001; Frank and Tweddale, 2006; Xie et al. 2008; Sant et al. 2014; Potter and Li 2014). High-resolution imagery (≤1 m) can be obtained for specific areas of interest as needed and as budget permits for estimating fractional cover of desert vegetation lifeforms (i.e., tree and shrub) (Frank and Tweddale 2006; Hamada et al. 2014) using automated or manual image analysis. Regardless of the image resolution used, the most appropriate metric for the imagery obtained should be determined after the relative accuracy of multiple metrics have been tested against field observations. Significance up-front effort will be required to validate image analysis.

Baseline cover of vegetation should be estimated first in the three impact strata (buffer, SEZ, and reference) by using existing pre-construction imagery where available. Changes in the area and fractional cover vegetation will be compared among locations (buffer, SEZ, and reference) and time (before and solar facility construction) for evidence of an impact using a BACI design statistical analysis framework (Section 2.3.2).

5.2.5.2 AIM Vegetation Indicators

Total vegetation cover and the proportion of soil surface in large intercanopy gaps will be calculated by using the methods of Herrick et al. (2015). Species richness and vegetation composition (including non-native species and plant species of management concern) can also be derived. For each biophysical stratum, changes in the AIM vegetation indicators should be compared among locations (buffer, SEZ, and reference) and time (before and after solar facility construction) for evidence of an impact by using a BACI statistical analysis (Section 2.3.2).

Together, the remote-sensing and field-based vegetation indicators can be used to assess large-scale and fine-scale changes in vegetation communities in the Riverside East SEZ related to solar energy development. A summary of the monitoring indicators and sampling design for vegetation monitoring is shown in Table 5-9.

Table 5-9 Summary of Monitoring Indicators and Monitoring Plan Proposed to Monitor Vegetation Communities

Indicator (s)	Method	Sampling Strata	Data Analysis
Vegetation cover	Quantify cover of vegetation, using remote sensing and image analysis	Remotely sensed imagery will be used to map continuous groundcover of vegetation within each solar impact stratum (buffer, SEZ, and reference).	BACI; comparison of quantitative changes in vegetation cover within buffer, SEZ, and reference impact strata before and after facility construction.
AIM core vegetation indicators	As specified in Herrick et al. (2015)	Biophysical strata and three solar impact strata (buffer, SEZ, and reference).	BACI; comparison of quantitative changes in AIM core indicators in buffer, SEZ, and reference impact strata before and after facility construction.

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5.3 Wildlife Indicators

5.3.1 The Abundance and Distribution of Wildlife Indicator Species

5.3.1.1 Rationale for Monitoring the Indicators

The Sonoran Desert supports both resident and migratory wildlife. Migratory species include neotropical migratory birds that make use of the Sonoran Desert as resting and foraging habitat as they move along the Pacific flyway. Resident species are present year-round and have evolved specialized behavioral and physiological traits that allow them to survive in the harsh desert environment. Some resident species have restricted ranges, making them vulnerable to changes in the landscape. Consequently, some resident species have undergone population declines because of habitat loss and degradation.

Several direct and indirect impacts on wildlife have been identified as potentially resulting from solar energy development (including transmission lines and roads) (Figure 5-8). BLM and DOE (2010) and Lovich and Ennen (2011) provide comprehensive descriptions of these potential impacts. Examples of wildlife stressors related to solar energy facilities include the following:

- *Construction*. Habitat reduction, alteration, and fragmentation; wildlife disturbance (e.g., noise and worker presence); injury or mortality of wildlife; and exposure to contaminants or fires.
- *Operations and Maintenance*. Ongoing habitat reduction, alteration, and fragmentation; wildlife disturbance; collisions with aboveground facilities; exposure to contaminants and fires; burning (bats and birds) from flying through standby points and reflection beams; and glare; introduction of non-native species.
- *Decommissioning/Reclamation*. Similar to construction.

Studies of the impacts of solar energy development are currently very few (Lovich and Ennen 2011; Turney and Fthenakis, 2011). Consequently, few data are available to distinguish speculative from realized impacts on wildlife resulting from solar energy development. To address these data gaps, the Riverside East SEZ LTMS will monitor several indicators that address impacts on wildlife. Indicators useful for monitoring physical and ecological changes in wildlife habitat are addressed in Section 5.2. This section describes the monitoring methods for directly monitoring changes in wildlife indicator species abundance and distribution in relation to solar energy development.

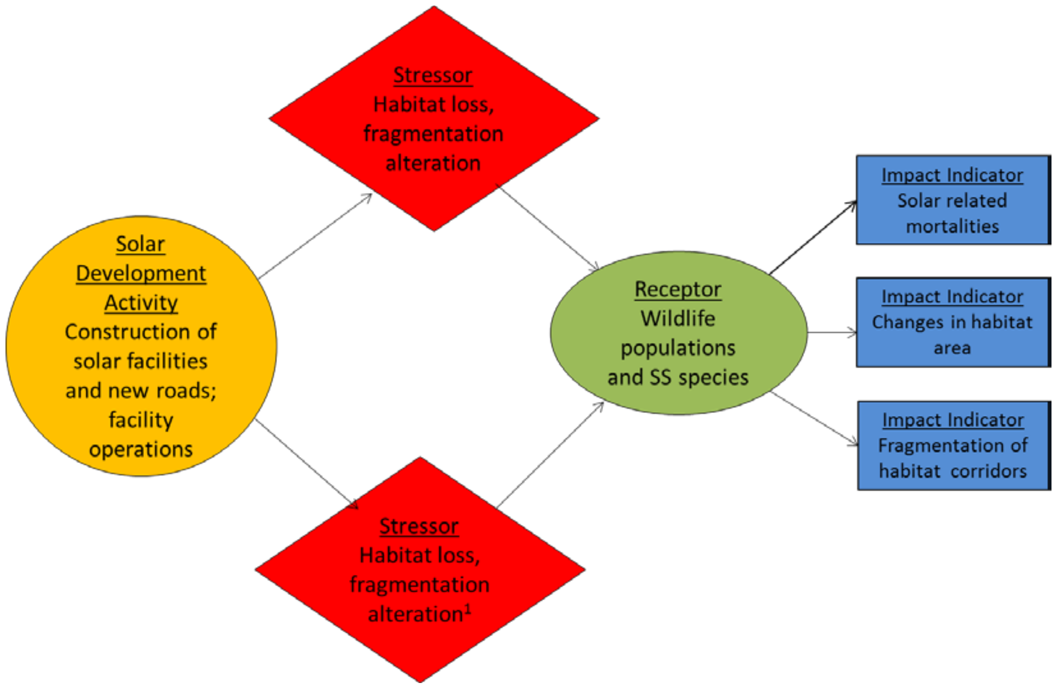

Figure 5-8 Conceptual Model Illustrating Potential Impacts on Wildlife Resulting from Solar Development Activities and the Impact Indicators Used for the Riverside East SEZ LTMS

More than 30 reptile and amphibian, 100 bird, and 40 mammal species have ranges that overlap the Riverside East SEZ (BLM and DOE 2010). Long-term monitoring of such a large number of species would be infeasible both logistically and monetarily. To simplify long-term monitoring, four wildlife indicator species have been selected: black-tailed gnatcatcher (*Polioptila melanura*), loggerhead shrike (*Lanius ludovicianus*), verdin (*Auriparus flaviceps*), and desert kit fox (*Vulpes macrotis*). In addition, because of its ecological importance, we will conduct general bird monitoring in specific microphyll woodlands.

The black-tailed gnatcatcher was selected as a wildlife indicator species because it is characteristic of arroyos and washes, is a good indicator for undisturbed areas, and is not adapting to exotic vegetation or high density of structures. It is primarily insectivorous and forages preferentially on thorn trees. It tends to forage in the lower portion of the canopy (e.g., <3 m high) (Tinant 2006).

The loggerhead shrike was selected as a wildlife indicator species because it is widespread in the SEZ. Although desert populations appear to be robust, this species is experiencing widespread population declines elsewhere in California and the rest of the United States from habitat loss and degradation and collisions with vehicles (Wiggins 2005).

The verdin was selected as a wildlife indicator species because of its use of desert riparian areas and wash habitats. Verdins are able to adapt to urban settings, and this may make populations more resilient to disturbance of natural areas. It is normally associated with paloverde, mesquite, catclaw, creosote bush, and smoke tree (Churchwell 2007).

The desert kit fox (*Vulpes macrotis*) is a species of high stakeholder concern because it has declined throughout its U.S. range during the last several decades (Dempsey et al. 2014). The kit fox is a common carnivore in the SEZ, and there are concerns that solar development could stress the population. For example, an outbreak of canine distemper, a fatal condition, occurred following the construction of one solar facility (http://www.dfg.ca.gov/Report/2012_Text.html; accessed April 28, 2015).

BLM policies for preserving, protecting, and maintaining ecological resources are laid out in the following documents:

Federal:

- Fish and Wildlife Coordination Act (16 USC 661 et seq.)
- Bald and Golden Eagle Protection Act (16 USC 668 et seq.)
- Migratory Bird Act (16 USC 703 et seq.)
- Endangered Species Act (16 USC 1531 et seq.)
- Executive Order 11990, "Protection of Wetlands," May 24, 1977
- Executive Order 13112, "Invasive Species," February 3, 1999
- Executive Order 13186, "Responsibilities of Federal Agencies to ProtectMigratory Birds," January 10, 2001

California:

- Migratory Birds (*Fish and Game Code*, 355 et seq.)
- Wildlife Conservation Law of 1947 (*Fish and Game Code*, 1300 et seq.)
- Fish and Game Management (*Fish and Game Code*, 1500 et seq.)
- Fish and Wildlife Protection and Conservation (*Fish and Game Code*, 1600 et seq.)
- Native Species Conservation and Enhancement (*Fish and Game Code*, 1750 et seq.)
- Conservation of Wildlife Resources (*Fish and Game Code*, 1800 et seq.)
- Endangered Species (*Fish and Game Code*, 2050 et seq.)
- Protected Reptiles and Turtles (*Fish and Game Code*, 5000 et seq.)
- California Wilderness Preservation System (*Public Resources Code*, 5093.30 et seq.)

Internal policies, as laid out in the following documents, further the BLM goal of preserving, protecting, and maintaining ecological resources within their boundaries:

- BLM Manual 1734, Rangeland Interagency Ecological Site Manual, and BLM Handbook 1734-1, Interagency Ecological Site Handbook for Rangelands
- BLM Manual 5000, *Forest Management*, and BLM Handbook 5000-1, *Forest Management*
- BLM Manual 5711, *Site Preparation*
- BLM Manual 6840, Special Status Species
- BLM Handbook 1740-2, Integrated Vegetation Management Handbook
- BLM Information Memoranda 2014-112
  "Policy for Solar and Wind Energy Inspection and Enforcement."

5.3.1.2 Related Management Questions, Management Goals, and Monitoring Objectives Addressed by the Indicator

Monitoring the four indicator species will address the management question, management goal, and monitoring objective in Table 5-10.

Table 5-10 Management Question, Management Goal, and Monitoring Objective Addressed by Monitoring the Black-tailed Gnatcatcher (*Polioptila melanura*), Loggerhead Shrike (*Lanius ludovicianus*), Verdin (*Auriparus flaviceps*), and Desert Kit Fox (*Vulpes macrotis*)

Management Question
• How are solar facilities affecting wildlife populations?
Management Goal
• Maintain population within historical ranges.
Monitoring Objective
• Detect temporal changes in the abundance of wildlife indicator species within the SEZ relative to control sites

5.3.1.3 Spatial and Temporal Considerations for Monitoring the Indicator

Animal populations can be monitored at multiple spatial scales, each of which may exhibit different resource trends. Determining regional population trends would require consideration of the home ranges and seasonal movement of the indicator species, both of which may extend beyond the SEZ. Consequently, regional population trends are outside the scope of the LTMS. The indicator species monitoring has a more limited objective of detecting relative trends in abundance (counts or densities) in reference areas and in areas potentially affected by solar energy development. Therefore, the spatial extent of expected solar development impacts on wildlife is a primary consideration in determining the area of analysis. Other spatial and temporal considerations for monitoring wildlife indicator species are largely a function of species specific life history traits and habitat associations. In general, surveys should be conducted in habitats, at times of day, and in seasons when species are easiest to detect. Descriptions of habitat associations for the indicator species are provided in the following paragraphs.

5.3.1.3.1 Black-tailed Gnatcatcher

The black-tailed gnatcatcher occurs throughout the non-urban area of the Sonoran Desert and locally in the central and eastern Mojave Desert (Tinant 2006) and is restricted to scrub and woodlands on arid hillsides, mesas, and washes (CalPIF 2009). The species also occurs sparingly in desert scrub habitat, especially during the winter. They nest along densely lined arroyos or washes dominated by diverse shrubs or microphyll woodland trees. Suitable habitat for black-tailed gnatcatcher is shown in Figure 5-9.

5.3.1.3.2 Loggerhead Shrike

In California, loggerhead shrikes nest mainly in shrublands or open woodlands that contain some grass cover mixed with open ground (Shuford and Gardali 2008) as well in agricultural areas such as the Palo Verde Valley. Nests are constructed in a variety of substrates, especially mesquite, but other thorny or spiny species may be preferred locally. Shrikes are opportunistic nesters and will nest low to the ground in shrub steppe habitat or higher off the ground when trees are available (Wiggins 2005). They also require tall, isolated perches, such as trees or power lines, from which to hunt. Perches tend to be located near open areas of short grasses, forbs, or bare ground. They also require impaling sites to hang their prey (e.g., thorns or barbed wire). Surveys should be restricted to areas with vegetation density less than 10% because shrikes prefer open habitats (Peterson 2011). Suitable habitat for loggerhead shrike is shown in Figure 5-10.

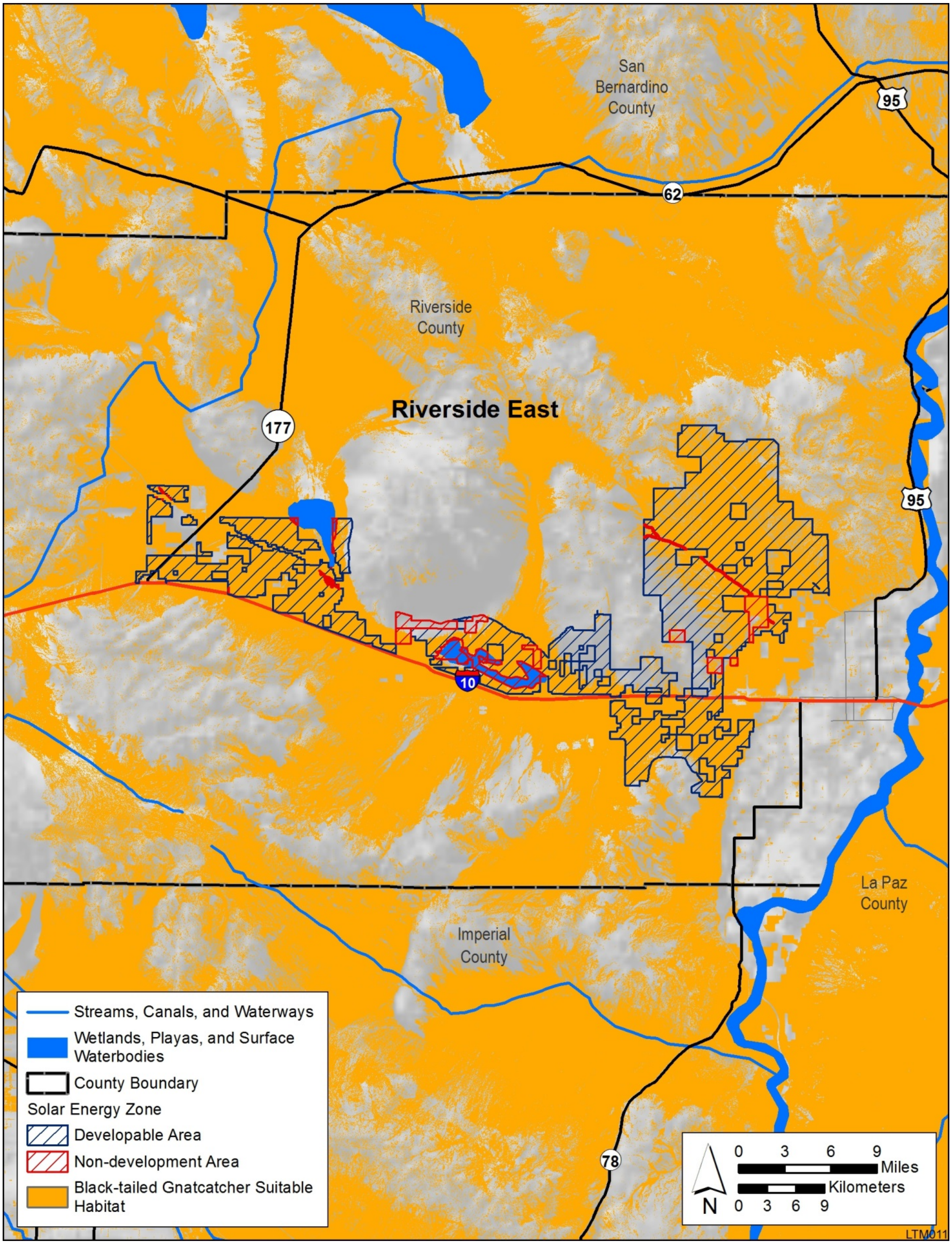

Figure 5-9 Black-tailed Gnatcatcher Suitable Habitat (Source: USGS 2013)

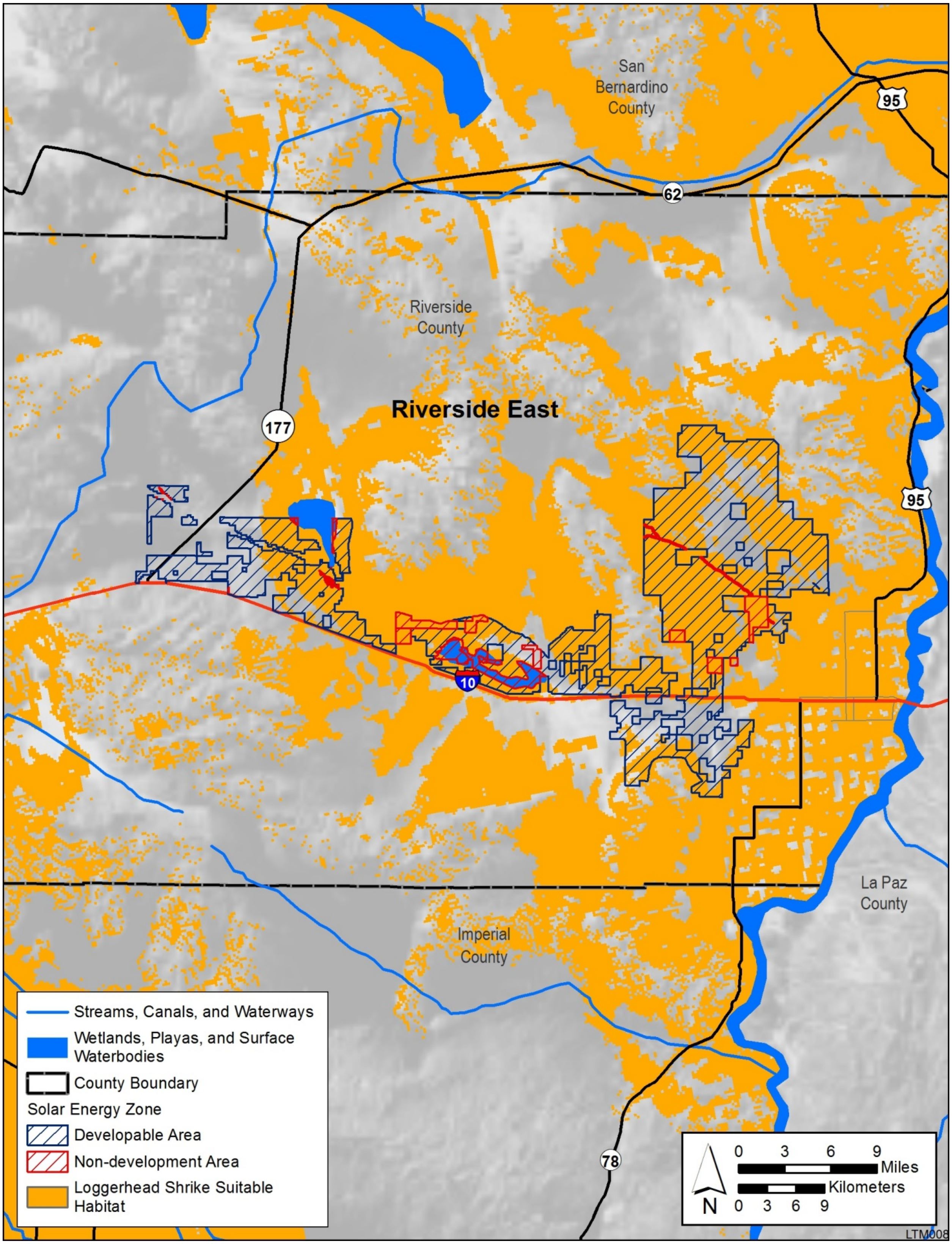

Figure 5-10 Suitable Habitat Identified for Loggerhead Shrike (Source: USCB 2013)

5.3.1.3.3 Verdin

The verdin is common to abundant in the Sonoran Desert but somewhat less common in the Mojave Desert. The verdin occupies desert riparian, desert wash, desert scrub, and alkali desert scrub areas within the SEZ. This primarily insectivorous species captures insects from foliage and twigs in riparian areas including washes. The species is not dependent on water, but prefers washes with thicker vegetation over open desert areas (Zeiner et al. 1990a). Nests are commonly located in outer branches of a spiny shrub. Their nests are sturdy and may persist for years, and this may give the illusion that there are more verdins than are actually present. The nest from past years may be used by other nesting birds including black-tailed gnatcatchers (Churchwell 2007). Suitable habitat for verdin is shown in Figure 5-11.

5.3.1.3.4 Desert Kit Fox

Desert kit foxes were once abundant throughout their desert and semi-arid range, but they are now considered rare (Dempsey et al. 2014). They occur in grasslands or areas dominated by scattered trees, shrubs, and scrub. Kit foxes dig burrows and dens in open, level areas with loose-textured, sandy, and loamy soils. Surveys may focus along drainages and secondary roads because they are often used by carnivores. Suitable habitat for desert kit fox is shown in Figure 5-12.

The primary temporal considerations for monitoring wildlife are related to species life history (breeding season, activity level). In general, surveys should be conducted during the time of day and season when species are easiest to detect. For example, the breeding season is the preferred time to monitor the kit fox (Dempsey et al. 2014). Also, the kit fox is mainly nocturnal but may also be active during the day in cool weather (Zeiner et al. 1990b). Because all four wildlife indicator species are year-round residents in the study area, surveys across seasons may not be as necessary as for migratory species. Minimally, surveys would be conducted throughout the breeding season for each species (Table 5-11).

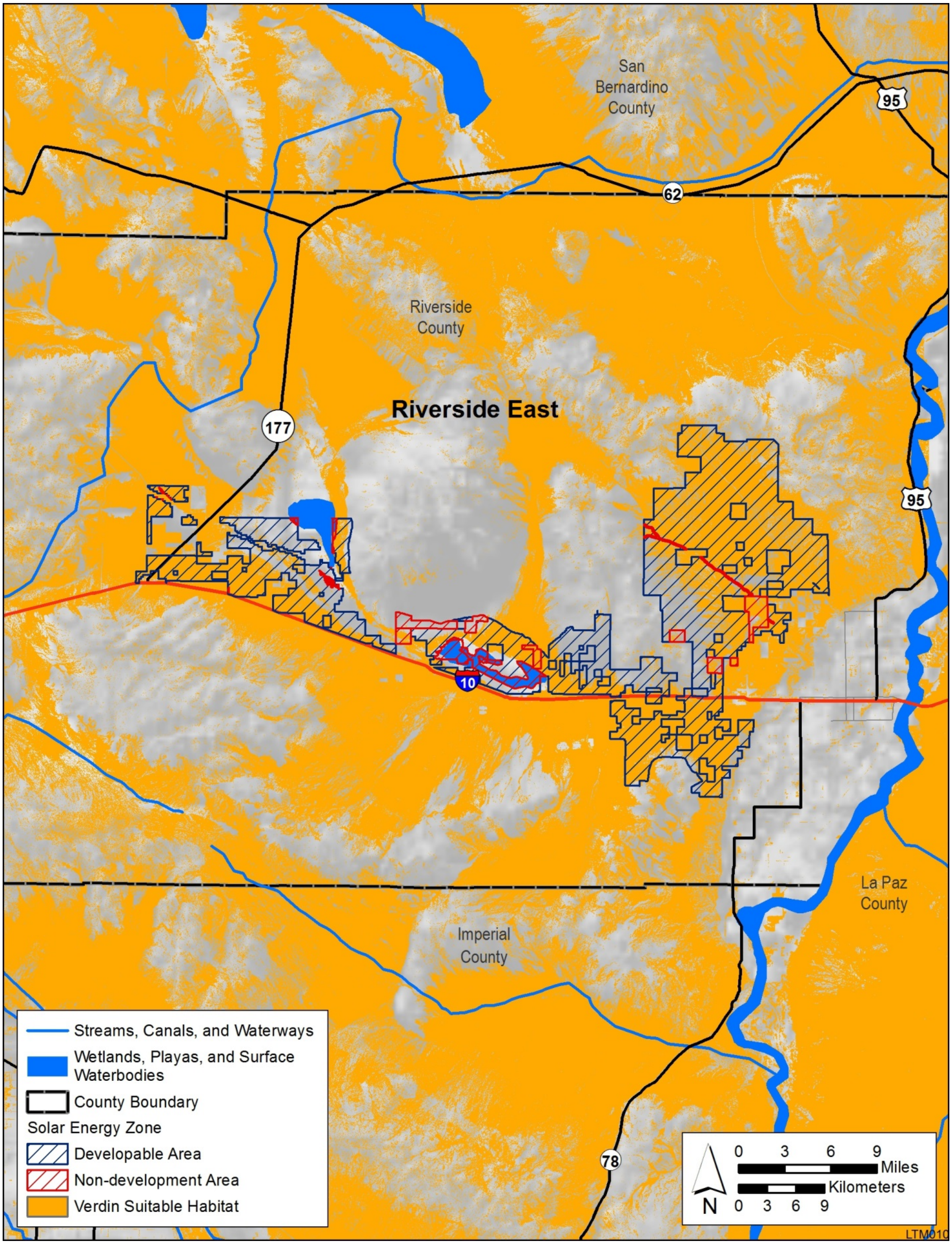

Figure 5-11 Suitable Habitat for Verdin (Source: USGS 2013)

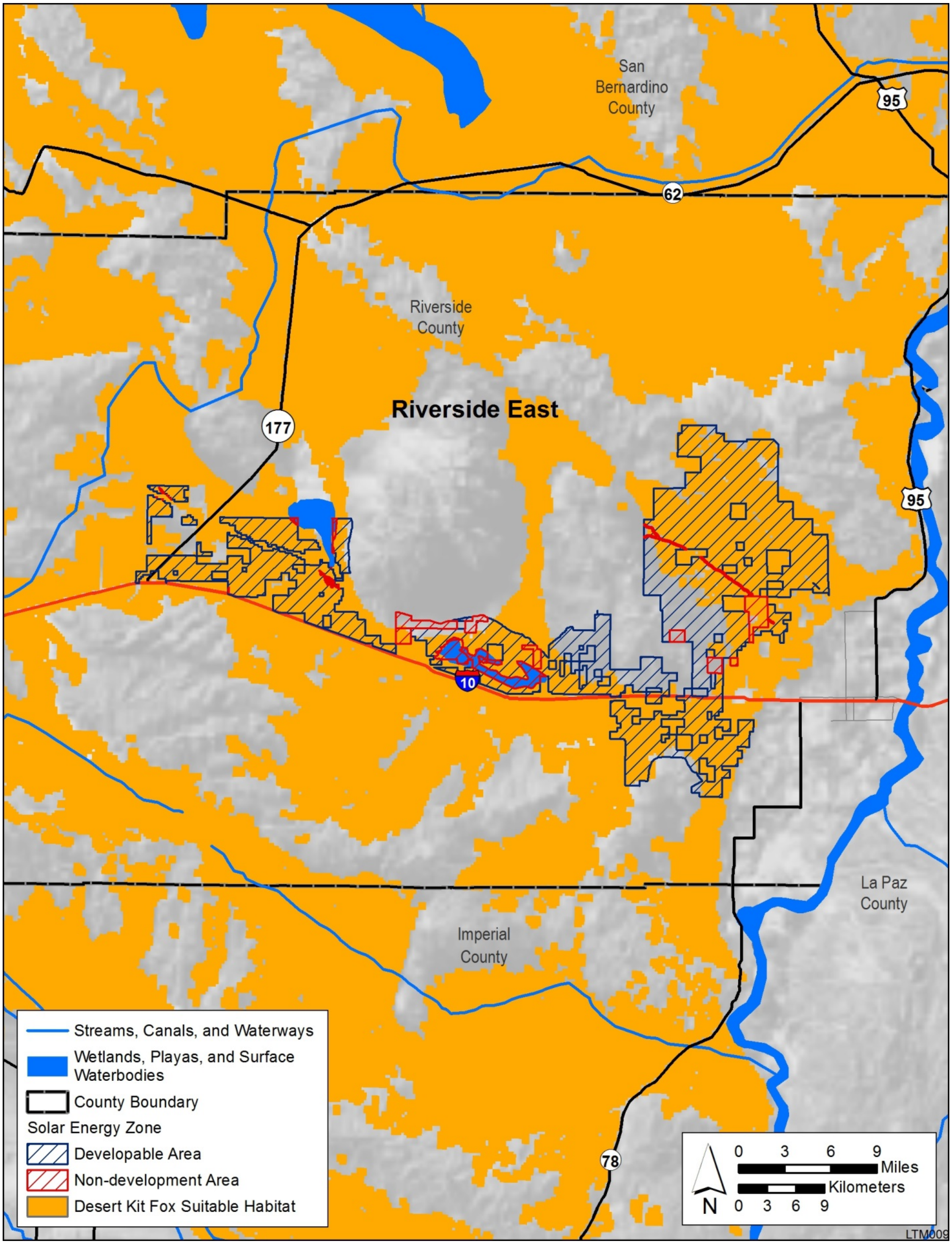

Figure 5-12 Suitable Habitat for Desert Kit Fox (Source: UCSB 2012)

Table 5-11 Breeding Season for the Black-tailed Gnatcatcher (*Polioptila melanura*), Loggerhead Shrike (*Lanius ludovicianus*), Verdin (*Auriparus flaviceps*), and Desert Kit Fox (*Vulpes macrotis*)

Wildlife Indicator	Breeding Season
Loggerhead shrike	Loggerhead shrikes begin breeding in January and February and may continue through July. Egg-laying and incubation tend to occur from mid-March to mid-June (Peterson 2011).
Verdin	Verdins nest from late February to mid-June with peak activity in April and May (Zeiner et al. 1990a).
Black-tailed gnatcatcher	Peak nesting occurs in April and May (Zeiner et al. 1990a).
Desert kit fox	Peak breeding season occurs from February through April (Zeiner et al. 1990b).

5.3.1.4 Existing Data Sources

There are few data sources available to establish current baseline abundance and distribution for the four indicator species within the SEZ. The California Department of Fish and Wildlife started a desert kit fox monitoring program in 2012 at four sites within the Riverside East area (First Solar, Palen, Genesis, and the Colorado River substation). Kit foxes were collared and tracked, with information collected on health status and disease (e.g., canine distemper). This program has ended because of a lack of funding.

Currently, point count bird surveys and acoustic monitoring are being conducted in the microphyll woodlands within the Riverside East SEZ. There is no ongoing data collection relevant to the black-tailed gnatcatcher, loggerhead shrike, verdin, and desert kit fox. However, the California Natural Diversity Database maintained by the California Department of Fish and Wildlife includes numerous records of black-tailed gnatcatcher.

5.3.1.5 New Indicator Data Collection Recommended for the Riverside East SEZ LTMS

Surveys should be used to determine abundance (counts or densities), distribution, and nest number (birds only) of each indicator species. In addition, general bird surveys will be conducted in microphyll woodlands within the SEZ including Pinto Wash in Chuckwalla Valley, McCoy Wash and in the larger drainages located on the east slope of the McCoy Mountains, and the expansive microphyll woodland between the Palen and McCoy mountains. Monitoring should be initiated at the start of the LTMS. Surveys for the four indicator species should be confined to areas representing potential habitat see habitat descriptions above). To conform to a BACI design, surveys should be conducted within each of the general solar impact-monitoring strata described in Section 2.3.2 (buffer, SEZ, and reference). The results of this initial monitoring combined with available historic data should be used to establish baseline relative abundance and distribution within the three sampling strata. Subsequent surveys should be conducted annually (at minimum) to monitor the operational impacts of existing facilities as well as the impacts of new solar facilities.

Potential monitoring methods that could be used to monitor indicators species for the Riverside East SEZ LTMS are described in the following paragraphs.

5.3.1.5.1 Avian Species

Point count surveys and nesting surveys conducted at permanent plots are recommended for estimating the relative abundance of avian species within the three sampling strata (Ralph et al. 1993). Point count surveys can be conducted on foot or by driving along transects. Point counts usually require an observer to record all birds seen or heard at a sampling station within 3-5 minutes (Ralph, Droege, and Sauer 1995). Smaller time interval sampling may give a truer estimate of bird density by avoiding repeat counting. Bird counts can be converted to densities if the survey occurs in a defined area (plot) or transect length (Johnson, 2008). The plot size should be large enough to avoid large numbers of plots with zero birds of the target species. For example, smaller plots (~100-m radius) may be adequate for the more abundant species like the verdin and black-tailed gnatcatcher, but larger plots (≥300-m radius) may be necessary to adequately sample loggerhead shrikes, which are less densely distributed. The number of sampling stations required depends on the size of the study area. A minimum distance greater than 250 m between sampling stations is recommenced for open environments where birds are easier to detect. The minimum distance between sampling points for those driving a vehicle should be 500 m (Ralph, Droege, and Sauer 1995).

Nesting surveys are conducted to determine whether bird species are successfully breeding within the study area by locating breeding individuals and their nests and revisiting nests every 3–4 days until fledging or failure occurs (Ralph et al. 1993; Peterson, 2011). Nests can be located by walking transects or by observing behaviors of nesting birds and following them to nests. Typical reproductive data collected from nesting sites include clutch initiation date, clutch size, hatching date, hatching success, and fledging success (Wiggins 2005). However, nest surveys are labor-intensive, and their feasibility will depend on the budget and manpower available to the LTMS.

Point counts and nest searches should be conducted during the breeding season (Ralph et al. 1993). Some species-specific monitoring methods should be used based on habitats or behaviors unique to each wildlife indicator. For example, survey transects may need to be longer for loggerhead shrikes than for other species because of the species' large breeding territories. See Peterson (2011) for a detailed loggerhead shrike survey methodology. See Ralph et al. (2003) for a detailed description of point count and nesting survey methods. Avian use-monitoring plans with detailed descriptions of survey methods have also been developed specifically for some solar facilities (H. T. Harvey & Associates 2014, 2011; WEST 2014).

5.3.1.5.2 Desert Kit Fox

Survey methods for the kit fox include scent-station transects (involving scat and/or track observations), motion-triggered cameras, capture-recapture, spotlight surveys, howling response, track counts, activity index, and area-search surveys. There is little consensus on the best method for surveying kit foxes; however, scat deposition transects may be the most successful with scent survey transects being the next best (Dempsey et al. 2014). Scat deposition transects are used to measure relative abundance by clearing transects of all scat and then surveying transects 14 days later to determine the number of scats deposited (Dempsey et al. 2014). Scent survey transects are used to measure relative abundance by placing a Scented Predator Survey Disk (SPSD) along a transect and clearing a circle of lightly sifted sand around the SPSD. Stations are checked every morning for tracks (Dempsey et al. 2014; Sargeant et al. 1998; Kronland 2011). Surveys aimed at ascertaining reliable counts and natural history traits of kit foxes at den sites should employ a survey methodology of remote cameras or video over a multiday period (Kluever et al. 2013). Camera stations can also be used to identify carnivore linkages and potential dispersal barriers (Kronland 2011). See Kluever et al. (2013), Demspey (2013), and Dempsey et al. (2014) for applicable survey protocols.

5.3.1.6 Data Analysis and Summary of Monitoring Strategy

Spatial and temporal trends in relative abundance of the kit fox as well as avian species abundance, nest numbers, clutch size, hatching success, and fledging success will be quantified at the three impact strata (buffer, SEZ, and reference) and analyzed for evidence of solar development impacts by using a BACI statistical framework. See Section 2.3.2 for a discussion of the statistical analysis of BACI study designs. See Torres et al. (2011) and Dahl et al. (2012) for examples of the application of a BACI approach to assessing the impacts of construction projects on wildlife. The proposed monitoring plan for wildlife indicator species is summarized in Table 5-12.

Table 5-12 Summary of Monitoring Indicators and Monitoring Plan Proposed to Monitor Wildlife Indicator Species

Indicator (s)	Method	Sampling Strata	Data Analysis
The abundance and distribution of wildlife indicator species	Point count surveys and nesting surveys for abundance nest number, clutch size, hatching success, and fledging success (birds only) of black-tailed gnatcatcher loggerhead shrike, and verdin; methods for desert kit fox abundance not specified.	Surveys should be confined to areas representing potential habitat for each wildlife indicator within each general solar impact-monitoring stratum (buffer, SEZ, and reference) to establish baseline. Post-construction surveys should be conducted annually (at minimum).	Spatial and temporal trends in relative abundance, nest numbers, clutch size, hatching success, and fledging success will be quantified at the three impact strata (buffer, SEZ, and reference) and analyzed for evidence of solar development impacts using a BACI statistical framework.

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5.3.2 Special Status Species Indicators

5.3.2.1 Rationale for Monitoring the Indicator

Based on analyses presented in the Solar PEIS (BLM and DOE 2012), approximately 70 special status species could be directly or indirectly affected by solar energy development on the Riverside East SEZ. Impacts of solar energy development on special status species are fundamentally similar to or the same as those described for impacts on wildlife (Section 5.3.1; Figure 5-13). However, because of their small population sizes and often specialized habitat needs or dependence on rare habitats, special status species may be more vulnerable to impacts than common and widespread species.

Long-term monitoring of the many special status species in the SEZ would be infeasible both logistically and monetarily. In addition, it may be difficult or impractical to monitor populations of special status species because of their small population size and their (often) large home ranges. The combination of these factors could make the probability of detecting these species in areas adjacent to projects very low. To simplify long-term monitoring, a smaller set of special status species has been selected as indicators: Mojave desert tortoise (*Gopherus agassizii*), Mojave fringe-toed lizard (*Uma scoparia*), desert bighorn sheep (*Ovis canadensis nelsoni*), and burro deer (*Odocoileus hemionus eremicus*). These species were chosen based on stakeholder concern, availability of spatial data, and their likely vulnerability to impacts from solar development. In addition, habitat condition indicators (i.e., vegetation) can also be used to monitor known habitat and corridors associated with these species. These habitats are also representative of the habitats upon which other special status species in the Riverside East SEZ depend. The following indicators should be quantified for the Riverside East SEZ LTMS:

- Ecological changes in habitat and habitat corridor condition identified for the Mojave fringe-toed lizard, desert tortoise, burro deer, and bighorn sheep;

- Bighorn sheep and burro deer use of designated wildlife corridors as identified in the DRECP or other suitable corridor model developed for these species; and
- Mojave fringe-toed lizard abundance and distribution.

The Riverside East SEZ LTMS does not include direct monitoring of Mojave Desert tortoise because of the low abundance of this species in the SEZ.

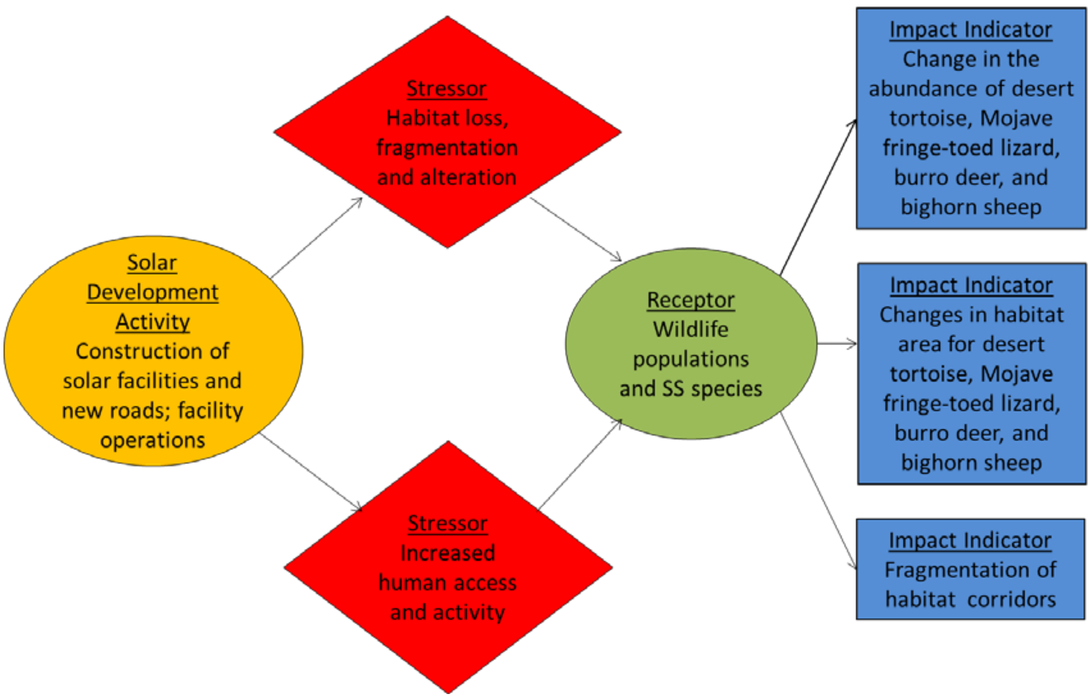

Figure 5-13 Conceptual Model Illustrating Potential Impacts on Special Status Species Resulting from Solar Development Activities and the Impact Indicators used for the Riverside East SEZ LTMS

All relevant policies outlined for wildlife indicators (Section 5.3.1) would be applicable for special status species.

5.3.2.2 Related Management Questions, Management Goals, and Monitoring Objectives Addressed by the Indicator

Monitoring the special status species indicators will address the management question, management goal, and monitoring objectives in Table 5-13.

Table 5-13 Management Question, Management Goal, and Monitoring Objectives Addressed by the Special Status Species Monitoring Indicators

Management Question
- What is the condition of habitats for special status species before and after solar facility construction and operations?

Management Goal
- Protect unique vegetation alliances and sand sources for special status species on and near the SEZ, including Ford and Palen dry lakes.

Monitoring Objectives
- Detect temporal changes of management significance in the abundance of the Mojave fringe-toed lizard relative to control areas.
- Detect temporal changes of management significance in habitat quality and connectivity for desert tortoise, burro deer, and Mojave fringe-toed lizard of within the SEZ relative to control areas..
- Detect temporal changes of management significance in use of designated wildlife corridors within the SEZ by desert bighorn sheep and burro deer relative to control areas.

5.3.2.3 Spatial and Temporal Considerations for Monitoring the Indicator

Determining regional population trends for the four special status species would require consideration of the home ranges and seasonal movement of the indicator species over large spatial scales including areas outside of the SEZ. In addition, regional population trends exhibit large natural variation because of a number factors not related to solar energy development. Consequently, these large-scale trends are outside the scope of the Riverside East SEZ LTMS. The monitoring objectives of the LTMS have a more limited scope of detecting relative trends in abundance (counts or densities) in reference areas compared to areas affected by solar energy development. Therefore, the spatial extent of expected solar development impacts on wildlife is a primary consideration in determining the area of analysis. See Section 2.3.2 for a description of the spatial stratification of the Riverside East SEZ LTMS.

Other spatial and temporal considerations for monitoring the four special status species are largely a function of species life history and specific habitat associations. Habitat associations and seasonal movements for each indicator species are described in the following paragraphs.

5.3.2.3.1 Mojave Desert Tortoise

The Mojave desert tortoise (*Gopherus agassizii*) occurs in low numbers within the Riverside East SEZ. Desert tortoises are generally absent from the playas and dunes within the lowest elevations of the SEZ. Habitat quality improves higher up the bajadas (alluvial fans), especially in areas with incised washes. The Chuckwalla CHU occurs immediately south of the SEZ (Figure 5-14). Within the

Chuckwalla CHU are areas of historically high desert tortoise abundance (e.g., the Chuckwalla Bench). A habitat suitability model developed by the USGS (Nussear et al. 2009) shows lower habitat suitability within the SEZ compared to areas outside the SEZ (Figure 5-14).

Despite the low habitat suitability of the SEZ, the SEZ contains important habitat linkages that are critical to maintaining north–south movements of tortoises between areas of greater habitat suitability. These linkages have been mapped by the USFWS (Averill-Murray et al. 2013) and considered as part of a larger connectivity mapping effort in the DRECP EIS (DRECP 2014). Currently, it is considered unlikely that the desert tortoises would be found within the identified habitat linkages. Therefore, only habitat monitoring rather than direct tortoise monitoring is included in the LTMS. However, if desert tortoises are found within the SEZ, their movement could be monitored with radio telemetry.

5.3.2.3.2 Mojave Fringe-toed Lizard

The Mojave fringe-toed lizard (*Uma scoparia*) is restricted to areas of wind-blown sand in the Mojave and Sonoran deserts.. According to a habitat suitability model developed for the DRECP EIS (DRECP 2014), potentially suitable habitat for the Mojave fringe-toed lizard occurs in distinct areas of aeolian sand deposits and dune systems within the Riverside East SEZ (Figure 5-15). These sand dune systems occur in the central portion of the Riverside East SEZ near the Ford and Palen Dry Lakes (Figure 5-15).

To improve chances of detection, special status animal species should be monitored during their peak activity seasons. Mojave fringe-toed lizards are most active from March to October during the hotter periods of the day (http://drecp.org/whatisdrecp/species/Mojave_Fringe-toed_Lizard.pdf). Hibernation occurs during the winter months, November to February. Tinant et al. (2005) recommended annual sampling during the late spring and early summer when fringe-toed lizards are most active.

5.3.2.3.3 Desert Bighorn Sheep and Burro Deer

The desert bighorn sheep (*Ovis canadensis nelsoni*) prefers visually open, steep, mountainous terrain in the vicinity of the Riverside East SEZ; however, the species will also utilize basin systems such as desert shrub-scrub desert riparian systems as intermountain movement corridors between montane habitats. Because most core habitats occur in isolated mountainous regions, desert bighorn sheep populations are relatively small and vulnerable to local extirpation (DRECP 2014). According to a habitat suitability model developed for the DRECP EIS, potentially suitable intermountain habitat for the species occurs in the SEZ (Figure 5-16). USFWS (2000) recommends that bighorn sheep surveys be conducted near water during the hottest and driest time of the year when individuals are most likely to make use of water sources.

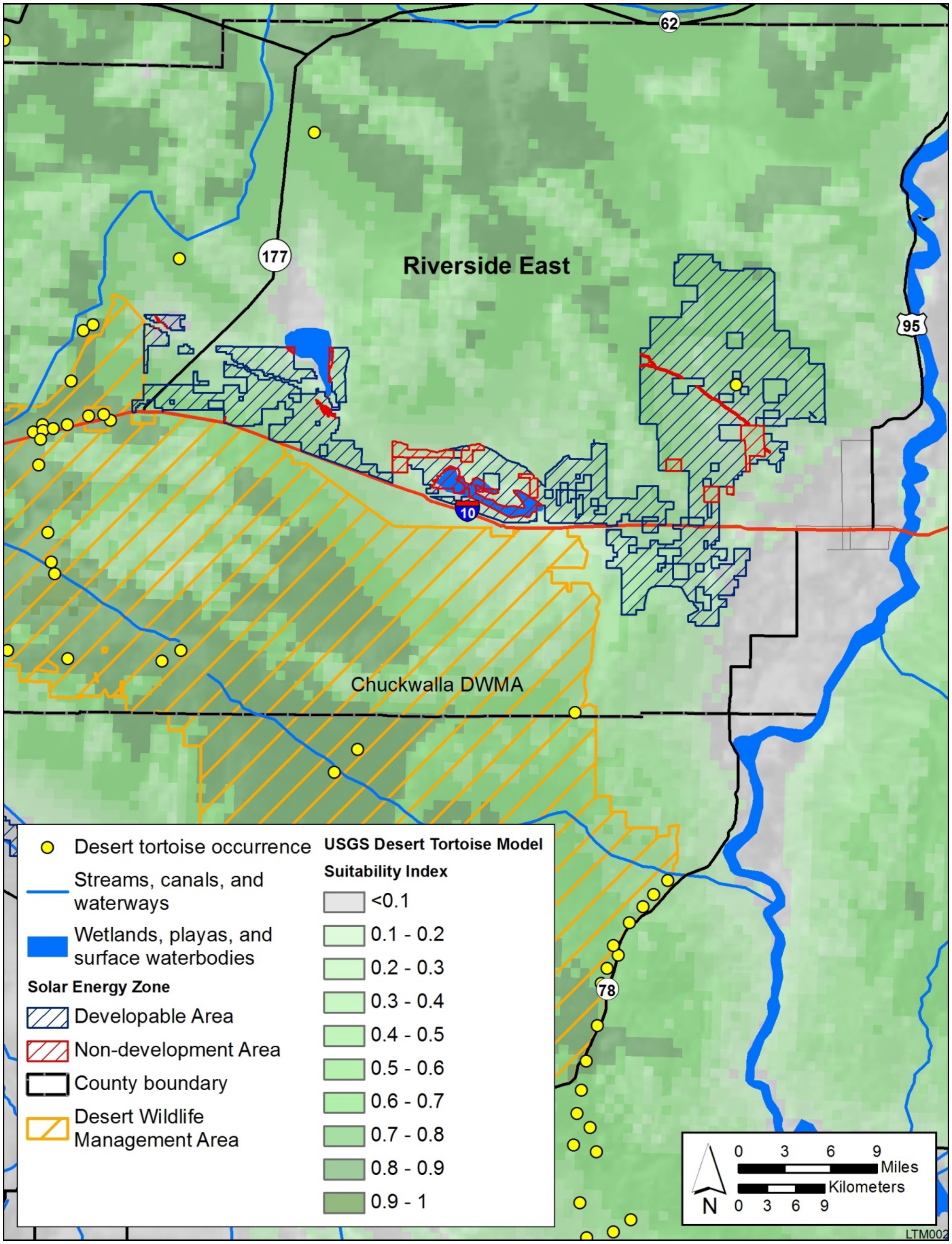

Figure 5-14 Desert Tortoise Suitable Habitat on and in the Vicinity of the Riverside East SEZ (model source: Nussear et al. 2009; element occurrence source: California Natural Diversity Database)

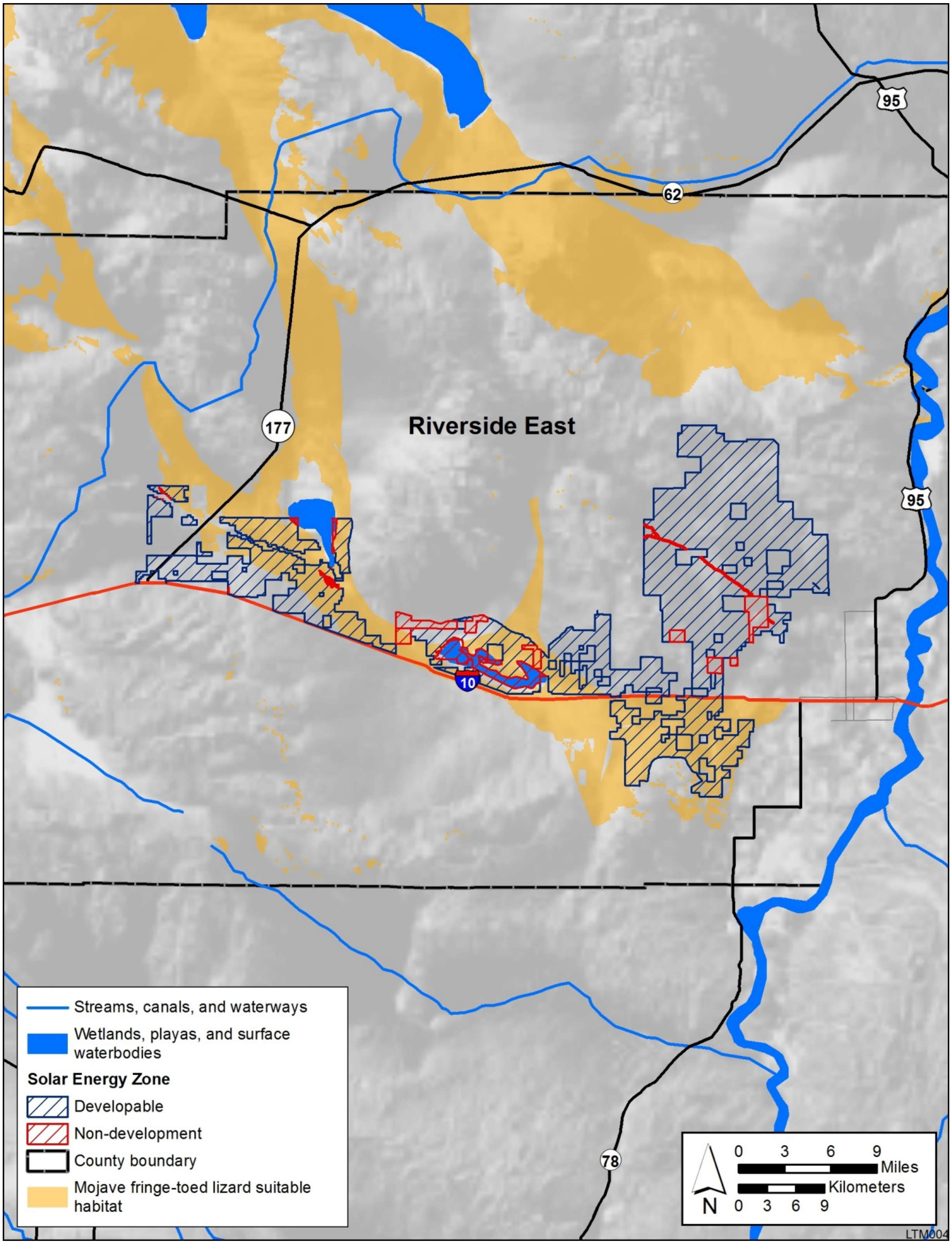

Figure 5-15 Suitable Habitat for the Mojave fringe-toed Lizard on and in the Vicinity of the Riverside East SEZ (DRECP EIS [DRECP 2014]).

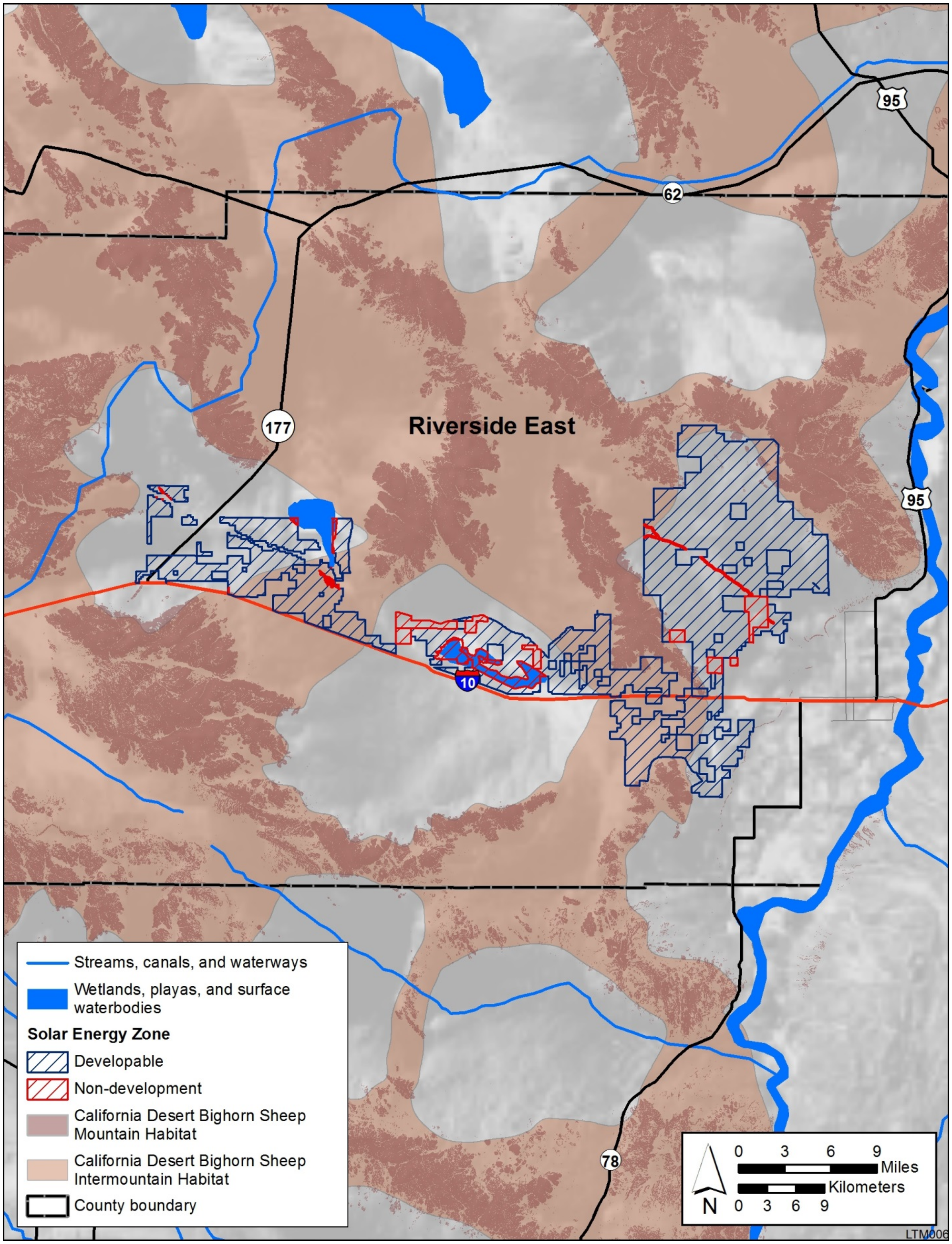

Figure 5-16 Mountain and Intermountain Habitat for the Desert Bighorn Sheep on and in the Vicinity of the Riverside East SEZ (DRECP EIS [DRECP 2014]).

The burro deer (*Odocoileus hemionus eremicus*) is a desert-dwelling subspecies of the mule deer. Although the burro deer is not federally or state listed, it is considered a special status species indicator because it was a planning species evaluated in the DRECP EIS (DRECP 2014) and it has experienced habitat fragmentation and degradation in the vicinity of the Riverside East SEZ. The burro deer utilizes desert riparian washes and open mountainous terrains. According to a habitat suitability model developed for the DRECP EIS (DRECP 2014), potentially suitably habitat for the burro deer occurs in the SEZ (Figure 5-17).

In addition to the habitat suitability models for the desert tortoise, Mojave fringe-toed lizard, bighorn sheep, and burro deer, a model of terrestrial habitat linkages and movement corridors for these species was developed for the DRECP EIS (Figure 5-18) (DRECP 2014). Landscape habitat linkages are large, open-space areas on the landscape that contain natural habitat and provide connection between at least two larger adjacent open spaces or habitat areas. Wildlife corridors are linear landscape elements that enable species movement and dispersal between two or more habitats, but do not necessarily have enough habitat for all life history requirements of terrestrial species (Rosenberg et al. 1995, 1997). Based on the model developed for the DRECP EIS, terrestrial habitat linkages and movement corridors occur on the Riverside East SEZ and generally connect core habitat areas north and south of the SEZ (Figure 5-18). The habitat linkage and movement corridors represent important dispersal and movement pathways for special status species indicators such as the desert tortoise, bighorn sheep, and burro deer.

5.3.2.4 Existing Data Sources

Available spatial data that could be used for the Riverside East SEZ LTMS are listed in Table 5-14. Descriptions of existing data are given in the following paragraphs for the four indicator species.

Monitoring of Mojave desert tortoise populations is currently conducted within designated Tortoise Conservation Areas (TCAs) according to the *Revised Recovery Plan for the Mojave Population of the Desert Tortoise* (USFWS 2011), and monitoring guidelines for the desert tortoise have been established (USFWS 2015). The USFWS conducted line-distance sampling within the Mojave desert tortoise CHU yearly from 2001 to 2013. However, the surveys have been discontinued because of a lack of funds.

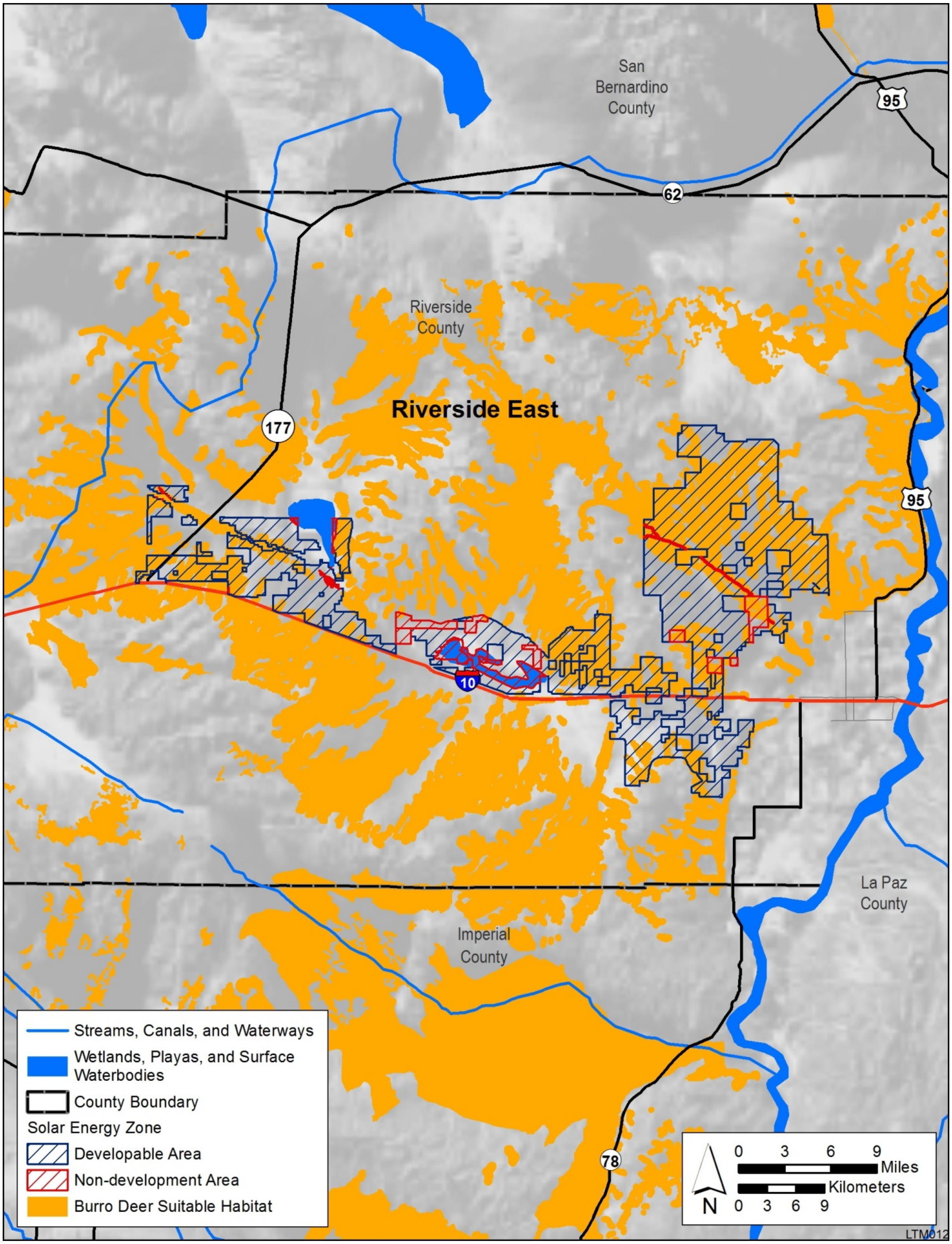

Figure 5-17 Suitable Habitat for the Burro Deer on and in the Vicinity of the Riverside East SEZ (DRECP EIS [DRECP 2014]).

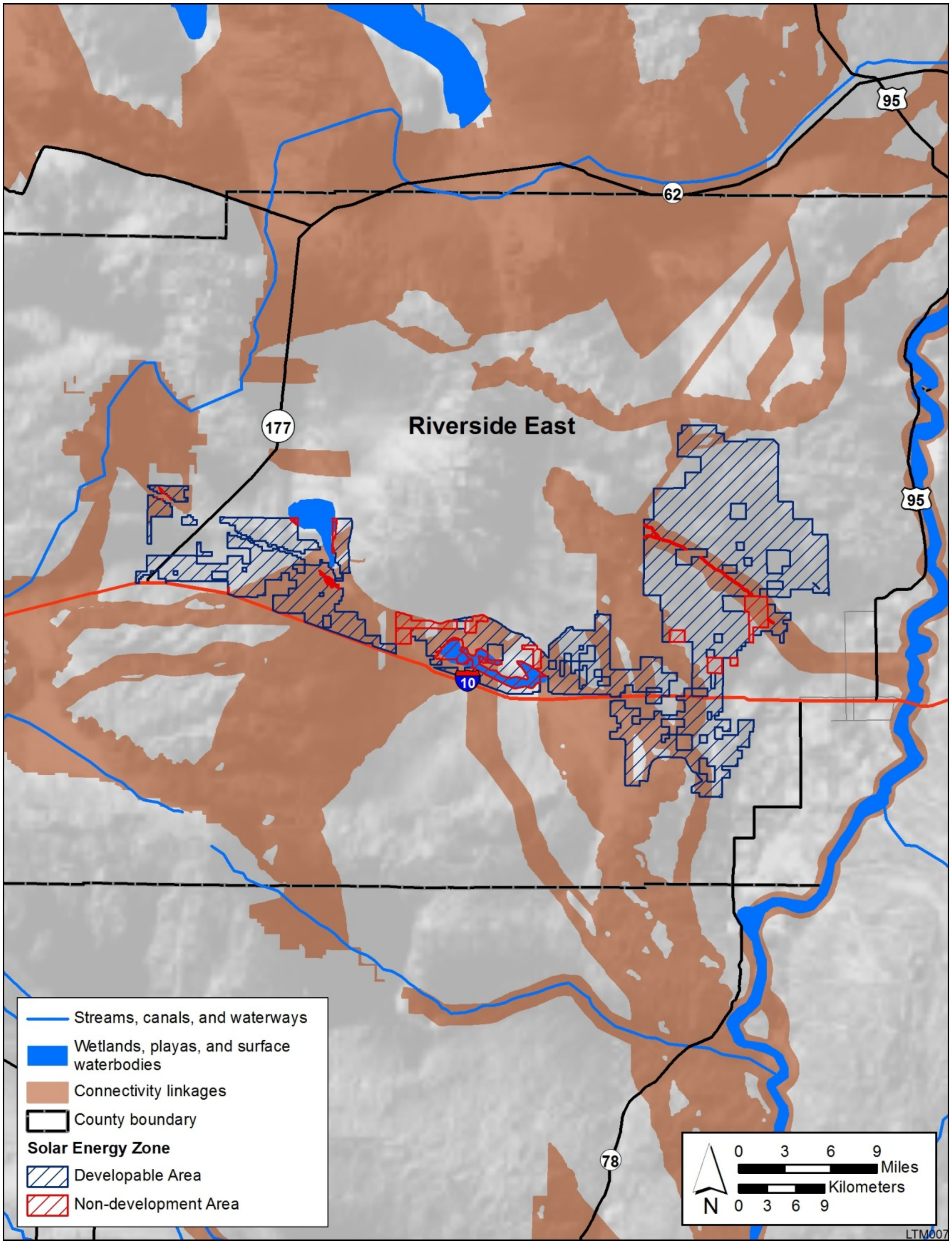

Figure 5-18 Habitat Linkages and Movement Corridors for Terrestrial Wildlife on and in the Vicinity of the Riverside East SEZ (DRECP 2014; Penrod et al. 2014).

The California Department of Fish and Wildlife (CDFW) conducts annual aerial surveys for desert bighorn sheep in the Orocopia and Chuckwalla Mountains, the information from which may inform long-term monitoring assessments for the desert bighorn sheep.

There are currently no monitoring data being collected on the Mojave fringe-toed lizard or the burro deer.

Table 5-14 Summary of Available Spatial Data for Special Status Species Indicators

Indicator	Status[a]	Available Spatial Data[b]
Mojave desert tortoise (*Gopherus agassizii*)	ESA-T; CA-T	• 2009 USGS desert tortoise habitat model • USFWS designated critical habitat (Desert Wildlife Management Areas)
Mojave fringe-toed lizard (*Uma scoparia*)	BLM-S	• Mohave fringe-toed lizard habitat model • Sand and dune systems • California Geological Survey 2014 mapping of Riverside East including active areas of deposition, source areas, and zones of sand transport
Desert bighorn sheep (Ovis canadensis nelsoni) Burro deer (*Odocoileus hemionus eremicus*)[c]	BLM-S N/A	• Desert bighorn sheep intermountain habitat • Burro deer habitat • Habitat linkages and wildlife movement corridors

a BLM-S = BLM sensitive; CA-T = California state threatened; ESA-T = ESA threatened: N/A – not available or not listed.

b Refer to individual sections below for data sources.

c The burro deer has no federal or state status but is considered in this section because it was a planning species evaluated in the DRECP EIS.

5.3.2.5 New Indicator Data Collection Recommended for the Riverside East SEZ LTMS

Monitoring of the special status species indicators should be initiated at the start of the LTMS. Habitat monitoring should be confined to areas representing potential habitat or movement corridors for each special status indicator species (see habitat descriptions above). To conform to a BACI design, surveys should be conducted within each of the general solar impact-monitoring strata described in Section 2.3.2 (buffer, SEZ, and reference). The results of this initial monitoring combined with available historic data should be used to establish current baseline indicator species habitat condition as well as the relative abundance and distribution of burro deer, bighorn sheep, and Mojave fringe-toed lizard within the three sampling strata. Subsequent surveys should be conducted annually (at minimum) to monitor the operational impacts of existing facilities as well as the impacts of new solar facilities.

Habitat and/or direct monitoring methods are described in the following paragraphs by species.

5.3.2.5.1 Desert Tortoise

Vegetation cover should be monitored within desert tortoise habitat including designated CHUs. Monitoring vegetation cover should utilize field work and remote sensing methods. Monitoring methods, sampling design, and statistical analysis for vegetation are described in Section 5.2.

5.3.2.5.2 Mojave Fringe-toed Lizard

The Mojave fringe-toed lizard is not currently being monitored at the Riverside East SEZ. The Riverside East SEZ LTMS includes new monitoring of habitat indicators for sand dune systems (e.g., monitoring size, distribution, and changes in these systems), which is the primary habitat for the Mojave fringe-toed lizard (Figure 5-15). As described in Section 4.3, sand dune and sand transport can be quantified using field and/or remote sensing at the Ford-Palen dunes (near the site of several authorized or proposed solar energy developments), as well as a reference sand dune system where no solar development is expected to occur.

Direct monitoring of the Mojave fringe-toed lizard is also a recommended component of the Riverside East SEZ LTMS. Methods for surveying the fringe-toed lizard on public land are described in detail in Tinant et al. (2005). Monitoring involves counting all Mojave fringe-toed lizards observed along permanent belt transects placed at least 150 m apart. Tinant et al. (2005) recommends annual sampling during the late spring and early summer when fringe-toed lizards are most active.

5.3.2.5.3 Desert Bighorn Sheep and Burro Deer

The data collection for desert bighorn sheep and burro deer includes monitoring vegetation cover within bighorn sheep and burro deer wildlife corridors identified in the DRECP (including intermountain habitat linkages for the bighorn sheep) (Figures 5-16 and 5-17). Monitoring vegetation cover within these habitats will entail field work and remote sensing approaches. Monitoring methods, sampling design, and statistical analysis for vegetation are described in Section 5.2.

Use of these corridors by the bighorn sheep and burro deer should be monitored to detect changes in use patterns. Guidance for conducting surveys of animal populations is provided in Cooperrider et al. (1986), Hayek and Buzas (1997), Thompson et al. (1998), and Davis (1982). The NECO Plan (BLM

2002) emphasizes the use of aerial and ground surveys to establish baseline occurrence of bighorn sheep in occupied and unoccupied habitats on and in the vicinity of the SEZ. Radio telemetry studies and field sign (e.g., scat, tracks, and the like) surveys may be needed to detect habitat use patterns and movement pathways within the broader habitat linkages (e.g., Bleich et al. 2010). Monitoring should include the tracking of individual movements through intermountain habitat linkages using a combination of ground and GPS collars on a sample of individual animals based on a study design developed by experts from the state and federal resource agencies (e.g., USFWS, CDFW) and academia.

5.3.2.6 Data Analysis and Summary of Monitoring Strategy

Data analysis for habitat monitoring indicators are described for sand dunes and vegetation in Section 4.3 and Section 5.2, respectively. Temporal trends in habitat monitoring indicators should be compared within the three impact strata (two mile buffer, SEZ, reference areas) using a BACI statistical framework.

Spatial and temporal trends in the relative abundance of the Mojave fringe-toed lizard, burro deer, and bighorn sheep should be quantified in their respective corridor areas located within the three impact strata (buffer, SEZ, reference) and analyzed for evidence of solar development impacts using a BACI statistical framework (Section 2.3.2). See Torres et al. (2011) and Dahl et al. (2012) for examples of the application of a BACI approach to assess the impacts of construction projects on wildlife. The proposed monitoring plan for special status species is summarized in Table 5-15.

Table 5-15 Summary of Monitoring Indicators and Monitoring Plan Proposed to Monitor Special Status Species

Indicator (s)	Method	Sampling Strata	Data Analysis
Special status species indicators	(1) Monitoring habitat and habitat linkages for desert tortoise, Mojave fringe-toed lizard, burro deer, and bighorn sheep (2) Direct species monitoring of the burro deer, bighorn sheep, and Mojave fringe-toed lizard	Habitat and species monitoring should be conducted in potential habitat or movement corridors within each solar impact monitoring stratum (buffer, SEZ, and reference).	Habitat monitoring methods include sand dunes and vegetation. Temporal trends in habitat monitoring indicators will be compared within the three impact strata (buffer, SEZ, reference) using a BACI statistical framework. Spatial and temporal trends in relative abundance of the Mojave fringe-toed lizard, burro deer, and bighorn sheep will be quantified in their respective habitat and corridor areas located within the three impact strata (buffer, SEZ, reference) and analyzed for evidence of solar development impacts using a BACI statistical framework.

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5.3.3 Raven and Coyote Abundance

5.3.3.1 Rationale for Monitoring the Indicator

Predators and scavengers may be attracted to solar energy facilities because of greater food availability, water sources, and nesting/perching areas (Figure 5-19). An increase in predators has the potential to affect populations of special status species, such as the Mojave desert tortoise (*Gopherus agassizii*), Mojave fringe-toed lizard (*Uma scoparia*), and burrowing owl (*Athene cunicularia*).

The Riverside East SEZ LTMS will focus on monitoring the abundance of common raven (*Corvus corax*) and coyote (*Canis latrans*). Predation on juvenile and hatchling tortoises by the common raven has been observed in the Mojave Desert (USFWS 2008). In addition to preying on the desert tortoise and other native species, the common raven is a nuisance due to disease issues associated with its fecal deposits (Merrell 2012). Concerns related to the coyote stem from its predation on kit foxes as well as the desert tortoise (Esque et al. 2010).

The common raven and coyote monitoring effort is intended to provide qualitative data that can be interpreted to determine whether project design features and control measures are working or whether additional management and control measures are needed to mitigate impacts on the desert tortoise and other species.

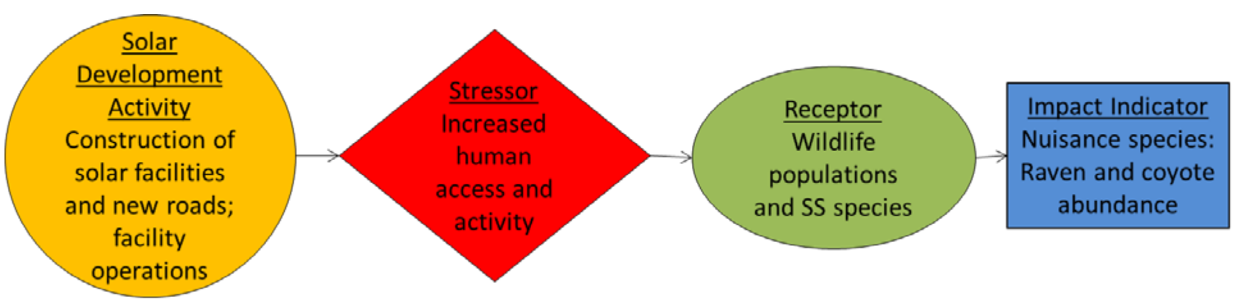

Figure 5-19 Conceptual Model Illustrating Potential Impacts on Wildlife Resulting from Solar Development Activities and the Impact Indicators Used for the Riverside East SEZ LTMS

BLM policies for preserving, protecting, and maintaining ecological resources are laid out in the following documents:

- BLM Handbook H-1601-1, *Land Use Planning* 2005, and Amendments

- California Desert Conservation Area Plan, 1999, and Amendments
- BLM Manual 1734, Rangeland Interagency Ecological Site Manual, and BLM Handbook 1734-1, Interagency Ecological Site Handbook for Rangelands
- BLM Manual 5000, *Forest Management*, and BLM Handbook 5000-1, *Forest Management*
- BLM Manual 5711, *Site Preparation*
- BLM Manual 6840, Special Status Species
- BLM Handbook 1740-2, Integrated Vegetation Management Handbook
- BLM Information Memoranda 2014-112, ;"Policy for Solar and Wind Energy Inspection and Enforcement."

5.3.3.2 Related Management Questions, Management Goals, and Monitoring Objectives Addressed by the Indicator

The AIM indicators will address the management question, management goal, and monitoring objective in Table 5-16.

Table 5-16 Management Question, Management Goal, and Monitoring Objective Addressed by Monitoring Coyote and Raven Abundance

Management Question
• Is solar development leading to increasing populations of tortoise predators (e.g., ravens and coyotes)?
Management Goas
• Reduce tortoise direct mortality resulting from interspecific (e.g., raven predation) and intraspecific (e.g., disease) conflicts that likely result from human-induced changes in ecosystem processes.
Monitoring Objective
• Detect new invasive wildlife species within the SEZ.

5.3.3.3 Spatial and Temporal Considerations for Monitoring the Indicator

The spatial scale over which the raven and coyote abundance will be monitored includes the SEZ and reference locations. The monitoring objective is to detect relative trends in abundance in reference areas and areas influenced by solar energy development. Therefore, the proximity to solar development sites is the primary spatial consideration for monitoring raven and coyote. See Section 2.3.2 for a description of spatial sampling stratification.

Other spatial and temporal considerations for monitoring raven and coyote abundance are largely a function of species life history and specific habitat associations. In general, surveys should be conducted during the time of day and the season when species are easiest to detect. For example, the coyote is mainly nocturnal, but may also be active during the day in cool weather (Zeiner et al. 1990b). Because both nuisance species are year-long residents in the study area, surveys across seasons may not be as necessary to determine abundance, as is the case for migratory species. Annual surveys are expected to be sufficient to detect trends in raven and coyote abundance. Habitat associations and seasonal movements for raven and coyote are described in the following paragraphs.

5.3.3.3.1 Common Raven

Common ravens are year-round residents within the Riverside East SEZ and occur in most habitats found within the study area. The desert populations of common ravens are increasing rapidly because of food subsidization from humans (CalPIF 2009). They roost primarily in trees and nest on cliffs, bluffs, tall trees, or human-made structures. Peak nesting occurs in May and June (Zeiner et al., 1990a). Established nests are often used in successive years. Common ravens travel long distances between their territories and roost sites to visit subsidized food sources (CH2MHILL 2008). Nonbreeding ravens are concentrated near dependable food sources, while nonbreeding ravens are more distributed throughout the desert. The common raven is an omnivore and feeds on carrion, small vertebrates, bird eggs and young, insects, and seeds. Common raven foraging is typically concentrated in the morning and late afternoon (CH2MHILL 2008).

5.3.3.3.2 Coyote

Coyotes are year-round residents throughout California. They are habitat generalists and are often found in open brush, scrub, shrub, and herbaceous habitats. In California, the coyotes mate from January to March and young are born from March through May (Zeiner et al. 1990b). Coyotes are mainly nocturnal, but may be active at any time of day. Surveys may focus along drainages and secondary roads where carnivores often travel.

5.3.3.4 Existing Data Sources

Raven monitoring is required in some project specific monitoring plans. For example, the raven-monitoring and control plan for the Genesis Solar Energy Project includes monitoring raven abundance in the project vicinity. Overall, however, few data sources can be used to establish current baseline raven and coyote distribution and abundance in the Riverside East SEZ.

5.3.3.5 New Indicator Data Collection Recommended for the Riverside East SEZ LTMS

Monitoring coyote and raven abundance should be initiated at the start of the LTMS. Surveys should be confined to areas representing potential habitat for coyote and ravens. To conform to a BACI design, surveys should be conducted within each general solar impact monitoring stratum described in Section 2.3.2 (buffer, SEZ, and reference). Additional monitoring locations should focus on detecting changes in raven and numbers in the Chuckwalla CHU. The results of this initial monitoring combined with available historic data should be used to establish baseline relative abundance and distribution for raven and coyotes within the three sampling strata. Subsequent surveys should be conducted annually.

Potential sampling methods that could be used to monitor ravens and coyote abundance for the Riverside East SEZ LTMS are described in the following paragraphs.

5.3.3.5.1 Common Raven

Methods for monitoring avian species are described in Section 5.3.1.5. These methods are applicable to the common raven and include point count surveys conducted annually during the breeding season. For more specifics on common raven monitoring procedures, refer to the common raven management plans prepared by EDAW (2008), CH2MHILL (2008), Tetra Tech EC (2010), and Ironwood Consulting (2010). Equipment needed for bird surveys may generally include cameras, binoculars, telescoping mirror and pole, handheld Global Positioning System (GPS) unit, maps, field guide, spotting scope (potentially), thermometer, timer, and data sheets.

5.3.3.5.2 Coyote

Surveys of large mammals can be expensive and labor intensive (Kronland 2009). Survey methods for the coyote include scent-station transects (involving scat and/or track observations), vocalization responses, mark-recapture, motion-triggered cameras, and area-search surveys (Henke and Knowlton 1995). Scent stations are the most widely used and standardized method for determining coyote abundance (Henke and Knowlton 1995). Scent survey transects are used to measure relative abundance by placing scent stations along a transect and clearing a circle of lightly sifted sand around the station. Stations are checked every morning for tracks (Dempsey et al. 2014; Sargeant et al. 1998; Kronland 2011, 2009; Linhart and Knowlton 1975). Scat deposition transects are one of the more practical survey methods for coyotes and are used to measure relative abundance by clearing transects of all scat and then surveying transects later to determine the number of scats deposited (Dempsey et al. 2014; Kronland 2009; Henke and Knowlton 1995). Camera stations can also be used to identify carnivore presence, linkages, and potential dispersal barriers (Kronland 2011). See Kronland (2009), Henke and Knowlton (1995), and Linhart and Knowlton (1975) for various coyote survey protocols. Equipment needed for coyote track surveys may include fine-grain silica sand or motion-triggered cameras.

5.3.3.6 Data Analysis and Summary of Monitoring Strategy

Spatial and temporal trends in raven and coyote abundance should be analyzed within the three impact strata (buffer, SEZ, and reference) over time by using a BACI statistical framework. See Section 2.3.2 for a discussion of the statistical analysis of BACI study designs. The proposed monitoring plan for nuisance species is summarized in Table 5-17.

Table 5-17 Summary of Monitoring Indicators and Monitoring Plan Proposed to Monitor Nuisance Species

Indicator (s)	Method	Sampling Strata	Data Analysis
Raven and coyote abundance	Methods for coyote abundance not specified; point count surveys for raven abundance	Surveys should be confined to areas representing potential habitat for coyote and ravens within each solar impact monitoring stratum (buffer, SEZ, and reference). Additional monitoring locations will focus on detecting changes in raven and coyote numbers in the Chuckwalla CHU.	Spatial and temporal trends in raven and coyote abundance will be analyzed within the three impact strata (buffer, SEZ, and reference) over time using a BACI statistical framework.

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6 SOCIOCULTURAL MONITORING

6.1 Visual Impact Indicators

6.1.1 Visual Contrast in Views from Visually Sensitive Areas (VSAs)

6.1.1.1 Rationale for Monitoring the Indicator

The introduction of new elements into the landscape causes new visual contrasts that may cause visual impacts, depending on the nature and magnitude of the contrasts (BLM 1986; BLM 2013; Sullivan and Meyer 2014). These impacts include change in scenic quality and character of the landscape, and changes to the visual values for specific views from visually sensitive areas (VSAs) (Figure 6-1). VSAs include not only specially designated areas (SDAs) but also communities, roads, and other points of interest that do not have special designations. VSAs identified in the Riverside East SEZ with the potential to experience moderate and high visual contrasts are shown in Figure 6-2. See Appendix B for a glossary of visual resource terms used in this section.

The construction and operation of utility-scale solar energy facilities create visual contrasts with the surrounding landscape, primarily because of the introduction of complex and visually distinctive structures on a large scale. In the southwestern states where most U.S. utility-scale solar facilities are in operation or planned, solar facility sites are relatively flat, open spaces, typically located in visually simple and uncluttered valley landscapes that often lack screening vegetation or structures. Because of the lack of screening elements, the open sightlines, and relatively clean air typical of the Riverside East SEZ, solar facilities may be visible for long distances, and their large size and distinctive visual qualities can give rise to strong visual contrasts in some circumstances (BLM and DOE 2010; Sullivan et al. 2012; Sullivan and Abplanalp 2015) (Figure 6-1). Stakeholders' negative response to the visual contrasts of solar facilities can result in opposition to individual proposed solar projects or to utility-scale solar energy generally. If the negative perceptions are sufficiently strong, such opposition could potentially result in delays or even cancellations of projects.

While stakeholder opposition resulting from perceived negative visual impacts is not documented to have led to the cancellation of any utility-scale solar projects in the United States to date, local governments, such as San Bernardino and Sonoma Counties in California, have recently passed ordinances restricting commercial solar facilities specifically to protect scenic resources, among other values (*San Bernardino County Sentinel* 2013; Sonoma County 2013). Visual impacts have increasingly become an important concern not only for individuals but also for organizations such as tribes, local governments, environmental groups, and the National Park.

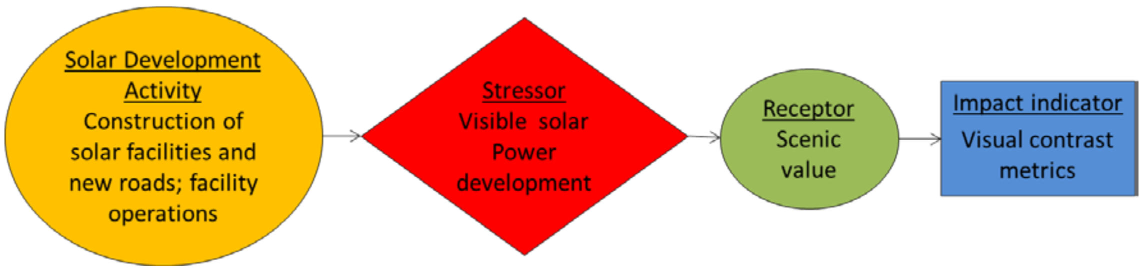

Figure 6-1 Conceptual Model Illustrating Potential Visual Impacts Resulting from Solar Development Activities and the Impact Indicator used for the Riverside East SEZ LTMS

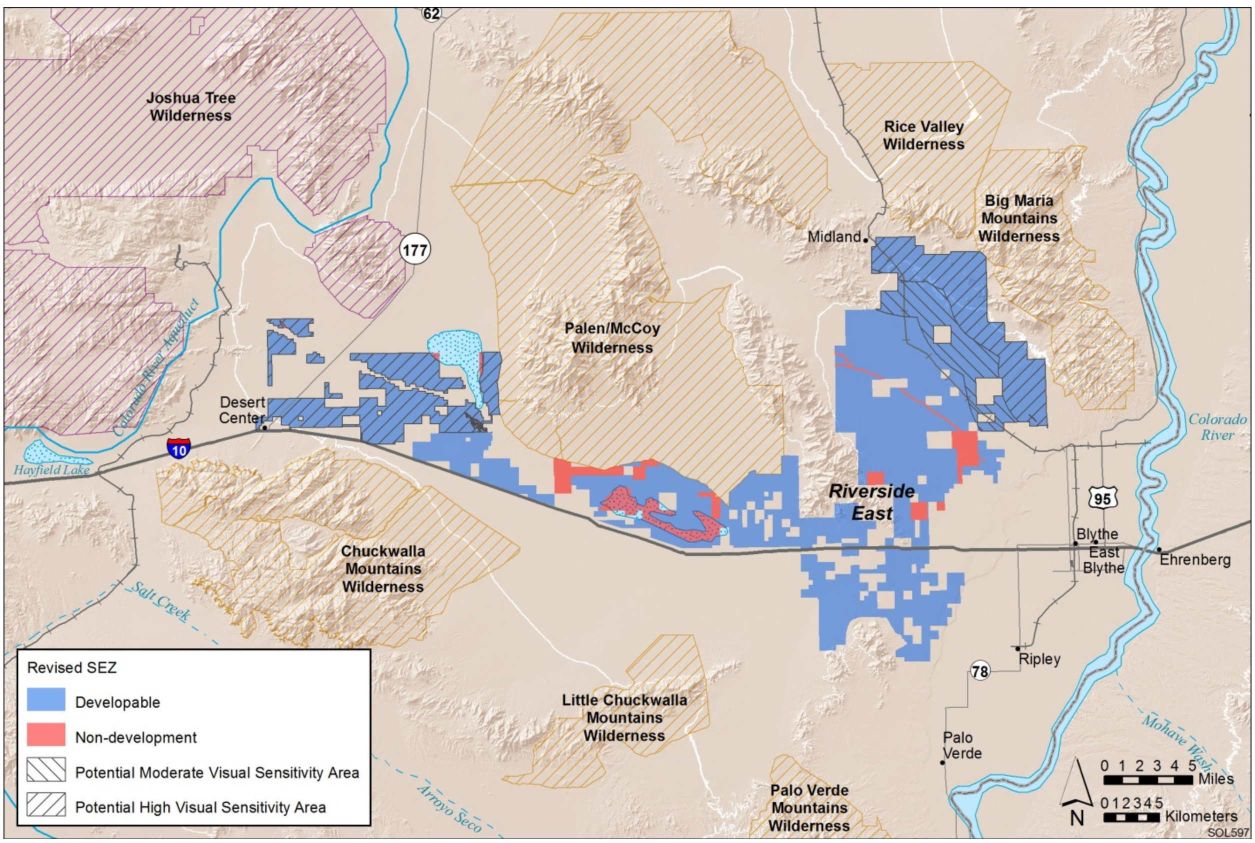

Figure 6-2 VSAs with the Potential to Experience Moderate and High Visual Contrasts in the Riverside East SEZ and Vicinity

Service (NPS). Stakeholders routinely express concerns over potential negative visual impacts of solar facilities during the environmental impact assessment processes that are required for these types of facilities (Basin and Range Watch 2010; DOE 2012; NPCA 2012; Colorado River Indian Tribes 2013; Kessler 2013; NPS 2013).

Unlike utility-scale wind turbines, the three major and distinctly different solar technologies work by substantially different underlying principles and mechanisms: PV, parabolic trough, and solar power tower facilities. The visual characteristics of these technologies differ in important ways, making the task of comprehensive visual impact assessment more complex than for wind energy facilities. Work conducted by Argonne for the BLM and the NPS documented the visibility, visual characteristics, and visual contrasts associated with utility-scale solar facilities (Sullivan 2011; Sullivan et al. 2012, 2013; Sullivan and Abplanalp 2015). These studies have shown that utility-scale solar facilities can sometimes be easily seen at distances as great as 35 mi or more and can cause substantial glare and other visual contrasts at long distances.

Visual contrast and mitigation monitoring is directed at addressing three issues related to visual contrast:

1. The change in scenic values that results from the introduction of individual proposed projects into the existing landscape as seen from VSAs;
2. The observed visual contrasts from built solar facilities in the SEZ differing from those predicted by the visual impact analyses for those facilities; and
3. The level of compliance with and effectiveness of visual impact mitigation methods specified by BLM for built solar facilities in the SEZ.

These assessments are essential to determine the necessity and nature of corrective mitigation actions that may be warranted if project impacts exceed the predicted levels or if required mitigation is not implemented or is ineffective.

6.1.1.2 Related Management Questions, Management Goals, and Monitoring Objective Addressed by the Indicator

Monitoring visual changes to views from VSAs within the SEZ will address the management questions, management goals, and monitoring objectives in Table 6-1.

Table 6-1 Management Questions, Management Goals and Monitoring Objectives Addressed by Monitoring Visual Contrast in Views from VSAs

Management Questions

- Do site construction, operations, and increased site access and visitation negatively affect user experiences and cultural values?
- Does cumulative solar development within the SEZ negatively affect visual values within and near the SEZ for daytime views, and if so, what are the nature and extent of the changes?
- Do the visual impact levels predicted in the project EISs accurately reflect the impacts of the projects, whether or not required mitigation was in fact implemented, and whether or not it was effective where it was implemented?

Management Goals

- Maintain baseline recreational quality of experiences.
- Maintain scenic quality consistent with inventoried VRI class value in order to preserve landscape/scenic values.
- Minimize impacts from nighttime illumination and daytime glare.
- Minimize impacts over time to views from VSAs.
- Ensure compliance with and effectiveness of visual impact mitigation for solar energy projects within the SEZ.

Monitoring Objectives

- Detect temporal changes in visual contrast of the views from VSAs that include solar facilities in the SEZ within their viewsheds.

6.1.1.3 Spatial and Temporal Considerations for the Monitoring the Indicator

Visual contrast and mitigation monitoring will require conducting field work at VSAs both within and outside the SEZ but all within the viewshed of the SEZ. Visual contrast monitoring should begin at the start of the Riverside East SEZ LTMS project to establish existing visual qualities of the landscape within and near the SEZ for use as a baseline against which to measure changes to the landscape over time, and before any additional visible disturbance of the project site. This baseline assessment would omit mitigation compliance and effectiveness monitoring.

One monitoring assessment (including mitigation monitoring) should occur during the construction phase of any projects built during the course of the LTMS project. Potentially, this assessment could be conducted concurrently with the routine construction inspections that are normally conducted for projects on BLM-managed lands.

The single most important monitoring assessment should take place approximately 1 year after operation has commenced, because after the passage of a full cycle of seasons, many soil and vegetative disturbances would be somewhat less apparent, and the facility should appear much as it will during most of its operational lifetime.

An assessment of visual contrast monitoring should be conducted after the plant has been operational for a number of years, *if* change to the landscape has resulted from project-related causes, for example, vegetation, erosion, or failed mitigation efforts , and the change would be noticed by a casual observer at one or more KOPs used in the analysis. The timing for the assessment should be determined by inspecting the site periodically for the occurrence and rate of change in visual contrast. If change has occurred slowly, the final monitoring assessment might be delayed to as long as 10 years after operations commence; if change has occurred more rapidly, more frequent monitoring assessments should be made.

An assessment should be made once within 5 years after decommissioning. This assessment would provide information about the initial recoverability of visual values after decommissioning of solar projects. At the time of monitoring, a decision should be made regarding the stability of the visible landscape condition and the need for further monitoring.

Visual contrast and mitigation monitoring should be conducted only on sunny days with good visibility relative to the normal conditions for the area or visibility meets some other criteria such as the Lake Tahoe 10-mi visibility standard (extinction of 0.07 per kilometer).

6.1.1.4 New Data Collection and Data Analysis Recommended for the Riverside East SEZ LTMS

Visual contrast is a major component of visual impacts (BLM 2013; Sullivan and Meyer 2014), and the assessment of contrast is a routine part of visual impact assessment (Sullivan and Meyer 2014). The Riverside East SEZ visual contrast and mitigation monitoring methodology is primarily based on the VCR process the BLM requires to assess the impacts of proposed projects or actions on BLM-administered lands (BLM 1986), as specified by guidance developed for the BLM Solar Regional Mitigation Strategy (SRMS) program (BLM in press). The SRMS guidance provides detailed instructions for the assessment of impacts on VSAs from solar energy development in the SEZs. The VCR is a component of the BLM Visual Resource Management (VRM) system (BLM 1984), and the SRMS guidance is consistent with the VRM policy.

The implementation of the visual contrast and mitigation monitoring would rely on a variety of data and information, including primarily the Solar PEIS (for VRM classes specified for the SEZ and required design features) and the EISs for proposed projects (for predicted contrast and impact levels, and mitigation).Visual contrast and mitigation LTMS requires both field work and pre- and post-field work analysis and documentation. For each KOP within a VSA, an approximately 1- to 2-hr field visit would be required for each monitoring assessment as well as 4–5 hours of office-based analysis. A minimum of two persons should participate in the field assessment, and they should be familiar with the BLM VCR rating process.

The analysis should include a visual impact assessment that identifies VSAs within the viewshed of the SEZ and typically will include KOPs within these VSAs. These KOPs should be included in the visual contrast and mitigation monitoring. The identification of additional VSAs and KOPs may be necessary. The visual impact analysis for the Riverside East SEZ in the Final Solar PEIS (BLM and DOE 2010) included preliminary assessments of potential visual contrasts for representative viewpoints (rather than specific KOPs) within numerous VSAs near the Riverside East SEZ. However, the PEIS visual impact analysis did not include areas important to tribes, nor were VSAs selected with input from BLM staff or local stakeholders. These parties should be engaged to identify new VSAs and KOPs.

The following steps are recommended to determine the visual impact on the VSAs:

1. Use the Final Solar PEIS analysis and impact summary (BLM and DOE 2012) and the project EIS to identify VSAs within the project viewshed. For these and any additional VSAs within the project viewshed, document the following information:
    a. VSA name.
    b. Type of VSA. VSAs may include communities (town, neighborhood, rural subdivision, farmstead, private special land use authorization by local or state government), tribal land, or SDAs (e.g., wilderness area, area of critical environmental concern, special recreation management area, national park unit, national historic trail, and the like).
    c. The area within the VSA (acreage/percentage of area) that potentially may have views of solar development in the SEZ.
    d. Distance from the SEZ to the affected areas within the VSA.
    e. The type of recreation and/or other activities within the VSA.
    f. The approximate number of users within the VSA.
    g. Estimated proportion of visitors conducting each major type of activity.
    h. The role that the affected areas play in the management objectives defined within the respective community and tribal comprehensive land use master plans and within SDA land use plans.
    i. Other forms of cultural modifications (any visible human-caused changes) within the viewshed.
    j. The full context of the observer's horizontal field of view.
    k. The amount of potential SEZ development that could occupy the view.

l. The spatial orientation of the solar energy development within the field of view.

2. For the VSAs listed under step 1, identify locations of critical or representative KOPs in each VSA.

   KOPs for visual contrast monitoring should include the KOPs selected for the original NEPA assessment. These KOPs should be good observation points for contrast monitoring because at the time of the original impact assessment, they were identified as sensitive viewpoints, and because there may already be photographs, simulations, and contrast assessments for these locations to serve as a basis for comparison.

   In addition to using KOPs from the original impact assessment, other points may be deemed appropriate to document the observed visual contrasts, because (1) they are sensitive viewpoints but were not included in the original impact assessment, (2) changes in the use of the landscape over time have increased the sensitivity of these locations, or (3) unanticipated impacts not addressed in the original impact assessment are visible from these locations.

   KOPs should be identified based on input from BLM staff and other stakeholders (if possible) to identify frequently visited or sensitive viewpoints within the VSA that are also within the viewshed of the SEZ; these points would be critical KOPs. For VSAs where no critical KOPs can be identified, representative KOPs can be used; these points should be representative of views from the VSAs.

3. Prepare maps that label the locations of KOPs, show the full context of the VSAs, and illustrate the affected viewshed within the VSAs exposed to the SEZ.

4. Provide the rationale for selecting KOPs within the VSAs and for identifying which are critical and which are representative KOPs.

5. For critical KOPs, describe the critical nature of the affected views in comparison with the other areas within the VSA.

6. Document how people access the KOPs (motorized travel on road, trail hike, river navigation, and so on).

7. In a field visit, observe and photograph the facility from each KOP. Photographs should include panoramic images of the facility in its landscape setting, and enough of the surrounding landscape to understand the spatial and visual relationship of the project to the surrounding landscape.

8. During the field visit, prepare a Visual Resource Contrast Rating evaluation (see BLM Handbook H-8431-1 [BLM 1986]) for the facility from selected KOPs, and identify to which VRM class the outcome is closest in conformance.

9. Based on the field observation, document how the 10 environmental factors influence the degree of SEZ noticeability for casual observers within the visually exposed areas of the VSA (see BLM Handbook H-8431-1 [BLM 1986]).
10. Provide a detailed assessment of human use of the VSA and how exposure to solar development within the SEZ could affect the quality of life or recreational experience for visitors within the VSA.
11. Summarize the level of visual exposure based on the representative VRM class objective closest in alignment with the contrast rating results. Also, summarize the impact on the casual observer, taking all 10 environmental factors, the field of view, and other site conditions into consideration.

The results of each step of the impact analysis should be documented in an impact assessment report that provides documentation for the analysis for each KOP as well as a finding of the observed contrast for the facility for each VSA. The photographs and form data should then be entered into a database for storage and retrieval and also for a summary report of the findings of the visual contrast monitoring assessment that would be included in the impact assessment report. As described below, the contrast finding can then be used for determining the accuracy of the original impact assessment in the National Environmental Policy Act of 1969 (NEPA) analysis for the project.

6.1.1.4.1 EIS Impact Assessment Accuracy Monitoring

To determine the accuracy of the visual impact analysis in the project EIS, the VCR results and photographs for each KOP should be compared to the VCRs and simulations documented in the project EIS. Any significant differences between the VCRs contained in the project EIS and those observed during the monitoring assessment should be documented, and similarly, discrepancies between the simulations in the project EIS and the photographs taken during the monitoring assessment should be documented. An example of the application of this technique can be found in the Ivanpah Visibility and Visual Characteristics study by Sullivan and Abplanalp (2015).

Equipment needed for visual contrast monitoring should include the following:

- A GPS-enabled, digital, single-lens-reflex camera with a tripod;
- Handheld computing devices to navigate to KOPs, determine distances and bearings, and record ancillary data, such as sun angle and elevation, weather, and lighting conditions; and
- Data collection forms and clipboards, including the BLM VCR form and a form for recording basic information about the field assessment, with KOP and VSA name,

recorder/evaluator names, date and time, KOP location (using GPS coordinates), weather and lighting conditions, the view bearing, and width of field of the view.

6.1.1.4.2 Mitigation Compliance and Effectiveness Monitoring

Visual impact mitigation monitoring involves the development of a photographic and text-based record of the observed measures taken to mitigate visual impact associated with the various stages of development of a utility-scale solar energy facility. The record should note whether the mitigation specified in the environmental assessment and any permitting document appears to have been implemented and, if it was, whether it has been effective in mitigating visual impacts in the manner intended, that is, whether the mitigation has reduced visual contrasts from the project to the extent that is shown in the visual simulations created for the visual impact assessment for the proposed project, or if simulations are not available, using professional judgment to assess whether the mitigation has noticeably diminished contrast from the project.

Project planning and data collection, entry, and analysis procedures for mitigation compliance and effectiveness monitoring are very similar to the procedures used for visual contrast monitoring (see above), except that a mitigation-monitoring form is used rather than a VCR form, and the photographic subjects are specific mitigation practices rather than the facility and its surroundings. In general, the mitigation compliance and effectiveness monitoring work would likely be completed at the same time as the visual contrast monitoring, but that actually does not need to be the case. Note that mitigation may include lighting design, materials, and procedures for mitigating night sky impacts, and while mitigation compliance for lighting mitigation might be determined during the day, mitigation effectiveness monitoring would need to be conducted at night.

After a list of specified and recommended mitigation measures is compiled from the project EIS and ROD, the facility and its surroundings should be photographed from established observation points deemed appropriate for documenting the implementation and effectiveness of visual impact mitigation (i.e., the KOPs used in the visual impact assessment for the project if they have a clear view of the mitigated project elements or, if not, from new observation points established so that they have a clear view of the mitigated project elements). These points may include the KOPs selected for the original project EIS. Data observation forms should be completed at the same time that the photographs are taken, in order to record data on whether the specified mitigation measure appears to have been implemented and the degree to which it has been effective. The photographs and data from forms should then be entered into a database for storage and retrieval and for a report that summarizes the findings of the mitigation monitoring assessment. The report and database can then be used to compare the actual mitigation practices with those that were specified and to compare the effectiveness of mitigation at different phases of development. The proposed monitoring plan for visual contrast is summarized in Table 6-2.

Table 6-2 Summary of Monitoring Indicators and Monitoring Plan Proposed to Monitor Visual Contrast at VSAs

Indicator (s)	Method	Sampling Strata	Data Analysis
Visual contrast at VSAs	Field assessment, using the BLM VCR process at each KOP within a VSA	KOPs within VSAs within the viewshed of the SEZ, as identified and assessed in the PEIS. The PEIS visual impact analysis did not include areas important to tribes, nor were VSAs selected with input from BLM staff or local stakeholders. These parties should be engaged to identify new VSAs and KOPs.	The VCR results and photographs for each KOP should be compared to the VCRs and simulations from the project EIS. Any significant differences should be documented, and similarly, discrepancies between the simulations in the project EIS and the photographs taken during the monitoring assessment should be documented. Visual impact mitigation monitoring involves analyzing the photographic and text-based record of the observed measures taken to mitigate visual impact associated with the various stages of development of a utility-scale solar energy facility.

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6.1.2 Nighttime Illumination (Night Sky)

6.1.2.1 Rationale for Monitoring the Indicator

Types of light pollution include (1) skyglow, (2) light spill, (3) glare, and (4) light clutter (Moore 2001; Lighting Research Center 2007; AECOM 2014). Night sky impacts from lighting at facilities can include all these types of light pollution. Of particular interest for the Riverside East SEZ LTMS are *skyglow*, the reduction in the overall darkness of the night sky resulting from all sources of light present, and *light spill (*sometimes referred to as *light trespass),* the introduction of directly viewed light sources that attract visual attention, interfere with nighttime landscape visibility, and interfere with scotopic vision (vision in dim light) (Moore 2001, 2015). Sullivan et al. (2012) and Sullivan and Abplanalp (2015) observed that lighting at solar facilities can be visible at long distances and relatively bright light sources at distances of several miles. As with daytime visual contrasts, the nature and magnitude of night sky impacts from solar facilities is dependent on the solar technology type, with PV facilities typically requiring substantially lower levels of lighting at night than parabolic trough power tower facilities (Sullivan and Meyer 2014).

Of particular concern is the proximity of the Riverside East SEZ to the eastern portions of Joshua Tree National Park (JTNP), which could be subjected to both skyglow and direct glare from solar facilities in the SEZ. JTNP is known for its high-quality night skies and offers regular astronomy events (NPS 2015; IDSA 2007). The recommended night sky impact monitoring for the Riverside East SEZ includes monitoring changes in skyglow for the SEZ as a whole over time and monitoring changes in directly visible lighting from solar facilities (light spill).

Skyglow is the overall brightening of the sky and loss of visual contrast between objects visible in the night sky (e.g., stars, galaxies, nebulae) and the background, and also the absorption and scattering of light as a result of air pollution and humidity, as well as other natural causes (Moore 2001; NLPIP 2007). The nighttime illumination indicator addresses the effect of solar development within the SEZ on night sky quality and on the nighttime views of the landscape within the SEZ, as well as quantifies the nature and extent of the changes (Figure 6-3.)

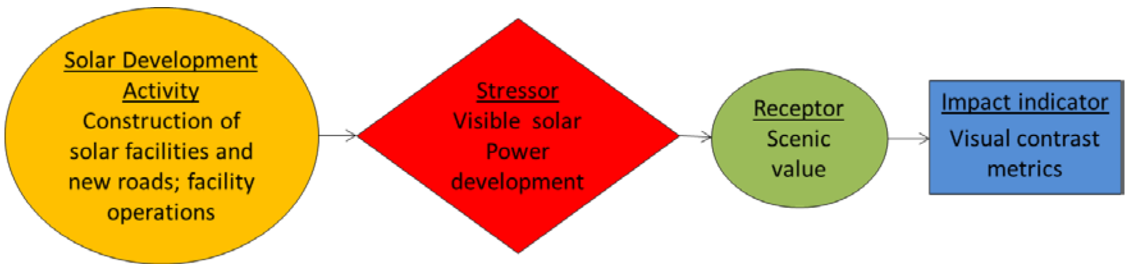

Figure 6-3 Conceptual Model Illustrating Potential Visual Impacts Resulting from Solar Development Activities and the Impact Indicator Used for the Riverside East SEZ LTMS

6.1.2.2 Related Management Questions, Management Goals, and Monitoring Objectives Addressed by the Indicator

Monitoring nighttime illumination will address the management questions, management goals, and monitoring objectives in Table 6-3.

Table 6-3 Management Question, Management Goals, and Monitoring Objectives Addressed by the Nighttime Illumination Indicator

Management Question
- Does solar development within the SEZ negatively affect night sky quality and/or negatively affect nighttime views of the landscape within the SEZ?

Management Goals
- Maintain baseline quality of nighttime recreational experiences.
- Minimize impacts of light.

Monitoring Objectives
- Detect temporal changes in skyglow for the SEZ from lighting associated with solar facilities within the SEZ.
- Detect temporal changes in the nature and amount of lighting from solar facilities directly visible from locations within the SEZ, in order to monitor light spill and light clutter.

6.1.2.3 Spatial and Temporal Considerations for Monitoring the Indicator

Night skies impact monitoring would require field assessments at multiple locations within the SEZ. Night skies impact monitoring should begin at the start of the LTMS project to establish existing visual quality of the night sky as seen from the SEZ for use as the baseline against which to measure changes to the landscape over time. Night skies impact monitoring should be conducted at the time of year with the clearest night skies; typically this would be the season with the lowest average humidity.

6.1.2.4 New Data Collection and Analysis Recommended for the Riverside East SEZ LTMS

Skyglow can be measured in several ways, both “low-tech” and “high-tech.” “Low-tech” methods include estimation of limiting magnitude by star counts, by use of a scale such as the Bortle scale (Moore 2001, 2015) or inexpensive night sky meters (Moore 2015). “Hi-tech” approaches include photographic approaches for measuring the brightness of the night sky using a mosaic of CCD images obtained from an automated camera system (Duriscoe et al. 2007).

Little research specifying a methodology for light spill assessment was found; however, AECOM (2014) used a sophisticated assessment method for predicting light spill from a marine shipping terminal, using photographic methods, lighting software, and simulations. Among other activities, the method uses a light meter to directly measure light levels at specific locations where sensitive viewers might be exposed to lighting from the facility, and also included a description of the nature and magnitude of the lighting as it would be perceived from those locations. While thorough, the approach has the disadvantage of complexity and being designed for a proposed rather than an existing project.

The BLM does not currently have a policy or inventory and management approach with respect to night sky impacts from activities on BLM-administered lands. At the request of Argonne and BLM, staff of the NPS Night Skies and Natural Sounds Program (a recognized leader in night sky light pollution issues and impact assessment) recommended an approach for monitoring night sky impacts for the Riverside East SEZ (Moore 2015). This hybrid approach combines conventional night-sky photography with use of a relatively inexpensive light meter to measure light spill from solar facilities in the SEZ and, from the results, estimating sky glow effects.

The night sky monitoring effort would rely in part on imagery from the Visible Infrared Imaging Radiometer Suite (VIIRS) sensor aboard the Suomi National Polar-orbiting Partnership (S-NPP) satellite. Argonne currently has uncorrected VIIRS imagery for the study area. Monitoring for night skies impact requires both field work and pre- and post-field work analysis and documentation. The recommended night skies impact protocol for the Riverside East SEZ LTMS can be summarized as follows:

- Conducting a baseline assessment for skyglow with NPS equipment and procedures;.
- Conducting a baseline assessment for light spill sources with satellite imagery;
- Conducting ground-based assessments of light spill using a handheld light meter;
- Recording the number, spatial arrangement, color, and apparent brightness of visible light sources; and
- Using mathematical modeling to extrapolate lighting brightness values for desired locations within or near the SEZ, for example, VSAs, for both light spill and skyglow impacts.

Night sky impact monitoring should be conducted only on cloudless nights with no moon and with very good atmospheric clarity, as determined using the Bortle scale to determine limiting magnitude of visible stellar objects (Moore 2001, 2015). Observations should be conducted only after evening astronomical twilight and before morning astronomical twilight. The recommended approach for monitoring night sky impacts includes the following:

1. Establish initial conditions at one or more observation points at the start of the monitoring period by using a sophisticated instrument such as the NPS CCD camera. One of these instruments is available at JTNP. This method can establish the initial condition, distinguish natural from artificial light sources, and help calibrate the other methods. Depending on the size and complexity of the terrain, as few as two or three sites collected under ideal atmospheric conditions may be adequate. Locations as far as possible away from light sources , particularly roadways, should be sought. Specific locations should be chosen in the field (because of potential screening of parts of the sky by vegetation or landforms), but suggested locations include a location in the western portion of the SEZ between Desert Center and the Palen Mountains, one in the eastern portion of the SEZ between Midland Road and the McCoy Mountains, and one in the south central portion of the SEZ near Ford Dry Lake (but as far as possible away from I-10). Locations should be selected to minimize topographic screening by the Palen and McCoy Mountains.
2. Using land use maps and VIIRS imagery, identify existing light pollution sources. Take readings with an illuminance meter (e.g., the Minolta T-10 light meter) held vertically around the facility at fixed stand-off distances, for example, 50 m or 100 m, as circumstances permit. These measurements will track light spill emissions from that particular facility as well as enabling the modeling of light spill across the landscape from the measured facility.
3. Establish a network of photo monitoring points within the SEZ. The points should be selected so that their viewsheds cover the entire SEZ, but no point should be more than 10 mi from the next point. It may be possible to cover the entire SEZ with as few as six points. Specific locations should be chosen in the field because of potential screening of parts of the landscape by vegetation or landforms.

4. On a clear, moonless night during a nighttime field visit, utilize a sensitive Digital single lens reflex (DSLR) camera (e.g., Canon 5D MkII, or Sony alpha 7s) and a wide-angle fast lens to document visible light sources at each point. Photographs should include but not be limited to stitched panoramic images. These images serve as a qualitative assessment of light spill sources and will help visually track changes and communicate results to stakeholders and the public. Narrow-angle (zoom) shots should be used to document and help identify individual light sources. Proper calibration, control, and documentation of the camera settings may enable quantification from the imagery, but should also be used to produce images that approximate the "on the ground view" as closely as possible. Image quality can be field-checked by using a mobile computing device to simultaneously view the photograph and the real landscape.
5. At each photo monitoring point, document the number, color, apparent brightness, flashing/steady light condition, spatial arrangement, and bearing to visible lighting. If lighting appears to be clumped, measure and record the approximate horizontal width of field of the clump. Apparent brightness can be estimated by comparing the light to visible stars of known magnitude, using a mobile device with a stargazing software application.
6. After the field data collection, utilize modeling to "fill in" information between monitoring points and to estimate the extent of the impact of each facility. This should be done for spill light and, if resources allow, conducted for skyglow as well. Modeling of spill light is very simple, being the product of the Inverse-Square Law and a minor adjustment for atmospheric extinction. Modeling of spill light can be handled in a spreadsheet or a Geographic Information System (GIS) operation.
7. Night skies impact monitoring should be conducted when a new facility becomes operational, but need not include assessments from photo monitoring points that are not within the viewshed of the facility.

Equipment needed for night skies impact monitoring should include the following:

- A GPS-enabled, digital, single-lens-reflex camera with a tripod;
- Handheld computing devices to navigate to photo observation points, determine distances and bearings, and record ancillary data, such as bearings to light sources; and
- Data collection forms and clipboards, including a night skies impact monitoring form, which in addition to the lighting-related information above would also contain basic information about the field assessment—photo monitoring location name, recorder/evaluator names, date and time, photo monitoring location coordinates (using GPS), and weather conditions.

The proposed monitoring plan for night sky is summarized in Table 6-4.

Table 6-4 Summary of Monitoring Indicators and Monitoring Plan Proposed to Monitor Night Sky

Indicator (s)	Method	Sampling Strata	Data Analysis
Nighttime Illumination (night sky)	Estimation of limiting magnitude by star counts using Bortle scale or night sky meters; measuring brightness using CCD images from an automated camera system	Establish a network of photo monitoring points within the SEZ. It may be possible to cover the entire SEZ with as few as six points.	Change in night sky over time

6.1.2.5 Literature Cited

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6.1.3 Visual Resource Inventory (VRI) Factors and VRI Class

6.1.3.1 Rationale for Monitoring the Indicator

The VRI classification involves assigning an inventory class to all BLM-administered lands based on their VRI results using BLM VRI Handbook H-8410-1 (BLM 1986). The VRI for a given area consists of ratings for three factors: scenic quality, sensitivity (e.g., types and amount of users, special areas, public interest), and distance zone (relative visibility from travel routes or observation points). A matrix that contains all three factors is then used to derive the VRI Class of II, III, or IV, with II being high and IV being low relative visual value. VRI Class I is reserved for BLM specially designated areas such as wilderness areas, where a management decision has been made previously to preserve a natural-appearing landscape. VRI classes are informational in nature and provide the basis for considering visual values in the RMP process (Figure 6-4). They do not establish management direction and are not used as a basis for constraining or limiting surface disturbing activities.

As the SEZ is built out over the course of years, cumulative visual impacts from the introduction of multiple solar facilities utilizing different solar technologies are inevitable, and likely substantial, as noted in the Solar PEIS (DOE and BLM 2010). Additional potentially substantial cumulative visual impacts would result from the transmission facilities and roads that would be built in association with the facilities, and from other types of development and activities that are occurring or may occur in the future. Cumulative impacts may include the impacts associated with seeing two or more facilities at the same time from one location, or impacts that occur when facilities come into view successively as the viewer moves through the landscape. Because of the very large size of the Riverside East SEZ, both types of cumulative visual impacts are expected.

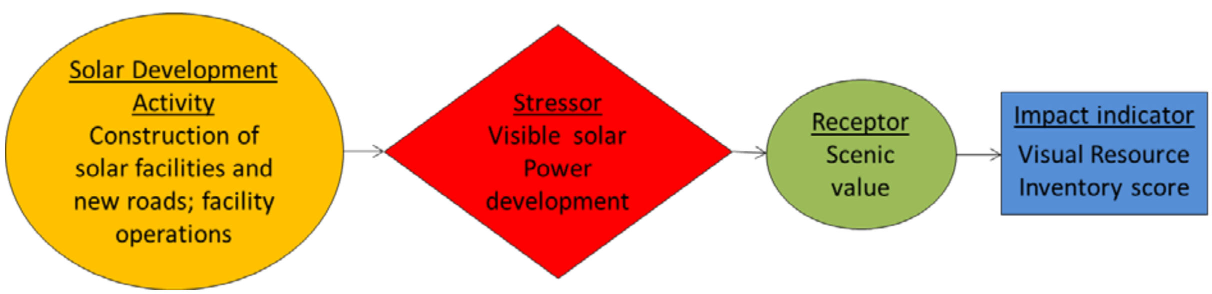

Figure 6-4 Conceptual Model Illustrating Potential Visual Impacts Resulting from Solar Development Activities and the Impact Indicator Used for the Riverside East SEZ LTMS

Cumulative impacts on visual resources have the potential to alter the VRI factors and the VRI class of areas within the SEZ. As described above, the BLM VRI evaluates three major factors that contribute to the VRI value for an area: scenic quality, sensitivity, and distance zones. The VRI for the Palm Springs-South Coast FO (Otak 2010) identified the area in which the SEZ is located as entirely within the Foreground-Middleground Distance Zone, and that factor will not change in the future; thus there is no need to reinventory distance zones. Sensitivity can potentially change over time, as usage patterns or levels of public concern change. Scenic quality can also change over time with the development of solar energy facilities in the SEZ primarily through the cultural modification component of the scenic quality rating. Specifically, the scenic quality rating for the Riverside East SEZ is just above the threshold for a rating change because even a modest decrease in the cultural modification component (a VRI component describing the degree of human-caused change in the visible landscape) would reduce scenic quality. As new facilities are built, the cultural modification score would change, and this could ultimately change the scenic quality rating and the VRI class. Changes in the vegetation component might also change the scenic quality rating and the VRI class. Consequently, the VRI factor ratings and the overall VRI classification are likely to be a responsive indicator for cumulative visual impacts from solar energy development. Recording the cumulative changes in scenic quality components and assessing their effects on the overall scenic quality visual values of the area are a primary purpose of monitoring VRI factors and VRI class.

6.1.3.2 Related Management Questions, Management Goals, and Monitoring Objectives Addressed by the Indicator

Monitoring the VRI factors will address the management questions, management goals, and monitoring objectives in Table 6-5. The indicator data will be used to determine whether the cumulative solar development within the SEZ has negatively affected visual values within and near the SEZ for daytime views over the long term, as well as the specific nature and extent of the changes.

Table 6-5 Management Questions, Management Goals, and Monitoring Objective Addressed by Monitoring VRI class

Management Questions
- Do site construction, operations, and increased site access and visitation negatively affect user experiences and cultural values?
- Does cumulative solar development within the SEZ negatively affect visual values within and near the SEZ for daytime views, and if so, what are the nature and extent of the changes?

Management Goals
- Minimize impacts, over time, on views from VSAs.
- Preserve VRI class to maintain landscapes and their scenic values.
- Maintain baseline recreational quality of experiences.

Monitoring Objective
- Detect changes in VRI factors and VRI class within the SEZ.

6.1.3.3 Spatial and Temporal Considerations for Monitoring the Indicator

The spatial scale for data collection will be the SEZ. A current VRI map for the SEZ and surrounding lands is shown in Figure 6-5. The map provides information from the BLM September 2010 VRI, which was finalized in October 2011(BLM and DOE 2011). As shown, the VRI classes for the SEZ are VRI Class II, indicating high relative visual values; Class III, indicating moderate relative visual values; and Class IV, indicating low relative visual values. Sensitivity for the SEZ area is high in the southeastern portion of the SEZ and also near the border of JTNP. Sensitivity was identified as moderate elsewhere; that is, in the west central portion of the SEZ and the northeast portion between the McCoy and Maria Mountains.

VRI evaluations should be conducted only on sunny days with at least normal atmospheric clarity and at various times during the construction, operation, and decommissioning of solar facilities in the SEZ. See Section 8.1.3.7 for discussion of the schedule for monitoring efforts. Work conducted by Argonne for the BLM and the NPS documented the visibility, visual characteristics, and visual contrasts associated with utility-scale solar facilities (Sullivan 2011; Sullivan et al. 2012, Sullivan and Abplanalp 2013, 2015). These studies have shown that utility-scale solar facilities can sometimes be easily seen at distances as great as 35 mi or more and can cause substantial glare and other visual contrasts at long distances.

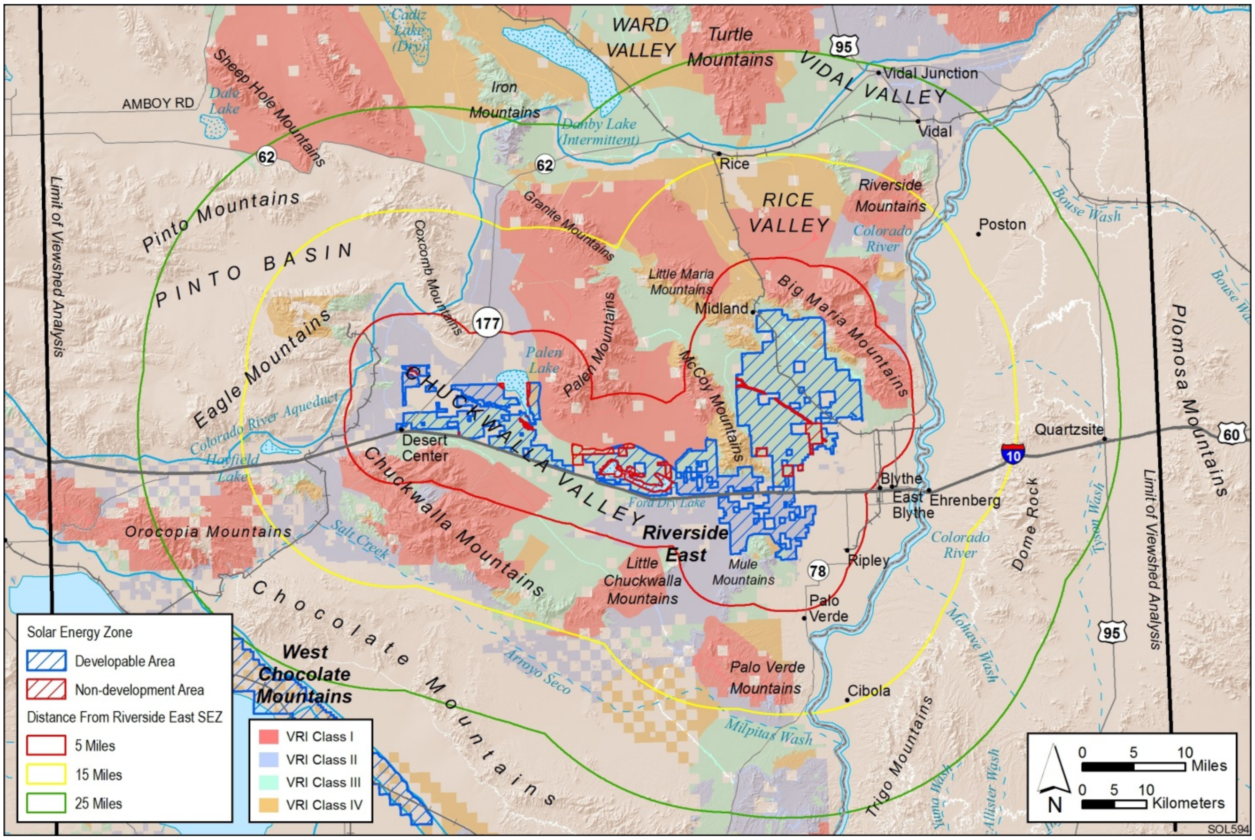

Figure 6-5 VRI Map for the Riverside East SEZ and Surrounding Lands

6.1.3.4 Existing Data Sources and New Indicator Data Collection Methods Recommended for the Riverside East SEZ LTMS

The BLM VRM policy does not specify a particular method for cumulative visual impact analysis; consequently, a new process is recommended that relies primarily on the BLM VRI for the SEZ and surrounding lands (Otak 2010). Monitoring the VRI factors and VRI class requires both field work and pre- and post-field work analysis and documentation. The spatial scale for data collection will be the SEZ.

New monitoring should be conducted as soon as possible after commencement of the Riverside East LTM project. Existing data sources that will serve as a baseline include the BLM September 2010 VRI, which was finalized in October 2011 (BLM and DOE 2011) (Figure 6-2). The first step is to determine whether solar development or other changes that have taken place since the 2010 VRI would justify any changes to the sensitivity level rating units (SLRUs) or scenic quality rating units (SQRUs). If this analysis indicates a new VRI evaluation is needed, the VRI assessments should be conducted at the IOPs used for the 2010 VRI (Figure 6-2). However, new IOPs may be established if the new solar facility or facilities are so far from existing IOPs that effects on scenic quality cannot be detected or assessed. One or more new IOPs may be needed for solar developments between Desert Center and Ford Dry Lake or the area between the Coxcomb and Palen Mountains. The field team would assess sensitivity levels and scenic quality using the same forms and procedures as for a normal VRI, as described in BLM VRI Handbook 8410-1 (BLM 1986).

As noted previously, VRI evaluations should be conducted only on sunny days with at least normal atmospheric clarity. Equipment needed for cumulative visual impact monitoring should include the following:

- A GPS-enabled, digital, single-lens-reflex camera with a tripod;
- Handheld computing devices to navigate to IOPs, determine distances and bearings, and record ancillary data, such as sun angle and elevation, weather, and lighting conditions; and
- Data collection forms and clipboards, including the BLM inventory form and a form for recording basic information about the field assessment, containing IOP identification number, recorder/evaluator names, date and time, IOP location (using GPS coordinates), and weather and lighting conditions.

Detailed notes describing changes to the scenic quality component scores should be made, so that the effects of solar development on scenic quality can be understood; this information is important to designing good mitigation. If it is necessary to develop new SLRUs or SQRUs over time, the new units should be developed prior to the assessment.

6.1.3.5 Data Analysis and Summary of Monitoring Strategy

With the 2010 inventory as a baseline, any changes over time to either the sensitivity or the scenic quality components, to the composite scores for the factors, or to the overall VRI class should be recorded and discussed in a report prepared for the assessment. The method for determining the VRI class from the VRI factor ratings is described in BLM VRI Handbook 8410-1(BLM 1986).

The proposed monitoring plan for VRI factors and Class is summarized in Table 6-6.

Table 6-6 Summary of Monitoring Indicators and Monitoring Plan Proposed to Monitor VRI Factors and Class

Indicator (s)	Method	Sampling Strata	Data Analysis
VRI factors and class	VRI class determined from the VRI factor ratings using BLM VRI handbook	The VRI assessments should be conducted at the IOPs used for the PEIS (BLM and DOE 2011). New IOPs may be established if the new solar facility or facilities are so far from existing IOPs that effects on scenic quality cannot be detected or assessed.	Using the 2011 inventory as a baseline, any changes over time to either the sensitivity or the scenic quality components, to the composite scores for the factors, or to the overall VRI class should be recorded and discussed in a report prepared for the assessment.

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6.2 Human Use Impact Indicators

6.2.1 Number of Requested and Issued Use Permits for the Midland LTVA

6.2.1.1 Rationale for Monitoring the Indicator

The Midland LTVA managed by the BLM provides long-term camping opportunities in the winter months and is located along Midland Road in the eastern portion of the SEZ (BLM 2015). Long-term permits are issued for the 7-month period from September 15 through April 15; short-term permits are issued for 2 weeks. The LTVA is located within the SEZ (near the eastern boundary; see Figure 6-6), and many of the visitors likely access areas within the SEZ while they are staying at the LTVA.

Two solar development projects have been authorized in the vicinity of the LTVA (Figure 6-6). Construction on the 750-MW McCoy Solar Energy project began in the spring of 2015; it consists of a 5,440-acre project area for a PV facility and is approximately 5 mi southwest of the LTVA at its nearest point. The 485-MW NextEra Blythe PV project has been approved and was in the compliance phase in late 2015; it is on 4,138 acres adjacent to the south border of the McCoy project.

There are several potential impacts on the LTVA that could result from solar energy development (Figure 6-7). For example, solar facilities in the eastern portion of the SEZ (east of the McCoy Mountains) and within view of the LTVA would likely detract from the remote desert experience of visitors because of their industrial appearance, large footprint, highly reflective surfaces, and lighting at night. The distance from which solar facilities can be seen depends on the type of facility. Because the LTVA is on the valley floor and the vertical angle of view of solar facilities would be low, PV facilities such as the McCoy and Blythe solar projects that will have low-height structures on the valley floor might not be visible from the LTVA. Parabolic trough facilities could be visible for much longer distances. Depending on the location within the eastern side of the SEZ, parabolic trough facilities could be screened by vegetation, topography, and earth curvature to the extent that they would be difficult to see. However, some of the structures would exceed the height of the scant vegetation in the area and the screening effect of earth curvature such that in most locations in the SEZ east of the McCoy Mountains they would be at least partially visible. The extremely focused reflected light from power tower receivers would be conspicuously bright at the LTVA regardless of the tower locations within the eastern side of the SEZ. The hazard navigation lighting on the receiver towers would also be visible. In addition, water vapor plumes (if present) from parabolic trough and power tower facilities would be visible anywhere within the SEZ where a clear line of sight existed. For all types of solar facilities substations, transmission towers, and transmission lines might be visible for several miles during the day, and lighting of the facilities and at substations would likely be visible for longer distances at night.

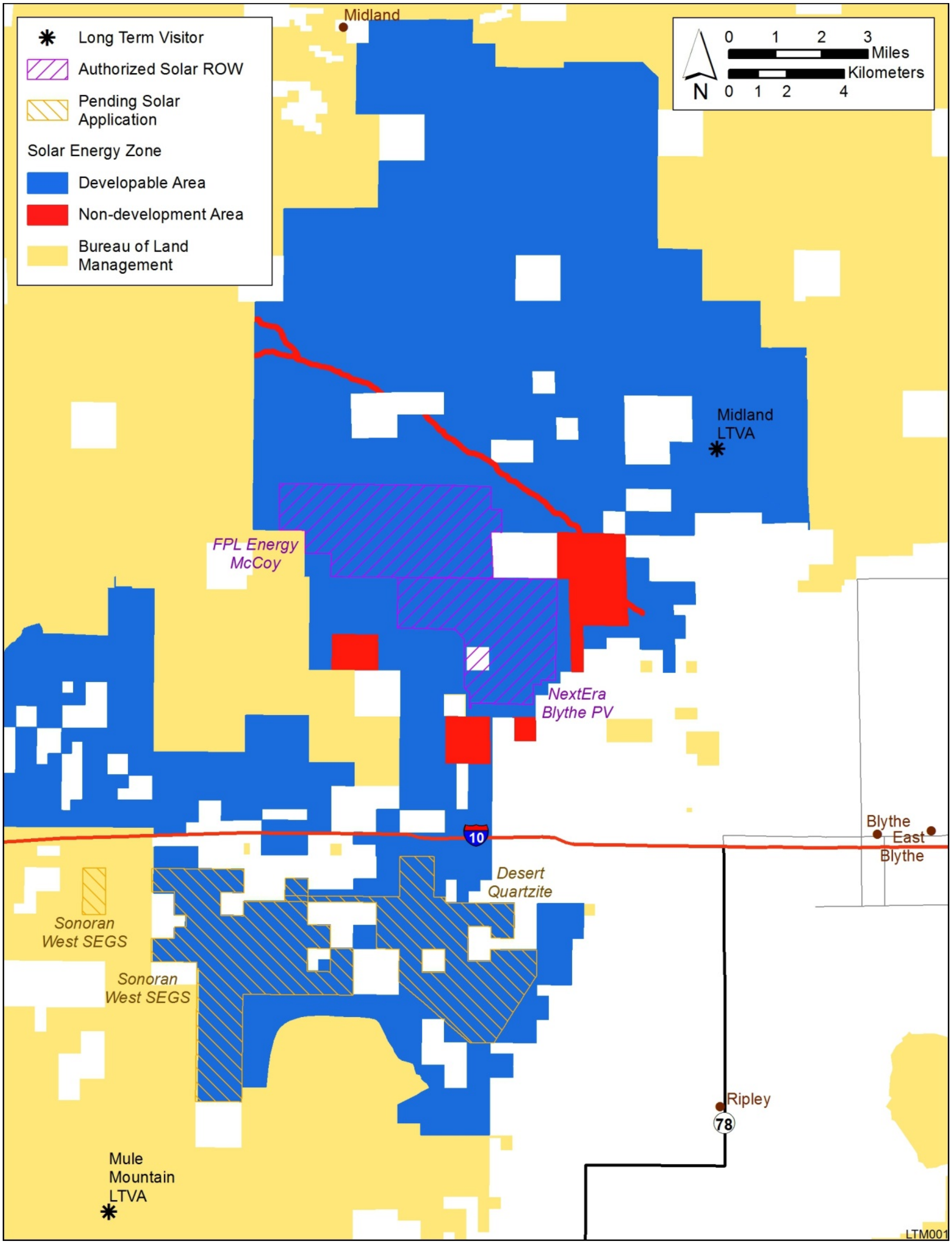

Figure 6-6 Location of the Midland LTVA within the Riverside East SEZ and the Mule Mountain LTVA Control Site

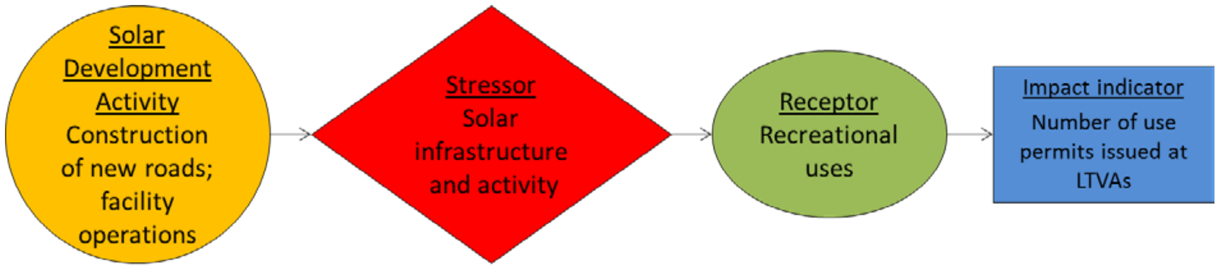

Figure 6-7 Conceptual Model Showing Solar Development Impact Indicators for LTVAs

Public interest in use of the Midland LTVA could be monitored to determine whether solar development in the SEZ affects recreational use of the area. Public interest could be monitored through tracking the number of LTVA use permits requested and issued by the BLM as an indicator of changes in public interest in or demand for LTVA use. It is hypothesized that impacts on LTVA recreational use would be larger from solar facilities that are close to and/or highly visible from the LTVA. An SEZ-specific design feature in the Solar PEIS ROD states that “a buffer area should be established between the Midland LTVA and solar development to preserve the setting of the LTVA. The size of the buffer should be determined based on the site and visitor-specific criteria” (BLM 2012). As of the beginning of 2015, the buffer area had not been established. However, after the buffer area is established, data from this human use impact indicator could be used to evaluate the effectiveness of the buffer area in mitigating impacts on the LTVA.

Relevant BLM policy documents with respect to recreation planning include the following:

- BLM Handbook H-1601-1, *Land Use Planning* , 2005, and Amendments
- California Desert Conservation Area Plan, 1999, and Amendments

6.2.1.2 Related Management Questions, Management Goals, and Monitoring Objectives Addressed by the Indicator

Monitoring the LTVA indicators will address the management questions, management goals and monitoring objectives in Table 6-7.

Table 6-7 Management Question, Management Goal, and Monitoring Objective Addressed by Monitoring the Number of Requested and Issued Use Permits for the Midland LTVA

Management Question
- Do site construction, operations, and increased site access and visitation negatively affect existing site uses, recreational value experience, or use?

Management Goal
- Manage lands adjacent to solar developments to improve conservation and balance other uses.

Monitoring Objective
- Detect temporal changes of management significance in the demand for and issuance of use permits in the LTVA.

6.2.1.3 Spatial and Temporal Considerations for Monitoring the Indicator

Monitoring should be restricted to the Midland LTVA (Figure 6-6) and its buffer. The primary temporal consideration in monitoring the LTVA is the seasonal nature of visitation. Permits are issued only for the period between September 15 and April 15 each year.

6.2.1.4 Existing Data Sources

The primary sources for establishing baseline and future data on LTVA permit requests and usage is the BLM Palm Springs/South Coast Field Office. Visitor use permits are issued by the BLM, and data on annual number of requested and issued permits can be obtained from the recreation planner (Schiffer-Burdett 2015). As reported in the Blythe project EIS, an average of 41 long-term permits were issued annually for the 2007–2008 and 2008–2009 seasons, corresponding to approximately 14,760 visitor-use days (assumes 2 visitors/permit and 180 days/long-term permit) (Hill 2015).

6.2.1.5 New Indicator Data Collection Recommended for the Riverside East LTMS

The sampling approach for this indicator is straightforward. Data for the previous season should be collected after April 15 and prior to September 15 annually. Major disturbances occurring within a 15-mi radius of the LTVA in the prior year should be recorded each year, including start of construction and beginning of operations of solar energy projects. A data request should be sent to the Recreation Planner each April. The request should be clear that data for the entire long-term visitor pass season (September 15 to April 15 of that year) are being requested. Items to request include the following:

Number of requests for long-term and short-term passes;

- Capacity of the LTVA (maximum number of permits that would be issued);
- Number of long-term passes issued;

- Number of short-term (2-week) passes issued;
- Number of visits (if available), including calculation method;
- Number of visitor days (if available), including calculation method;
- Additional notes (e.g., complaints received, major disturbance events within 15-mi radius of the LTVA).

Similar data should also be collected for a control site where no major disturbance from solar development or other activities is expected. The Mule Mountains LTVA can be used as a control site. The LTVA encompasses 3,424 acres and is located on Wiley's Well Road, 9 miles south of I-10 on a washboard road (see Figure 6-6). The Mule Mountains LTVA includes Coon Hollow Campground (BLM 2011a) and Wiley's Well Campground (BLM 2011b). Because the LTVA is also located in the Palms Springs/South Coast Field Office, data for this LTVA can be obtained from the same source as for the Midland LTVA.

6.2.1.6 Data Analysis and Summary of Monitoring Strategy

Data on the number of permits requested and issued will be evaluated for the Midland LTVA and the reference site before and after solar development activities. Relative changes in permit requests and visitation at the two areas over time will be analyzed by using a BACI statistical framework to determine whether any changes are related to solar development. If a change of 15% or greater in Midland LTVA permit requests and/or permit issuances relative to Mule Mountains LTVA is indicated following solar development, additional data on development in the area should be collected to determine whether the decrease in LTVA permit requests or permit issuances is correlated with solar development in the SEZ or there are other causes for the change. If the decrease is correlated with solar development in the SEZ, additional mitigation measures to address impacts on recreation in the area may be warranted.

However, the LTVA use indicator may not answer the question completely; if a decrease in requests for or issuances of LTVA permits is observed after solar development occurs, it may also be appropriate to conduct surveys of current and past visitors to determine whether decreased use is due to solar development. To do this type of follow-on research, it is assumed that visitors provide contact information (e.g., name and address or email address) when requesting long-term and short-term permits and thus could be contacted through a survey.

The proposed monitoring plan for LTVA use is summarized in Table 6-8.

Table 6-8 Summary and Prioritization of Monitoring Indicators Used for the Riverside East SEZ

Indicator (s)	Method	Sampling Strata	Point Sampling versus RM	Data Analysis
Number of requested and issued use permits for the LTVA	Midland LTVA data for the previous season should be collected after April 15 and prior to September 15 annually; data currently collected by BLM.	Data should be collected for Midland LTVA; the Mule Mountains LTVA can be used as a control site.	NA	Visitation data and permits issued will be calculated for the Midland LTVA and the reference site before and after solar development activities. Relative changes in permits and visitation at the two areas over time will be analyzed using a BACI statistical framework to determine whether any changes are related to solar development.

6.2.1.7 Literature Cited

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6.2.2 Traffic Amount and Distribution

6.2.2.1 Rationale for Monitoring the Indicator

Traffic on roads within and near the SEZ should be monitored to determine whether solar facility development leads to increased traffic amount and distribution, resulting in degradation of level of service on roads around the SEZ.

The largest road near the Riverside East SEZ is I-10, a six-lane east-west freeway running along the southern edge and then through the SEZ, as shown in Figure 6-9. The City of Blythe is situated at the eastern border of the SEZ. To the west, I-10 passes through Indio, about 47 mi (76 km) from the western edge of the SEZ. There are a number of exits from I-10 as it passes by and through the SEZ; they are listed in Table 6-9.

Other paved roads that cross parts of the Riverside East SEZ include State Route 177 and Midland Road. State Route 177 runs north–south through the western section of the SEZ between I-10 and State Route 62. In the eastern section of the SEZ, Midland Road crosses the northeastern portion from Blythe to the ghost town of Midland, which is situated at the northern edge of the eastern section of the SEZ. Other major local roads are U.S. 95, which runs north–south through Blythe and passes within 2 to 4 mi (3 to 6 km) of the eastern edge of the SEZ, and State Route 62, which run east-west about 14 mi (22.5 km) north of the northernmost point of the SEZ.

Increased traffic due to solar development in the SEZ may lead to decreased level of service on local roads and on I-10 (Figure 6-8). These impacts would be particularly likely during construction activities. Large solar energy projects may necessitate 2,000 or more additional vehicle trips per day near the SEZ, assuming ride-sharing was not implemented and all access to the SEZ was funneled through I-10 (i.e., no workers commuted to work via State Route 177 from State Route 62 to the north or via local roads from U.S. 95 to the east) (BLM and DOE 2010). Because the Riverside East SEZ has such a large area, more than one project could be under construction at the same time. If all construction workers used I-10, traffic volume on that road both in terms of annual average daily traffic (AADT) and peak hour volume could increase 10 to 25%, leading to moderate increased congestion (BLM and DOE 2010). If other roads like State Route 177 were also used by construction workers, traffic impacts might be greater because those roads are smaller, have much lower existing traffic levels, and are not equipped with freeway-type exits to allow speed to be maintained at turn-off locations.

To assess the potential impacts of solar energy development, traffic on roads within and near the SEZ would be monitored to determine whether solar facility development leads to increased traffic amount and distribution, resulting in degradation of level of service on roads around the SEZ. Traffic levels on the main roads around the SEZ should be monitored to identify and address significant increased traffic levels on those roadways resulting from solar development in the SEZ. County government agencies with jurisdiction over local roads and traffic management would be involved in planning to mitigate adverse traffic effects from solar development (County of Riverside 2015).

Table 6-9 Freeway Exits in the Vicinity of the Riverside East SEZ

Road Name	Exit Number/ Mile Marker
Desert Center Rice Road (State Route 177)	192
Corn Springs Road	201
Paled Dunes Drive and Chuckwalla Valley Road	217
Wiley's Well Road	222
Mesa Drive (at Blythe Airport)	232
Neighbours Boulevard (State Route 78) (western side of Blythe)	238

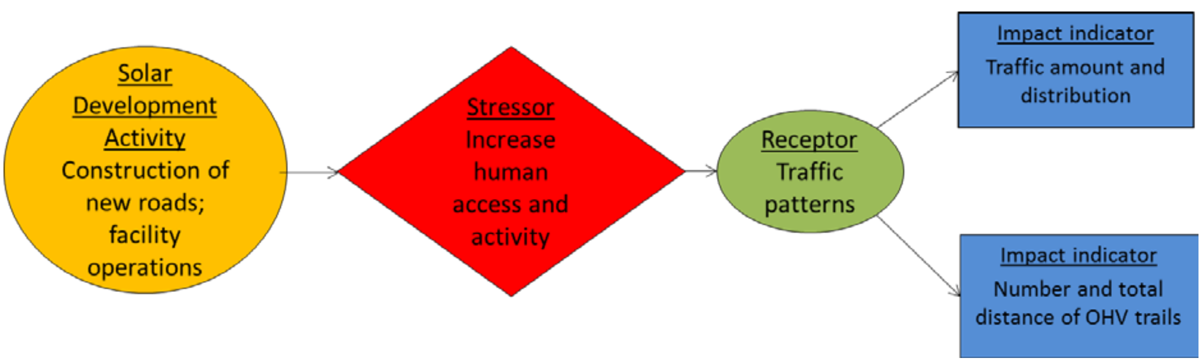

Figure 6-8 Conceptual Model Illustrating Potential Impacts on Traffic Patterns Resulting from Solar Development Activities and the Impact Indicators used for the Riverside East SEZ LTMS

No BLM policy relevant to traffic impact analysis is available. The BLM would follow relevant guidance from the Transportation Research Board (Ryus et al. 2010) and the California Department of Transportation (Caltrans 2002).

6.2.2.2 Related Management Questions, Management Goals, and Monitoring Objectives Addressed by the Indicator

Monitoring traffic within the SEZ will address the management question, management goals, and objective in Table 6-10.

Table 6-10 Management Question, Management Goals, and Monitoring Objective Addressed by Monitoring Traffic Amount and Distribution

Management Question
- Do site construction, operations, and increased site access and/or visitation negatively affect transportation

Management Goals
- Manage traffic associated with a solar facilities to maintain a high level of service on roads near the SEZ
- Protect cultural resources from increased visitation and accesses
- Maintain baseline recreational opportunities and uses, and quality of experiences

Monitoring Objective
- Detect temporal changes of management significance in traffic within and near the SEZ

6.2.2.3 Spatial and Temporal Considerations for Monitoring the Indicator

Major disturbances and new development occurring within an approximate 50-mi (80-km) radius of the SEZ in the prior year should be recorded, particularly the start of construction and the beginning of operations of solar energy projects. For solar projects, mitigation measures implemented to limit transportation impacts (e.g., shuttle programs for workers) should also be noted and monitored for effectiveness.

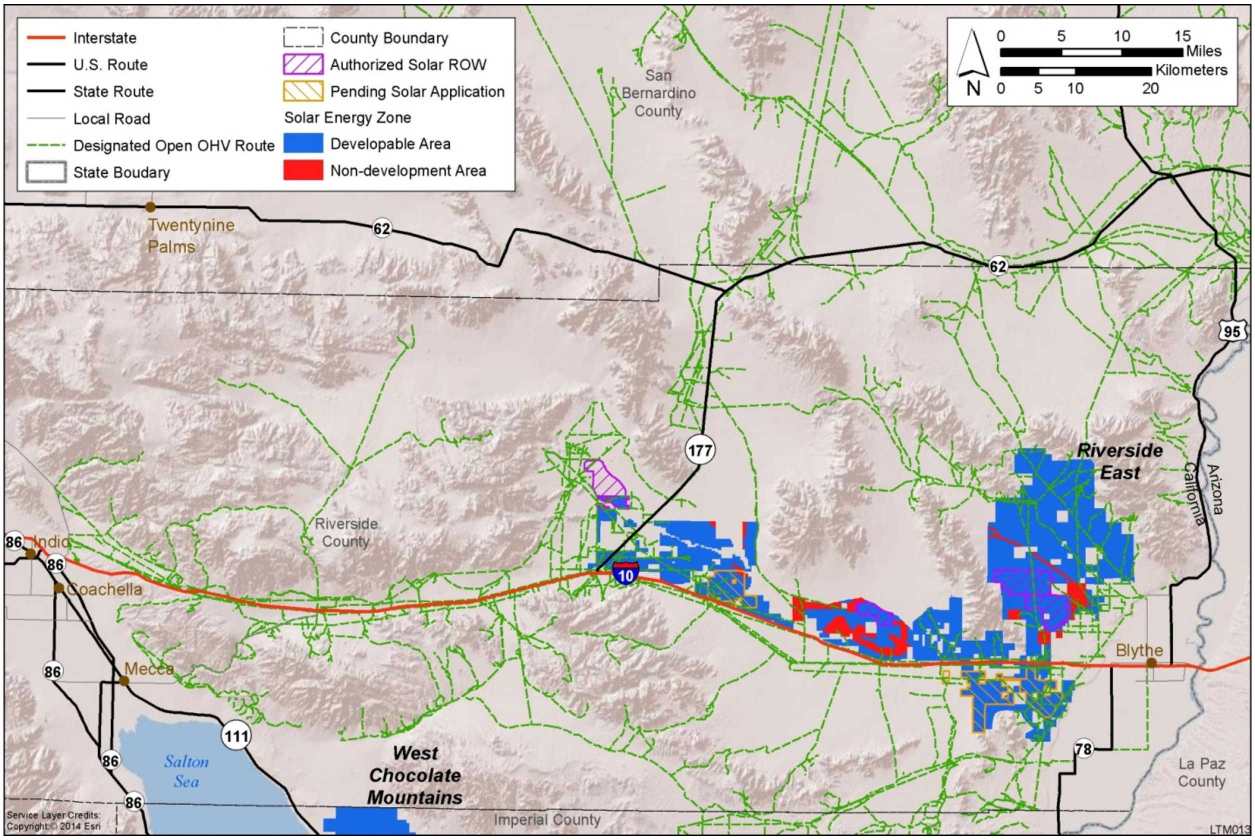

Figure 6-9 Locations of Major Roads and Open OHV Routes in the Vicinity of the Riverside East SEZ

6.2.2.4 Existing Data Sources and New Indicator Data Collection Recommended for the Riverside East SEZ LTMS

The main data source for monitoring traffic amount and distribution is traffic counts along roads passing through and near to the SEZ; these data are routinely collected by the California Department of Transportation (Caltrans 2015; note that this source does not provide data for Midland Road). Table 6-11 provides AADT[2] data for 2008, 2012, and 2013, as well as peak hour traffic data for 2013 for key intersections along I-10 and other major roads through and near the SEZ (2008 is included for comparison

[2] As defined in Caltrans 2015, "annual average daily traffic (AADT) is the total volume for the year divided by 365 days." The traffic count year is from October 1 through September 30. Very few locations in California are actually counted continuously. Traffic Counting is generally performed by electronic counting instruments moved from location to location throughout the state in a program of continuous traffic count sampling. The resulting counts are adjusted to an estimate of AADT by compensating for seasonal influence, weekly variation, and other variables that may be present. AADT is necessary for presenting a statewide picture of traffic flow, evaluating traffic trends, computing accident rates, planning and designing highways, and other purposes.

with data provided in the Solar PEIS [BLM and DOE 2010]). In addition, peak hour data for each intersection (i.e., distribution information) are provided.

As shown in Table 6-11, AADT on I-10 was very similar in 2012 and 2013. Along I-10 and State Route 177, AADT did not change very much between 2008 and 2013. However, AADT decreased 20–40% on State Route 62 and U.S. 95. In 2013, peak hour traffic ranged from 9 to 27% percent of AADT on these roads. These data form a baseline against which future traffic amount and distribution can be assessed.

AADT data for major roads near the SEZ (Table 6-11) should be collected on an annual basis. As long as the data are collected and analyzed annually, the time of year of data collection is not important, so it can be planned to coincide with other data collection activities. Data that should be collected include AADT and peak hour traffic for intersections of major roads near the SEZ (i.e., I-10; State Routes 62, 78, and 177; and U.S. 95).

In addition to traffic amount and distribution based on highway data, OHV traffic within the SEZ could be monitored (see Figure 6-9 for OHV route locations in the SEZ). In this case the purpose of the monitoring would be to identify impacts of development on recreational OHV use in the area, and data would be used to determine whether OHV use decreased due to development (a separate management question). The BLM Palm Springs Field Office monitors and maintains OHV routes in the area (BLM 2014). BLM guidance on management of OHV trails is available at http://www.blm.gov/wo/st/en/prog/Recreation/recreation_national/travel_management/travel_mgt_guidance.html.

Currently there are no traffic counters on the OHV routes in the SEZ. Solar development in the SEZ would very likely result in loss of some OHV routes, because they are present throughout the SEZ (see Figure 6-9). One design feature in the Solar PEIS ROD states that consideration should be given to "replacement of acreage lost for identified recreational opportunities, such as off-highway vehicle use" (BLM 2012). Rather than taking on the expense of setting up traffic counters for OHVs within the SEZ and analyzing the data annually, it is recommended that potential impacts on OHV routes in the SEZ be addressed through project-specific assessment and mitigation where appropriate.

Table 6-11 AADT Data for Major Roads near the Riverside East SEZ

Road	General Direction	Location	AADT 2008	AADT 2012	AADT 2013	% AADT Change between 2013 and 2008	Peak Hour Traffic 2013
I-10??	East–West	West of junction State Route 62 North	81,000	79,000	80,000	−1	7,800
		East of junction State Route 62 North	79,000	77,000	78,000	−1	7,000
		West of junction State Route 86 South	52,000	51,000	52,000	0	4,850
		East of junction State Route 86 South	25,000	24,000	25,000	0	2,350
		West of Chiriaco Summit Interchange	22,500	22,000	23,000	2	2,900
		West of junction State Route 177 North	23,000	22,500	23,500	2	2,950
		East of junction State Route 177 North	21,400	21,000	22,000	3	2,750
		Corn Springs Road Interchange	21,400	21,000	22,000	3	2,750
		West of Wiley’s Well Road	21,300	21,000	22,000	3	2,750
		East of Wiley’s Well Road	23,500	22,500	23,500	0	2,750
		East of Mesa Drive	22,500	22,000	23,000	2	2,950
		East of junction State Route 78 South	23,800	23,800	25,000	5	3,100
		West of junction U.S. 95 North	25,000	24,000	25,000	0	3,100
		East of junction U.S. 95 North	25,500	25,000	26,000	2	2,600
State Route 62	East–West	Junction State Route 177	2,200	1,400	1,400	−36	380
		Cadiz Road	2,000	1,400	1,400	−30	380
		Blythe Rice Road	2,000	1,400	1,400	−30	380
		Junction U.S. 95	2,700	2,300	2,300	−15	440
State Route 78	North–South	Junction I-10	2,900	2,900	2,800	−3	390
		South of 28th Avenue	1,800	2,000	1,900	6	180
		Fourth Street (Palo Verde)	2,650	1,600	1,500	−43	210
State Route 177	North–South	Junction I-10	3,700	3,700	3,700	0	480
		Junction State Route 62	1,300	1,200	1,200	−8	200
U.S. 95	North–South	Junction State Route 62	3,000	2,300	2,400	−20	330
		South of Riverside/San Bernardino Co. Line	1,900	1,450	1,450	−24	210
		North of Sixth Avenue (Blythe)	2,400	2,000	2,000	−17	220
		North of Hobson Way (Blythe)	3,500	3,000	2,850	−19	290

Source: Caltrans (2013). AADT = annual average daily traffic

6.2.2.5 Data Analysis and Summary of Monitoring Strategy

The *Highway Capacity Manual* (Ryus et al. 2010) is the primary guidance for calculating level of service for freeways and multilane rural highways. Methods for assessing traffic impacts and guidance on the assessment of traffic impacts due to land development are discussed in Caltrans (2002), ITE (2006) and Stover and Koepke (2002). Data analysis should include

- Percentage change from previous year
- Percentage change from baseline year (2013).

If an increase from either the previous year or the baseline year is observed, either for AADT or for peak hour traffic, additional data on development in the area should be collected to determine whether the increase in traffic amount and/or distribution is related to solar development in the SEZ or to other causes. If the increase is related to solar development in the SEZ, work with the County of Riverside Transportation Department (2015) should be initiated to determine whether the increased volume has resulted in decreased level of service for affected highway segments. If the answer is yes, additional mitigation measures to address traffic congestion may be warranted. Note that larger traffic impacts would likely be temporary because solar facility construction is a temporary activity. Mitigations should take into account whether the traffic impacts are temporary or more long term (i.e., associated with operations). The proposed monitoring plan for traffic patterns.is summarized in Table 6-12.

Table 6-12 Summary and Prioritization of Monitoring Indicators Used to Monitor Traffic Patterns for the Riverside East SEZ LTMS

Indicator (s)	Method	Sampling Strata	Point Sampling versus RM	Data Analysis
Traffic amount and distribution	Traffic counts by the California Department of Transportation; OHV traffic within the SEZ currently collected by the Palm Springs Field Office.	Key intersections along I-10 and other major roads through and near the SEZ	NA	Calculate percentage change from previous year and percentage change from baseline year (2013) using methods in Caltrans (2002), ITE (2006), Stover and Koepke (2002), and the *Highway Capacity Manual* (Ryus et al. 2010).

6.2.2.6 Literature Cited

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6.3 Cultural and Paleontological Indicators

The BLM is required to consider the short- and long-term management of cultural and paleontological resources under a number of federal laws, executive orders, and internal policies. For each approved solar and wind energy development ROW authorization, BLM Instruction Memorandum (IM) 2014-112 requires the preparation of an Environmental and Compliance Monitoring Plan (ECMP), which includes cultural and paleontological resources. Under this IM, "compliance monitors will remain on the project site(s) during all phases of the project at schedules approved by the BLM and coordinated with the [ROW] holder." This includes the construction, operation and maintenance, and decommissioning phases of each facility. The BLM may adjust the compliance monitor schedule as conditions demand. For both and cultural and paleontological resources, monitoring is typically focused on sites in areas where ground disturbance will occur during construction and decommissioning of a facility. Monitors in this role attempt to avoid damage to cultural and paleontological resources that have already been identified through a review of existing data, including results of project-specific inventories and impact assessments, but they are also to be on the lookout for undiscovered subsurface deposits unearthed during excavation activities and/or for resources that may not have been identified during the inventory. Rarely has monitoring occurred during the operational phase of a facility unless additional ground-disturbing activities are planned.

During the development of the Solar PEIS (BLM and DOE 2012), the BLM recognized the need to develop and implement monitoring and adaptive management strategies to continually improve its land management decisions. While a project-specific compliance monitoring program concentrates on ground-disturbing activities protects and/or mitigates short-term and local impacts on cultural and paleontological resources, it does not typically consider the effectiveness of mitigation efforts, nor does it take into consideration the potential direct and indirect effects on paleontological and cultural resources and areas of Native American concern within or outside of the study area that could occur as a result of solar facility operation. To effectively manage, maintain, and protect the condition and integrity of cultural and paleontological resources, a long-term monitoring plan is needed that (1) verifies whether the impacts identified in the Solar PEIS are occurring; (2) evaluates the efficacy of established mitigation measures and best management practices (i.e., design features) for protecting paleontological resources, cultural resources, and areas of Native American concern; (3) identifies anticipated adverse impacts of solar development; and (4) detects whether changes in resource conditions and trends at a landscape or ecoregional level are occurring.

To meet these needs, the Riverside East SEZ LTMS should monitor the following resource indicators: (1) number of reported impacts on cultural resources and in areas of Native American concern (Section 6.3.1) and (2) number of reported impacts on paleontological resources (Section 6.3.2). Reported impacts will primarily be based on monitoring by volunteer site stewards.

6.3.1 Number of Reported Impacts on Cultural Resources and Areas of Native American Concern

6.3.1.1 Rationale for Monitoring the Indicator

Cultural resources are defined by the BLM as the fragile, nonrenewable remains of human activity, occupation, or endeavor. These resources consist of (1) physical remains, (2) areas where significant human events occur or have occurred even though evidence of the events is not readily apparent to the untrained eye or the event no longer occurs, and (3) the environment immediately surrounding the resource (BLM 1994). Cultural resources have potential public and scientific uses and represent an important part of the nation's heritage (BLM 2004).

Archaeological resources contain nonrenewable, tangible evidence of past and current lifeways. Archaeological data are collected through systematic recovery of artifacts within their proper context, and when artifacts are moved, damaged, or taken from the site, original context is lost. Looting, vandalism, destruction, and damage (whether intentional or unintentional) of an archaeological resource diminish the integrity of the site.

Cultural landscapes, traditional use areas, and sacred sites often overlap with archaeological sites and other areas of Native American concern, and these resources are part of a larger setting for tribal histories and spiritual narratives important to contemporary lifeways. Long-term tribal monitoring programs in the Grand Canyon have shown that damage, such as vandalism, trailing, trampling, littering, removal of vegetation, removal of artifacts, and disturbance, to archaeological sites, cultural landscapes and other areas of Native American concern can affect the significance of and feelings associated with these areas and deter further use of some sacred spaces (Yeatts and Huisinga 2013; Jackson-Kelly et al. 2013; Bulletts et al. 2012; Bullets et al. 2008; Dongoske 2011). The operation of solar facilities within the Riverside East SEZ may be seen as visually incompatible or inconsistent with the natural and traditional character of the surrounding landscape by both Native Americans and members of the general public.

The Riverside East SEZ is rich in cultural resources and areas of Native American concern. Resources include, but are not limited to, historic properties, archaeological sites, trails, cultural landscapes, traditional use areas, and sacred sites. Significant historic and archaeological properties within the study area and surrounding environs include petroglyph panels; archaeological sites related to the Kaiser Mine; and portions the Desert Training Center/California–Arizona Maneuver Area (DTC/C-AMA), which contains scattered resources related to General Patton's World War II training area. Native American tribes are particularly concerned with potential impacts on the larger landscape of the Big Maria, Coxcomb, and Eagle Mountains; the Salt Song, Cocomaricopa, and Xam Kwatchan Trails, portions of which fall in the Riverside East SEZ; and other important landscape features within the study area. Impacts on these resources affect the value and integrity of the cultural landscape.

Landscape modification for solar energy development can increase natural stressors, such as wind and water erosion, bioturbation, or fire, or human impacts, such as new ROWs, vandalism, theft, damage, destruction (Figure 6-10). The following stressor–receptor interactions have been identified for the Riverside East study area:

- Solar facilities in previously remote areas may require new access corridors associated with the facility or transmission lines. Established trails tend to pique the interest of recreationists for further exploration. Whether by foot or OHV, these routes can be expected to be explored, and sites of interest along these routes would be placed at risk for intentional or unintentional damage, such as pedestrian trampling and OHV damage, looting (collecting artifacts, plants), and vandalism (defacement, graffiti, littering, destruction).
- Construction of solar facilities may disrupt ephemeral wash and intermittent stream patterns or disrupt geomorphic features by altering wind and water sediment transport processes and drainage patterns (erosion). This could affect alluvial fans, sand dunes, and channel networks and, in turn, have a negative effect on cultural resources, such as archaeological sites, trails, and traditional use areas.
- Solar development within the Riverside East SEZ may be seen as visually incompatible or inconsistent with the natural and rural character of the surrounding landscape.
- The construction and operation of solar facilities could result in the loss of culturally important plants or the loss of habitat for culturally important wildlife species, and/or affect the availability and quality of groundwater, all of which (i.e., ecosystem and landscape health) are indicative of traditional lifeways of Native Americans.

Impacts on cultural resources can diminish the information potential of the resource as well as the integrity of feeling, association, materials, and setting, all of which are used to evaluate an archaeological site or historic property eligibility for the National Register of Historic Places (NRHP). Impacts can also diminish the spiritual and emotional value of a resource. For example, Native Americans may experience a reduction in the number of plants gathered for medicinal and ceremonial purposes if the vegetation has been compromised by development, or they may experience a loss in significance and value of a shrine site if it has been damaged by visitors or natural effects, such as erosion, and they may be deterred from further use of the site.

By monitoring reported changes in resource condition as a result of weathering and erosion; detecting increased vehicular or pedestrian traffic as a result of new roads constructed for the facility, ROWs, or firebreaks; and consulting with Native Americans about potential changes in their experience, the BLM will better be able to adaptively manage cultural resources within its jurisdiction and apply those findings to other SEZs.

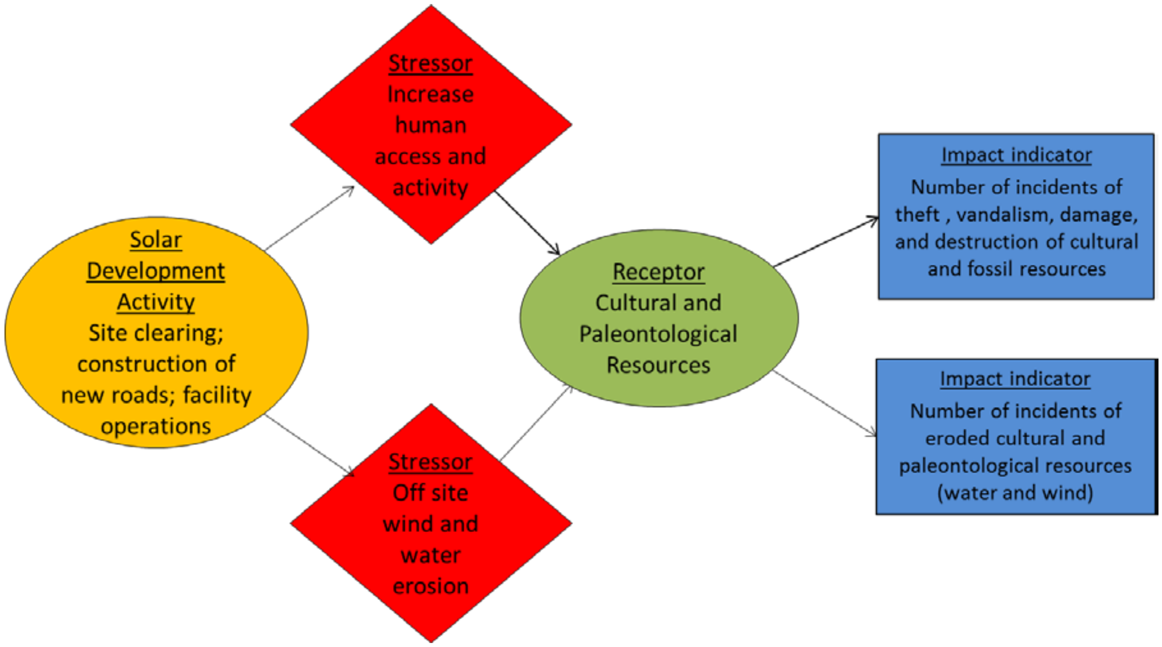

Figure 6-10 Conceptual Model Illustrating Potential Impacts on Cultural and Paleontological Resources Resulting from Solar Development Activities and the Impact Indicator Used for the Riverside East SEZ LTMS

The BLM is required to consider the short- and long-term management of cultural resources under the following federal policies:

- Section 106 and 110 of the National Historic Preservation Act of 1966 (as amended) [P.L. 89-665; 80 Stat. 915; 54 U.S.C. 300101 et seq.]
- National Environmental Policy Act of 1969 (P.L. 91-190; 83 Stat. 852; 42 U.S.C. 4321)
- Executive Order 11593, *Protection and Enhancement of the Cultural Environment* [36F.R. 8921, May 13, 1971]
- Federal Land Policy and Management Act of 1976 [P.L. 94-579; 90 Stat. 2743; 43 U.S.C.1701]
- Archaeological Resources Protection Act of 1979 (P.L. 96-95; 93 Stat. 721; 16 U.S.C. 470aa et seq.)
- National Trails System Act of 1968 (P.L. 90-543; 16 U.S.C. 1241 et. seq. as amended through P.L. 107-325, December 4, 2002)

- American Indian Religious Freedom Act of 1978 (P.L. 95-431; 92 Stat. 469; 42 U.S.C.1996)
- American Indian Graves Protection and Repatriation Act of 1990 (P.L. 101-601; 104 Stat. 3048; 25 U.S.C. 3001)
- Executive Order 13007, *Indian Sacred Sites* [61 F.R. 104, May 24, 1996)
- Executive Order 13287, *Preserve America* [68 F.R. 43, March 5, 2003]
- Department of the Interior Secretary's Order 3310, *Protecting Wilderness Characteristics on Lands Managed by the Bureau of Land Management* [December 22, 2010]
- Department of the Interior Secretary's Order 3323, *Establishment of the America's Great Outdoors Program* [September 12, 2012]

BLM policies for preserving, protecting, and maintaining ecological resources are laid out in the following documents:

- BLM Manual 8100, *The Foundation for Managing Cultural Resources*
- BLM Manual 8110, *Identification and Evaluation of Cultural Resources*
- BLM Manual 8120, *Tribal Consultation Under Cultural Resource Authorities*
- BLM Manual 8130, *Planning for Uses of Cultural Resources*
- IM-2012-067, *Clarification of Cultural Resource Considerations for Off-Highway Vehicle Designations and Travel Management*
- IM-2014-112, *Policy for Solar and Wind Energy Inspection and Enforcement*
- *Programmatic Agreement Among The United States Department Of Interior, Bureau Of Land Management, The Arizona State Historic Preservation Officer, The California State Historic Preservation Officer, The Colorado State Historic Preservation Officer, The New Mexico State Historic Preservation Officer, The Nevada State Historic Preservation Officer, The Utah State Historic Preservation Officer, And The Advisory Council On Historic Preservation Regarding Solar Energy Development On Lands Administered By The Bureau Of Land Management*
- *State Protocol Agreement Among the California State Director of the Bureau of Land Management and the California State Historic Preservation Officer and the Nevada State Historic Preservation Officer Regarding The Manner In Which The Bureau of Land Management Will Meet Its Responsibilities Under The National Historic Preservation Act and the National Programmatic Agreement Among the BLM, The Advisory Council on Historic Preservation, and the National Conference of State Historic Preservation Officers*

6.3.1.2 Related Management Questions, Management Goals, and Monitoring Objectives addressed by the Indicator

The indicator number of reported incidents of impacts on cultural resources and areas of Native American concern will address the management questions and goals and monitoring objectives in Table 6-13.

Table 6-13 Management Questions, Management Goals, and Monitoring Objectives Addressed by Monitoring the Number of Reported Incidents of Impacts on Cultural Resources and Areas of Native American Concern

Management Questions

- How is solar development affecting the contextual integrity of cultural resources?
- Do site operations change existing site uses, user experiences, and cultural values?
- Does facility construction increase site access and visitation in a way that negatively affects existing resources and uses?

Management Goals

- Protect cultural resources from solar-related impacts from wind and water erosion.
- Maintain integrity of cultural resources.
- Minimize erosion to sacred areas and trails.
- Minimize increased access and associated impacts (e.g., vandalism, theft, trampling).

Monitoring Objectives

- Detect temporal changes in the contextual integrity of cultural resources within the SEZ and surrounding area relative to control areas.
- Detect temporal changes in the cultural user and Native American experience.

6.3.1.3 Spatial and Temporal Considerations for Monitoring the Indicator

Monitoring should be conducted as soon as possible before additional new solar energy facilities are constructed or become operational. The study area for this indicator includes the entire East Riverside SEZ. Control sites and some portions of archaeological resources and areas of Native America concern will fall outside of the immediate study area. Potential seasonal constraints to site monitoring include major weather or environmental events, such as extreme heat, flash flooding, and fire.

6.3.1.4 Existing Data Sources

Cultural resource inventories and impact assessments have already been completed for a number of facilities within the Riverside East SEZ (BLM 2010, 2011, 2014a,b; BLM and DOE 2012). For each project that proposes ground disturbance, a cultural resources inventory and impact assessment is conducted within the area of potential effect (APE) of that designated project as part of the applicant's responsibilities under NEPA and Section 106 of the National Historic Preservation Act (NHPA). The inventory focuses on reviewing verifying, and updating existing data; identifying new sites; and developing recommendations to prevent or mitigate adverse impacts on cultural resources within the APE (BLM Handbook 8110-1 [BLM 2003]).

Often, staff limitations and funding constraints limit the availability of cultural resource managers and professionals to actively, continually monitor cultural resources at a landscape level. Many managers therefore rely heavily on site stewards and members of the general public to report damage to individual sites (Kelly 2007). The California BLM uses site stewards trained through the California Archaeology Site Steward Program (CASSP) for long-term monitoring of cultural resources within the Riverside East SEZ. Individuals enrolled in CASSP pay for their own training, which is offered by the Society for California Archaeology for the BLM and other federal and state agencies. Site stewards either are assigned specific sites to monitor regularly based on their location and interests or can contact the local BLM office when they are planning recreation activities and are assigned sites to monitor based on the locations they plan to visit.

Site stewards are currently supplied with monitoring forms that contain both general fill-in-the-blank prompts and check boxes to encourage site stewards to customize their reporting to the specific site. Site stewards monitor vehicles in the area and examine the site for footprints, tire tracks, animal tracks, trash, spent ammunition, targets, fire pits/rings, evidence of camping, and any ground-disturbing activities. Occasionally, BLM staff provides site stewards with previous site records so that they can compare what they see on the ground with what was originally recorded. Efforts are also under way to train some site stewards on how to update site records because many records are outdated, having been recorded prior to the conventional use of GPS and the current site recordation standards of State of California Department of Parks and Recreation. The BLM also relies on incident reports from law enforcement officers, tribal representatives, and members of the general public who may have an interest in cultural resource preservation. Law enforcement officers, tribal representatives, and the general public do not usually have the proper monitoring forms when impacts are noticed. When one of these individuals reports an incident, BLM staff works with the individual to gain as much information as possible on the impact on and resulting condition of the site. When an impact is reported, BLM staff records the information in its NRCS database. If immediate measures are needed to protect, restore, or mitigate future damage, steps are taken accordingly.

6.3.1.5 New Indicator Data Collection Recommended for the Riverside East SEZ LTMS

The Riverside East SEZ LTMS should incorporate existing cultural resource monitoring at the Riverside East SEZ, which is described in Section 6.3.1. The Riverside East SEZ LTMS should continue to use a site steward program for monitoring cultural resource sites and recording incidents of reported damage because it is considerably cost-effective, and by using trained volunteer labor, the program also relieves pressure on cultural resources staff limited in the amount of field work that they can conduct because of other responsibilities.

Archaeological site steward programs at the state and federal level vary in terms of types of resource monitored, individuals performing the monitoring, and collaboration between state and federal agencies and volunteers, but all have had success in assessing the long-term impacts on archaeological sites and historic properties as well as mitigating future damage. Typically these programs concentrate on the evaluation and protection of archaeological sites and historic properties where physical impacts can be assessed. Traditional use areas, sacred sites, and cultural landscapes should also be included in training and monitoring efforts by site stewards. Site steward programs are well established throughout the United States (Milner et al. 2006) and are an efficient, cost-effective way to monitor archaeological sites or historic properties and deter looting and vandalism in the long term (Kelly 2007).

6.3.1.5.1 Control and Impact Site Selection

In the monitoring of cultural resources, it is important to take into consideration the tangible and intangible aspects of the resource. Important considerations for cultural resource monitoring locations include the potential for erosion of the site, types of human activities that occur in the area (i.e., hiking, OHV use), the visual and/or acoustic setting, the distance of a resource from a populated place, the function of a resource, and its association with a group of people. Potential impact-monitoring locations could include archaeological sites that are NRHP-listed (or California Register of Historic Places-listed) or eligible, sites that are highly threatened by a particular impact such as erosion, sites that are highly visible from a road or frequently used trails, and sites with the potential to yield the most data (Versar, Inc. 2011; Hargrave 2009). Potential sample areas of Native American concern include important trail systems, sacred sites and traditional use areas, as determined through consultation.

Sites may be affected by more than one potential impact and more than one stressor–receptor interaction may be monitored at one time. In order to better understand the types of impacts affecting different site types, a sample selection of each site type with similar resources attributes should be selected. Sample selection and size will be dependent on staff and volunteer resources available. Areas of Native American concern selected for monitoring should be chosen in cooperation with tribal representatives during project-specific consultation.

Some impacts, such as the erosion of a cultural resource site, are more likely to occur near the project footprint. Consequently, these physical impacts are likely to be effectively detected by site stewards monitoring within the 2-mi (3 km) impact buffer (Section 2.3.2). However, areas outside of the 2-mi (3-km) buffer may be monitored for certain impacts such as increased human access or if particular areas outside the buffer are suggested for monitoring during tribal consultation. In addition, the impact monitoring area can be expanded if preliminary monitoring data suggests a larger survey area is needed to detect impacts on cultural resources.

Control sites for cultural resources would be monitored in a similar fashion to noncontrol sites but would be located outside of the APE of the solar development, but not so far as to exceed regional characteristics. Similar to noncontrol sites, control sites may be affected by more than one potential impact and more than one stressor–receptor interaction may be monitored at one time. Based on the size and type of the resource, one resource could contain both control and noncontrol sections. For example, if a trail segment extends beyond the study area, one portion of the trail could be used as a control segment, the other a noncontrol segment.

To the extent possible, both control and noncontrol sites should be accessed on foot or by other means (possibly using remote sensing) that would diminish the possibility of creating additional noticeable trails to the site. This would lessen the degree to which casual visitors would be likely to travel to the site and potentially sacrifice the integrity of the control site.

6.3.1.5.2 Baseline Data Collection

At a minimum, baseline data collection efforts should mimic BLM Class III (BLM 2003) and State of California Department of Parks and Recreation site recordation efforts as outlined in *Instructions for Recording Historical Resources* (COHP 1995). This information should be available from a review of existing information but may require a field visit to verify or update information. For the Riverside East SEZ, existing information can be found through the California Historical Resources Information System (CHRIS), DRECP Cultural Resources Element maps, and the site inventory and impact assessment conducted prior to development activities within the Riverside East SEZ (BLM 2010, 2011; 2014a,b BLM and DOE 2012).

Future baseline data collection efforts in permitted project areas within the SEZ should continue in this manner. Baseline data for control sites or sites within the study area but outside project-specific survey areas can be collected through a review of existing site records. If possible, a site visit should be completed to ensure accuracy. If a site record is found to be incomplete, inaccurate, or nonexistent, a thorough data collection effort should be made at the level required to fulfill necessary data needs.

Collecting baseline data for areas of Native American concern should include a review of appropriate ethnographic documents; the DRECP American Indian Element planning maps; technical reports for projects completed within the study area, including the various EISs completed for solar development within the Riverside East SEZ; and, most importantly, through communication with tribal representatives who have historic and ethnographic ties to the landscape and/or have expressed concerns with solar energy development within the study area.

It may be helpful to develop a specific baseline data collection form with prompts to document site characteristics and impacts to be completed during the applicant's cultural resource assessment. This form could be used in conjunction with the follow-up monitoring forms used by site stewards. Impacts are best measured through a "check-off" style form to ensure consistent identification of the nature and degree of impact (Hargrave 2009; Versar, Inc. 2011, Dierker and Leap 2006).

6.3.1.5.3 Follow-up Monitoring

The BLM should continue to work with solar energy project applicants to develop a long-term monitoring plan with a detailed treatment strategy and monitoring schedule reflecting the nature and degree of impacts as part of the cultural resources specific ECMP. In addition, the BLM should continue to use site stewards for routine follow-up monitoring and also to record impacts reported by other individuals, as described in Section 6.3.1.5. If possible, an effort should be made to increase the number and types of sites monitored to better represent impacts occurring across the landscape. The current monitoring forms used by site stewards should be adjusted as necessary to include prompts listed on a baseline data collection form, if one is developed, and a special category should be added to aid in determining whether the impact is a direct or indirect result of solar energy development.

Prior to each site visit, stewards should be equipped with copies of the full site record as well as subsequent baseline data collection and monitoring forms in order to assist in a more uniform comparison of site condition and impacts. It may also be beneficial to train site stewards in ways to identify whether impacts are a result of solar development. Resources of interest near established ROW corridors should be monitored to assess the extent these pathways are used, if users stay within the ROW (and, if not, the distance that users are most likely to wander off of the ROW), and if cultural and natural resources (e.g., plant and animal species and natural features of concern to Native Americans) are affected by human presence. Of particular concern should be traditional use areas, sacred sites, trail segments, trail connectivity areas, and important archaeological sites. A systematic surface inventory during each follow-up visit would recognize disturbance indicators, such as footprints, shovel holes, or tire tracks, and determine whether artifacts and plants are being collected. Simple observations of disturbance, littering, or defacement would help determine whether episodes of vandalism are occurring.

Indirect effects of natural processes that are influenced by the project include surface water movement, groundwater use, and aeolian processes. Impacts on cultural resources from these processes include site erosion, sedimentation, and land subsidence. The monitoring of surface impacts on water resources and geomorphology is described in Section 4. A systematic surface inventory would help determine whether artifacts are being displaced by the movement of water or soil and whether any new features or artifacts have been exposed or buried. Wherever these types of impacts occur, cultural resources should also be examined for erosion, deposition of soils, and land subsidence (e.g., artifact displacement, exposure of subsurface features, and concealment of a site). Of particular consideration, again, should be trail segments and trail connectivity areas because tribal representatives have expressed a great deal of concern over the potential impacts on these resources.

Visual impacts affect only a subset of cultural resource types (e.g., National Historic Landmarks, National Historic Trails, traditional cultural properties and sacred sites, other traditional use areas), and monitoring would be implemented only in cases in which visually sensitive resources are present. Section 6.1 describes the monitoring protocol that would be used to identify the extent to which visual impacts are occurring and the efficacy of visual mitigation measures.

Repeated field inspections may introduce their own impacts in the form of vehicle and foot traffic and could increase the level of site disturbance. These inspections may also draw unwanted attention to a particular site if monitors are continually observed at a particular place by residents or recreational visitors. The frequency of field inspections can be reduced by limiting field inspections to once a year, after observed incidents of impacts have been reported or after a major weather event, such as a heavy rain/flood or fire.

6.3.1.5.4 Potential Limitations

Although cost-effective, the use of site stewards presents some challenges. Given the varied nature of individual recording methods, data collection may not be consistent across the program. In addition, site stewards may prefer monitoring specific sites or only certain areas, and some resources, especially those in remote locations, may be neglected. Incidents are reported only when they are seen, and if a site has not been visited or is not visited regularly, impacts on those resources, such as erosion or repeated incidents of looting and vandalism, may go undetected for long periods of time, in some cases completely destroying any valuable information that could be attained (Swanson et al. 1992; Elia 1997). It has been noted that site stewards are more engaged in the monitoring process when monitoring resources they visit frequently (Versar, Inc. 2011).

6.3.1.6 Data Analysis and Summary of Monitoring Strategy

Analysis of these parameters can be accomplished most easily by comparing baseline data against data collected from follow-up visits using photo documentation and a written record of impacts. A thorough comparison of baseline and follow-up visit data will aid in assessing the degree and nature of human-related impacts identified in these stressor–receptor interaction. Emphasis should be placed on changes in site condition due to increased visitation, fluctuations in water runoff patterns, aeolian sediment deposition or removal, or to land subsidence caused by increased groundwater use, as a result of solar development.

Mitigation strategies would be identified after the collection and review of baseline data for areas where preservation and integrity are at a greater risk, and adjusted as necessary after a review of the follow-up visits. Results of site inspections should be analyzed in conjunction with reported incidents on a yearly basis to obtain a better understanding of the impacts affecting resources across the landscapes and the monitoring plan adjusted as necessary.

Additional mitigation measures could include consultation with tribal representatives to assess the added emotional and spiritual impact of incidents of damage or erosion as well as periodic interviews with Native American tribes to establish ongoing environmental, emotional, and spiritual concerns identified during the construction and operation of solar facilities. Measures may also include recording and addressing concerns from members of the public. If previous mitigation measures have already been initiated, the long-term monitoring programs should also evaluate the efficacy of those measures on protecting the resources of concern. The proposed monitoring plan for nuisance species is summarized in Table 6-14.

Table 6-14 Summary of Monitoring Indicators and Monitoring Plan Proposed to Monitor Cultural Resources and Areas of Native American Concern

Indicator	Method	Sampling Strata	Data Analysis
Number of reported impacts on cultural resources and areas of Native American concern	Site stewards supplied with monitoring forms; monitor vehicles, footprints, tire tracks, animal tracks, trash, spent ammunition, targets, fire pits/rings, camping; ground disturbance; incident reports from law enforcement officers, tribal representatives, and general public	Several project-specific cultural resource inventories and impact assessments in the SEZ have been completed; potential ongoing monitoring locations include NRHP/CRHP-listed sites, sites susceptible to a particular impact, highly visible, frequently used trails; areas of Native American concern include important trail systems, sacred sites, and traditional use areas, as determined through consultation with tribal representatives; sample selection and size will be dependent on staff and volunteer resources available; control sites for cultural resources would be monitored in a similar fashion.	Comparing baseline data against data collected from follow-up visits using photo documentation and a written record of impacts. Emphasis should be placed on changes in site condition due to increased visitation, fluctuations in water-runoff patterns, aeolian sediment deposition or removal or on land subsidence caused by increased groundwater use, as a result of solar development.

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6.3.2 Number of Reported Impacts on Paleontological Resources

6.3.2.1 Rationale for Monitoring the Indicator

Paleontological resources are considered by the BLM as "the fragile, nonrenewable scientific record of the history of life on earth and represent an important and critical component of America's natural heritage" (BLM 1998a). Like cultural resources, paleontological resources are vulnerable to impacts that are both human-induced and caused by nature as a result of land modification from solar development. Impacts on these resources affect the value and integrity of their scientific potential.

Preserving the scientific and educational values of paleontological resources requires the site to be undisturbed by human activity. Therefore, like archaeological resources, paleontological resources are best studied in situ. Damage to fossils and fossiliferous strata, whether from natural or human sources, can diminish the research potential and integrity of the site (Santucci et al. 2009). The greatest threats to paleontological resources are natural erosion, geohazards (earthquakes, landslides), change in hydrologic activity, and human activity (vandalism, fossil theft, trampling) (Santucci et al. 2009; Milner et al. 2006).

Stressors to paleontological resources related to solar energy development can be natural, such as wind and water erosion, bioturbation, or fire, or human-induced, such as new ROWs, vandalism, theft, damage, destruction, and illegal excavation (Figure 6-10). Stressors can cause physical impacts on a site and can diminish the research potential and integrity of the site for researchers and the general public. The following stressor–receptor interactions have been identified for the Riverside East SEZ:

- Solar facilities located in previously remote areas may require new access corridors associated with the facility or transmission lines. Established routes tend to pique the interest of recreationists for further exploration. Whether by foot or OHV, these routes can be expected to be explored, and sites of interest along these routes would be placed at risk for intentional or unintentional damage such as pedestrian trampling and OHV damage; looting; and vandalism.
- Construction of solar facilities may disrupt ephemeral wash and intermittent stream patterns or disrupt geomorphic features by altering wind and water sediment transport processes and drainage patterns (erosion). This could affect alluvial fans, sand dunes, and channel networks and, in turn, fossiliferous strata.

The scientific and educational values of paleontological resources are related to their stability. Disturbance to fossils and fossiliferous strata can diminish the research potential and integrity of the site (Santucci et al. 2009). By monitoring changes in resource condition as a result of weathering and erosion and detecting increased vehicular and pedestrian traffic as a result of new roads constructed for the facility, ROWs, or firebreaks, the BLM will better be able to adaptively manage for paleontological resources within their jurisdiction and apply those findings to other SEZs.

The BLM is required to manage and protect paleontological resources under the following policies:

- Antiquities Act of 1906 [16 USC 431-433],National Environmental Policy Act of 1969 (P.L. 91-190; 83 Stat. 852; 42 U.S.C. 4321)
- Federal Land Policy and Management Act of 1976 [P.L. 94-579; 90 Stat. 2743; 43 U.S.C.1701]
- P.L. 111-011,Title IV, Subtitle D of the Omnibus Public Land Management Act of 2009 (also known as the Paleontological Resources Preservation Act) [123 Stat. 1172; 16 U.S.C. 470aaa]
- Various subparts of Title 43 of the *Code of Federal Regulations*
- Executive Order 13287, *Preserve America* [68 F.R. 43, March 5, 2003]
- Department of the Interior Secretary's Order 3323, *Establishment of the America's Great Outdoors Program* [September 12, 2012].

BLM policies for preserving, protecting, and maintaining ecological resources are laid out in the following documents:

- BLM Manual 8270, Paleontological Resource Management
- BLM Manual 8270-1, General Procedural Guidance for Paleontological Resource Management
- IM 2008-009, Potential Fossil Yield Classification (PYFC) System for Paleontological Resources on Public Land
- IM 2009-011, Assessment and Mitigation of Potential Impacts to Paleontological Resources
- IM 2009-113, On Casual Collecting of Common Invertebrate and Plant Paleontological Resources under the Paleontological Resources Preservation Act of 2009
- IM 2012-140, Collecting Paleontological Resources under the Paleontological Resources Preservation Act of 2009
- IM 2012-141 on Confidentiality of Paleontological Locality Information under the Omnibus Public Lands Act of 2009, Title VI, Subtitle D on Paleontological Resources Preservation
- IM-2014-112, Policy for Solar and Wind Energy Inspection and Enforcement

6.3.2.2 Related Management Questions, Management Goals, and Monitoring Objectives Addressed by the Indicator

Monitoring the number of reported incidents of impacts on paleontological resources will address the management questions, management goals, and monitoring objectives in Table 6-15.

Table 6-15 Management Questions, Management Goals and Monitoring Objectives Addressed by Monitoring the Number of Reported Impacts on Paleontological Resources

Management Questions
- How is solar development affecting the contextual integrity of paleontological resources?
- Does facility construction increase site access and visitation in a way that negatively affects existing resources and uses?

Management Goals
- Protect paleontological resources from solar-related impacts from wind and water erosion.
- Maintain integrity of paleontological resources.
- Minimize removal of fossil resources.

Monitoring Objectives
- Detect temporal changes in the contextual integrity of paleontological resources within the SEZ.
- Detect temporal changes in traffic and access.

6.3.2.3 Spatial and Temporal Considerations for Monitoring the Indicator

The study area and monitoring schedule for this indicator are similar to those outlined for cultural resources in Section 6.3.1.3.

6.3.2.4 Existing Data Sources

The BLM does not currently have any regular, ongoing data collection efforts for paleontological resources within the Riverside East SEZ. For projects involving ground-disturbing activities, a paleontological resources inventory and impact assessment is conducted within the APE of that designated project as part of the applicant's responsibilities under NEPA and IM 2009-011. The inventory focuses on reviewing verifying, and updating existing data; identifying new resource sites; and developing recommendations to prevent or mitigate adverse impacts on paleontological resources within the APE (BLM Handbook 8270-1 [BLM 1998b]). Paleontological resource inventories and impact assessments have already been completed for a number of facilities within the Riverside East SEZ (BLM 2010, 2011, 2014a,b; BLM and DOE 2012).

6.3.2.5 New Indicator Data Collection Recommended for the Riverside East SEZ LTMS

As with cultural resources, implementing a volunteer site steward program would permit paleontological resources monitoring that is not currently possible because of staff limitations and funding constraints affect the availability of resource managers and professionals to monitor paleontological resources. BLM California does not have a paleontological site steward program, nor does it regularly check incident reports (Johnston 2015). However, these programs have been proven beneficial at other federal agencies and BLM state offices. For example, Zion National Park encourages staff and visitors to report paleontological localities and visitor centers to keep electronic versions of paleontological site report forms available for reporting. The park also encourage paleontological subject matter experts to train interested staff in techniques for identifying impacts on and monitoring paleontological resources (Clites and Santucci 2012). BLM Utah has developed a site steward program similar to the archaeological site steward programs in states across the West. The program requires a formal training and requests stewards to monitor their assigned locality four times a year (BLM 2015; Milner et al. 2006). Similar reporting programs should be implemented under the LTMS to monitor incidents of impacts on paleontological resources at the Riverside East SEZ.

6.3.2.5.1 Control and Impact Site Selection

Guidance for selection of control and noncontrol paleontological resources is similar to that for cultural resources as presented in Section 6.3.1.6. When paleontological resources are being selected for monitoring, it is important to take into consideration both the natural and human, existing and/or emerging stressors to the stability of the resource, including potential erosion rates; climatic conditions; proximity to active geohazards; changes in water patterns; and activities by visitors, monitors, and land managers (Santucci et al. 2009). Potential monitoring areas could include sites under the greatest threat of erosion, sites with the highest PYFC value, or sites frequently visited by recreational visitors. Special consideration should be given to areas where known fossiliferous formations were surveyed but were found not to contain fossils. These formations could contain buried deposits that could be exposed due to erosion or other impacts resulting from solar energy development.

6.3.2.5.2 Baseline Data Collection

At a minimum, baseline data collection efforts should mimic the *Procedures for Assessing and Mitigating Potential Impacts to Paleontological Resource* as outlined in BLM Manual 8270-1 (BLM 1998b). Typically this includes the completion of a paleontological locality form, which prompts for information that outlines the scope, significance, and distribution of fossils at each locality. Important baseline data to capture include the physical properties of fossiliferous strata, the relationship of overlying and underlying strata, degree of slope of fossiliferous strata, and type and percentage of vegetation cover (Santucci et al. 2009).

Much of this information should be available from a review of existing documents, but may require a field visit to verify or update information. For the Riverside East SEZ, existing paleontological locality forms, reports, and other paleontological data can be found at the Paleontological Department of the San Bernardino Natural History Museum. Project-specific inventory and impact assessments conducted prior to development activities within the Riverside East SEZ can also be consulted (BLM 2010, 2011, 2012, 2014a,b; BLM and DOE 2012).

Future baseline data collection efforts in permitted project areas within the SEZ should continue data collection through a review of paleontological locality forms, site inventories, and impact assessments described above. Baseline data for control sites or sites within the study area but outside project-specific survey areas can be collected through a review of available data. If existing data are found to be incomplete, inaccurate, or nonexistent, a thorough data collection effort should be made at the level required to fulfill necessary data needs.

6.3.2.5.3 Follow-up Monitoring

The BLM should work with solar energy project applicants to develop a long-term monitoring plan with a detailed treatment strategy and monitoring schedule reflecting the nature and degree of impacts as part of the paleontological resources specific ECMP. The BLM should also adopt a site steward program that follows the design of the BLM Utah Paleontological Site Stewardship Program (Milner et al. 2006; BLM 2015). BLM California should work closely with BLM Utah to develop a monitoring program that not only can use site stewards but also meets the needs of paleontological monitoring within the Riverside East SEZ. The BLM can also partner with the Southern California Paleontological Society during development of the program and for future site steward recruitment.

The BLM should also continue to record incidents that are reported from other individuals. Site data should be reviewed on a yearly basis to assess changes to site condition and provide mitigation measures accordingly.

6.3.2.6 Data Analysis and Summary of Monitoring Strategy

Data analysis would be similar to the methods used for cultural resources (Section 6.3.1.6). As with cultural resources, mitigation can be accomplished most easily by comparing baseline data against data collected from follow-up visits using photo documentation and written record of impacts to determine new or potential future impacts. The proposed monitoring plan for nuisance species is summarized in Table 6-16.

Table 6-16 Summary of Monitoring Indicators and Monitoring Plan Proposed to Monitor Paleontological Resources

Indicator	Method	Sampling Strata	Data Analysis
Number of Reported Impacts on Paleontological Resources	Site steward program modeled on the BLM Utah Paleontological Site Stewardship Program; requires trained stewards to monitor their assigned locality four times a year.	Sites under the greatest threat of erosion, sites with the highest PYFC value, or sites frequently visited for recreation. Special consideration should be given to areas where known fossiliferous formations were surveyed.	Data analysis would be similar to the methods used for Cultural resources: comparing baseline data against data collected from follow-up visits using photo documentation and written record of impacts to determine new or potential future impacts.

6.3.2.7 Literature Cited

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APPENDIX A: REMOTE SENSING

A.1 The Role of Remote-Sensing Technologies

The AIM strategy emphasizes the need to incorporate remote-sensing technologies into long-term monitoring programs, wherever feasible (Toevs et al. 2011). Remotely sensed data are collected with satellites, aircraft, and ground-based sensors. Remotely sensed data offer some advantages over field-based data collection because remotely sensed data can be collected over large and remote areas that may be difficult, expensive and time-consuming to characterize using traditional field methods. Because of the continuous spatial coverage provided, data derived from remotely sensed imagery also minimizes sources of sampling bias inherent in field data collections, such as sampling near the roads and undersampling areas that are difficult to access. Remote sensing consists of two major components: data collection and image analysis, each of which is discussed in the following paragraphs.

A.2 Remote-Sensing Data Collection

Remote sensing data can be collected by ground-based sensor systems or sensors mounted on satellite or aircraft. Sensor systems measure electromagnetic radiation, including visible, near infrared, thermal infrared (heat), and/or microwave spectral energy, which is reflected or emitted in varying degrees by all natural and synthetic materials (Figure A-1). Materials reflect, absorb, and emit electromagnetic radiation in different ways depending on their physical properties and chemical compositions. As a result, they create unique spectral signatures, which can be utilized to differentiate targets from background and to quantify their abundance.

Remote sensing can be divided into two categories: passive and active. Passive remote sensing entails measuring naturally occurring electromagnetic energy reflected or emitted by elements such as reflected sunlight. Aerial photography, CCDs (used for airborne and satellite sensors), and radiometers (used in more recent satellite and airborne sensors) are common types of sensors used for passive remote sensing (Table A-1). Active remote sensing, on the other hand, transmits pulses of electromagnetic energy from a transmitter and measures a portion of the energy reflected or backscattered by the targets by using an antenna. The intensity and the time delay between transmission and return allow the location, height, speed, and direction of the targets to be detected. Radio detection and ranging (RADAR) and light detection and ranging (LiDAR) are well-known active remote sensor systems (Table A-1).

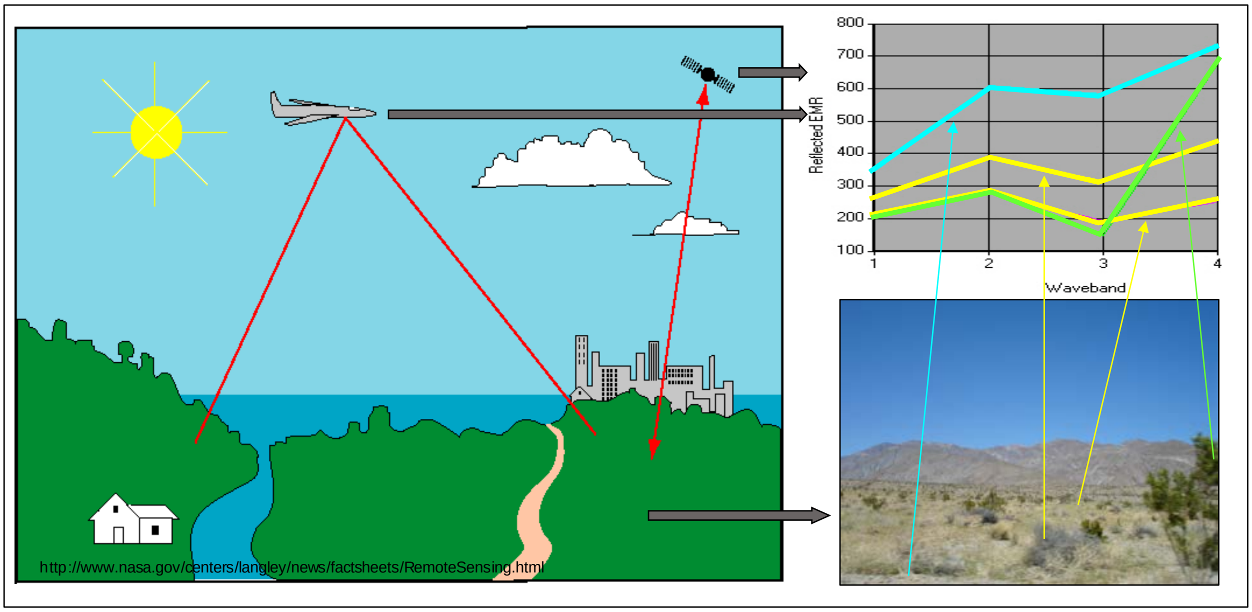

Figure A-1 Schematic Representation of Remote Sensing (Source: NASA 1998 and Argonne National Laboratory, unpublished draft)

The temporal and spatial resolutions of image collection are two primary considerations, particularly for multispectral remote-sensing studies. The resolution of remotely sensed imagery can range from coarse scale, such as 250-m Moderate Resolution Imaging Spectroradiometer (MODIS), to 1,000-m Advanced Very High Resolution Radiometer (AVHRR), to very high resolution, such as 2- to 3-cm resolution for custom aerials images (Table A-1). Publicly available satellite images tend to have coarse spatial resolution, and commercial satellite images often have sub-meter to meters spatial resolution (30-cm WorldView and 2.4-m QuickBird multispectral images). Aerial images can have sub-centimeter to centimeters resolution images. The temporal frequency of image collection also varies greatly between images. Low-resolution images are often collected at shorter intervals (sub-daily for AVHRR and daily for MODIS), while high-resolution images are collected less frequently (every 16 days for Landsat Thematic Mapper [TM]/Enhanced TM Plus [ETM+]) (Table A-1). This is particularly true for publicly available images. Commercial satellite images provide more options for spatial and temporal resolutions (Table A-1). Aerial imagery can be customized to the desired resolution and frequency.

For example, while low-resolution Landsat images are useful for detecting trends in regional vegetation cover, they are less useful for providing information on localized changes in surface channels or riparian vegetation. Remote-sensing image types should be carefully selected based on the monitoring objectives and resource characteristics. For example, dominant desert vegetation such as creosote, which is relatively short, small-leaved, and sparsely distributed across landscape, is relatively stable over multiple years. Consequently, coarse-resolution images, such as Landsat ETM+, collected annually may be sufficient to monitor relative abundance of the plant type or conditions of the community. In contrast, ephemeral streams, particularly narrow channels, are more dynamic. Thus, monitoring changes in narrow ephemeral streams would require finer resolution images at higher or customized frequencies (before and after the rainy season or major rain events).

Imagery collected over time for long-term monitoring should be obtained from a similar time of the year and day to reduce variation in environmental conditions and landscape phenology and ensure that the target–background relationship is fairly constant. This is particularly important when analyzing landscape imagery once a year or less. If cost-effective image collection and analysis methods are available, multiple image collections within a year (e.g., monthly and seasonal) would be possible. These images would help detecting changes in physical environmental conditions at an early stage that could provide insights into cause and facilitate early responses to degradation. Multiple images per year would also help discriminating vegetation types or life forms (e.g., trees, shrub, and herbs) that are difficult to differentiate from a single-date image because of how plants respond to environmental conditions such as moisture and temperature.

Table A-1 Aerial and Satellite Sensors Available for Collecting Imagery for Resource Monitoring

Sensor/ Platform	Resolution[a] (m)	Spectral Band or Products[b]	Frequency of Image Collection (Available Period)	Examples of Resource-Monitoring Applications	Cost[d]/ Minimum Order
Multispectral Satellite					
NOAA/ AVHRR	1,100	5 bands (G-R, NIR, MIR, TIR [2])	Twice a day (1979-present)	Overall photosynthetic activity (Kawabata et al. 2001); overall aboveground biomass (Eisfelder et al. 2011); overall vegetation productivity (Fensholt et al. 2012)	No cost
Terra, Aqua/ MODIS	250–1,000	Reflectance band 1–7, Leaf Area Index (LAI), land surface temperature, vegetation indices, gross primary productivity, net primary productivity, vegetation continuous cover	Twice a day (1999–present)	Overall photosynthetic activity (Zhang et al. 2003); overall plant moisture (Yebra et al. 2013, Castro et al. 2014); photosynthetic vegetation cover (Guerschman et al. 2015)	No cost
IRS	1–80	4 bands (B, G, R,NIR, MIR, SWIR), panchromatic	22–24 days (1988–present)	Similar to Landsat	
Landsat/ TM, ETM+, OLI	15–60	7 bands (B, G, R, NIR, SWIR [2], TIR), panchromatic	16 days (1982-present)	Broad scale loss and degradation of soils and habitats (Chabrillat 2006); fractional cover of shrub, herb, and bare ground (Sant et al. 2014); overall community structure, function, or species dominance (Mbow et al. 2013, Krofcheck et al. 2014); photosynthetic vegetation cover (Guerschman et al. 2015); biological soil crust distribution (Brungard and Boettinger 2014); distributions of desert pavement distribution, dunes, biological soil crust (Potter and Li 2014); shrub biomass (Zandler et al. 2015); wildlife habitat characteristics (Xian et al. 2012)	No cost
SPOT	1.5–10	4 bands (G, R, NIR, SWIR), panchromatic	Daily (1986–present)	Fractional cover of shrub, herb, bare ground (Hamada et al. 2013)	\$5.15–6.20/km^2 (100 km^2)
RapidEye	5	5 bands (B, G, R, RE, NIR)	Daily (2009–present)	GPP (Krofcheck et al. 2012); Community structure and function (Krofcheck et al. 2014); shrub biomass (Zandler et al. 2015)	\$1.28/km^2

Table A-1 (Cont.)

Sensor/ Platform	Resolution[a] (m)	Spectral Band or Products[b]	Frequency of Image Collection (Available Period)	Examples of Resource-Monitoring Applications	Cost[d]/ Minimum Order
Multispectral Satellite (Cont.)					
IKONOS	1–4	4 bands (B, G, R, NIR), panchromatic	~3 days (1999–present)	Fractional cover of shrub, herb, and bare ground (Sant et al. 2014)	$10–20/km^2$
WorldView	0.3-2	8 bands (Coastal, B, G, R, Y, RE, NIR [2]), panchromatic	7.25 days (2007–present)	Vegetation and land cover (Mucher et al. 2015)	$16–31.5/km^2$ (25–100 km^2)
QuickBird	0.6–2.4	4 bands (B, G, R, NIR), panchromatic	3.5 days (2001–present)	Fractional cover of shrub, herb, and bare ground (Hamada et al. 2013); archaeological features (De Laet et al. 2015; Hesse 2014)	$16–25/km^2$ (25–100 km^2)
GeoEye-1	0.5	4 bands (B, G, R, NIR), panchromatic	~3 days (2008–present)	Detection of fine-scale disturbances (e.g., pollution, urbanization and human movement, mapping tree falls, and small scale pest attacks)	$16–25/km^2$ (25–100 km^2)
Multispectral Aerial					
NAIP	1	RGB	Annual OR around each peak growing season (2004–2006, 2009, 2010, 2012, 2014)	Individual vegetation canopies and patches (Hamada et al. 2014, Potter and Li 2014)	No cost
Custom	0.15	B, G, R, NIR	Project-specific	Individual vegetation canopies and patches, fractional cover of trees, shrub, herb, and bare ground, ephemeral stream channels, site stability (Hamada et al. 2014)	
Hyperspectral Satellite					
HJ-1-A/ HSI	100	115 bands (visible to NIR range or 450–950 nm)	4 days	Fractional vegetation cover (Zhang et al. 2013)	Variable
EO-1/ Hyperion	30	220 bands (visible to SWIR range or 400–2500 nm)	16 days	Fractional cover of vegetation component (photosynthetic and nonphotosynthetic) and bare ground (sandy and sandy-loam soil and rock fragment) (Jafari and Lewis 2012); large archaeological features (Savage et al. 2012);	Variable

Table A-1 (Cont.)

Sensor/ Platform	Resolution[a] (m)	Spectral Band or Products[b]	Frequency of Image Collection (Available Period)	Examples of Resource-Monitoring Applications	Cost[d]/ Minimum Order
Hyperspectral Satellite (Cont.)					
Terra/ ASTER	15-90	14 bands (B, G, R, SWIR [3], TIR [5])	16 days (2000–-present)	Identifying disturbances (e.g., pest attacks that lead to changes in foliage color, and fine-scale modifications in grass biomass due to disturbances such as grazing); Biological soil crust types (Rozenstein and Karnieli 2015); soil properties (Aïchi et al. 2014)	Variable
Hyperspectral Aerial					
AVIRIS[e]	4	224 bands (visible to SWIR range or 400–2500 nm)	Project-specific[f]	Vegetation (Roberts et al. 1993); Plant moisture (Serrano et al. 2000); BSCs (Ustin et al. 2009);	Variable
AISA ;CASI	1.4–10	60-288 bands (visible to NIR range or 400–1000 nm)	Project-specific	Plant moisture (Al-Moustafa et al. 2012); plant species (Mansour et al. 2012); Biological soil crust types (Rodriguez-Caballero et al. 2014)	Variable
DAIS	1	79–211 bands (visible to TIR or 400–12,300 nm)	Project-specific	Biological soil crust types (Rozenstein and Karnieli 2015)	Variable
Alpha System[g]	1–5 m	(visible to SWIR range or 400–2,500 nm)	Project-specific	Plant species and vegetation community composition/structure (Baldeck et al. 2014)	Variable
Active Remote Sensing					
LiDAR				Vegetation structure in riparian zone (Hutton and Brazier 2012); canopy cover, height, and gap (Sankey et al. 2013); shrub distribution (Sankey et al. 2012)	Variable
RADAR (including SAR)				Total tree and shrub canopy cover (Mathieu et al. 2013); soil moisture and/or salinity (Lhissou et al. 2013, Gorrab et al. 2015);	Variable

Table A-1 (Cont.)

Abbreviations: AHS = Airborne Hyperspectral Scanner; AISA = Airborne Imaging Spectrometer; ASTER = Advanced Spaceborne Thermal Emission and Reflection Radiometer; AVHRR = Advanced Very High Resolution Radiometer; AVIRIS = Airborne Visible/Infrared Imaging Spectrometer; AVIS = Airborne Visible/Infrared Imaging Spectrometer; CASI = Compact Airborne Spectrographic Imager; DAIS = Digital Airborne Imaging Spectrometer; EPS=H = Environmental Protection System; ETM+ = Enhanced Thematic Mapper Plus; HIS = Hyperspectral Imager; HYDICE = Hyperspectral Digital Imagery Collection Experiment; HyMap = Hyperspectral Mapper; IRS = Indian Remote Sensing Satellite; LiDAR = Light Detection and Ranging; MODIS = Moderate Resolution Imaging Spectroradiometer; NAIP = National Agriculture Imagery Program; OLI = Operational Land Imager; RADAR = Radio Detection and Ranging; SAR = Synthetic Aperture Rader; TM = Thematic Mapper.

[a] Image resolution of each satellite sensor/platform varies depending on the spectral band, product, and platform version.

[b] Specific number of band and wavelength vary depending on the sensor version. B=blue, G=green, Y=yellow, R=red, RE=red-edge, NIR=near-infrared, MIR=mid-infrared, SWIR=shortwave infrared, and TIR = thermal infrared spectral bands. The number of bands corresponding to a common spectral band is indicated in brackets [ ].

[c] Frequency of available image or products may not correspond to the image collection frequency.

[d] Image cost per unit area varies dependent on the status of image (e.g., archive, new image, tasking).

[e] AVIRIS was a hyperspectral imager developed by NASA-Jet Propulsion Laboratory, Pasadena, California, U.S.A.

[f] The NASA Ames group recently collected a data cube to investigate biological soil crust distribution in the area including the Riverside East SEZ.

[g] The Carnegie Airborne Observatory Alpha System consists of hyperspectral imaging and Light Detecting and Ranging capability.

A.3 Image interpretation techniques

Data collected via remote sensing need to be interpreted in order to extract useful information on the resource of interest. There are numerous options for extracting resource information from the imagery. They range from visual image interpretation to methods using semi-automated processing algorithms that identify and quantify specific features in the images. Basic visual interpretation of multiyear images have long been used to assess changes in landscape features. An alternative method involves importing images into GIS software and overlaying these images with sampling plots. As with field surveying, resource characteristics (e.g., canopy width, ground cover types) can then be measured and identified manually at each plot (Karl, Duniway, and Schrader 2012; Karl et al. 2012). For this technique, high-resolution data are required because individual features need to be clearly identifiable in the image. Semi-automated, computer-assisted image processing supports more efficient and systematic interpretation than manual techniques for (1) detection of resource features, (2) differentiation between elements (e.g., types of vegetation, land cover, soil), and (3) quantification of parameters (e.g., vegetation cover and its spatial distribution). Examples include spectral vegetation indices such as the Normalized Difference Vegetation Index (NDVI) and Soil Adjusted Vegetation Index (SAVI), which are effective for quantifying changes in vegetation cover (Elmore et al. 2000). Specific resource applications are discussed in Section A.3.

A.4 Application of Remote Sensing to the Riverside East SEZ LTMS

A.4.1 Ecological Resources

Remote sensing has been used to monitor multiple physical and ecological resources. There are several well-accepted remote-sensing applications for assessing and monitoring hydrologic and geomorphologic resources, which include channel network patterns (Hughes et al. 2006; Yang et al. 1999) and erosion and deposition (Pelletier et al. 2005). Several studies have also demonstrated that remote-sensing methods are cost-effective and can quantify or classify land cover with accuracy similar to field-based data collection (Karl et al. 2012; Duniway 2012; Hulet et al. 2014). Characteristic vegetation patterns for channels and alluvial fans are indirect yet would be useful indicators of change in hydrologic and geomorphologic resources. The abundance and distribution of riparian habitats are indicative of channel locations and can be effectively extracted using remote sensing (Gilvear et al. 1999). Individual shrubs and clusters of shrubs in desert environments may be detected and monitored by using fine-resolution imagery in order to examine changes in alluvial fans (Laliberte et al. 2004).

The AIM core indicators can be monitored using remote-sensing methods, which can supplement or reduce the field effort required to reliably detect environmental change (Taylor et al. 2014). For example, strong relationship between AIM core indicator data collected in the field and metrics derived from remotely sensed imagery was demonstrated in a study conducted at the USDA–ARS Jornada Experimental Range (Jornada) (Duniway et al. 2012). The study used a semi-automated approach in which transects were overlain on very large scale aerial (VLSA) imagery and ground cover (an AIM core indicator) at points along the transects, which were then classified as one of nine cover types (e.g., shrub, sub-shrub, succulent, tree, forb, grass, litter, rock, and soil). The results were then compared to field-based cover classifications using the line point intercept method specified by AIM protocols (MacKinnon et al. 2011). There was a strong relationship ($R^2 > 0.9$) between field-based and image interpretation-based cover classifications for woody vegetation and nonwoody classes. However, the image interpretation method was less capable of distinguishing herbaceous vegetation and vegetation litter because they were difficult to distinguish visually in the image (Duniway et al. 2012). This method is likely applicable for discrete locations, rather than a spatially contiguous area over a large extent.

Canopy gap distance is another AIM core indicator. Karl, Duniway, and Schrader (2012) compared canopy gap estimates derived from VLSA (3-cm resolution) imagery and field-collected measurements (Table A-2). The study evaluated several sites in the Southwest with a broad range of arid and semi-arid shrubland vegetation communities. They found the two methods produced similar results for canopy gaps greater than 50 cm, suggesting the remote-sensing method was most suitable for areas with sparse vegetation cover. However, litter and bare ground were difficult to distinguish in the imagery, resulting in inaccurate ground cover estimates for some plots. The results suggest image resolution should be determined by the density of land cover in the study area, with higher resolution for areas with higher vegetation density (Karl, Duniway, and Schrader 2012). This method is likely applicable for discrete locations, rather than a spatially contiguous area over a large extent.

Gillan et al. (2014) used high-resolution (3-cm) digital stereo-pair aerial images and 5-cm resolution digital surface models (DSMs) to compare the heights of individual shrubs derived from imagery to field measurements. They found that individual shrub heights estimated from imagery were typically lower than field-based estimates. However, accuracy was higher for dense, compact shrubs than for shrubs with thin branches. Image analysis was not useful for determining the heights of grasses and forbs because of their small size.

Table A-2 Core Terrestrial Indicators and Monitoring Using Remote Sensing

AIM Core Indicator	Reliability of Remote-Sensing Estimates
Amount of bare ground	Less accurate in high-density vegetation
Species inventory	Only possible with visually distinct dominants
Non-native invasive species	Generally possible only with highly invasive, visually distinctive species
Plant species of management concern	Generally not possible due to rarity of plants
Vegetation height	Accurate for woody vegetation
Proportion of site in large, intercanopy gaps	Possible for larger canopy gaps (>50 cm)
Land cover (habitat) amount, location, and pattern	Possible for visually distinctive cover types

Using very high spatial resolution (VHSR; 15 cm) imagery, Argonne was able to map land surface features and properties associated with the AIM core indicators (Hamada et al. 2014). For example, distribution of vegetation and desert pavement and fractional cover of vegetation types and bare ground are mapped using the Visible Atmospherically Resistant Index (VARI) that was determined to be most accurate identifying desert vegetation in the East Riverside SEZ (Hamada and Grippo 2015). Ephemeral stream channels in a part of the SEZ were mapped at a fine scale, which were considerably more detailed than those represented in the USGS National Hydrography Dataset (NHD) (Hamada et al. 2014). Argonne also developed a remote sensing metric that could indicate potential surface erosion risks that could be used to identify locations where erosion would likely occur (Hamada et al. 2015).

Although the results have yet to be validated in the field, remote sensing has also been applied to mapping three key desert resources in the Riverside East SEZ: biological soil crusts (BSC), desert pavement, and sand dunes. In support of the Desert Renewables Conservation Plan, researchers at the NASA Ames Research Center and California State University, Monterey Bay, have mapped BSCs, desert pavement, and sand dunes in the Riverside East SEZ (Potter and Li 2014). Using NAIP imagery and Landsat imagery, they were able to distinguish two categories of BSC cover (≥33% and <33%). Sand dunes and desert pavement were also mapped using NAIP and Landsat imagery. Using VHSR imagery (e.g., <1 m ground sampling distance) Argonne was able to distinguish features such as desert pavement and vegetated surface from other surface types at a fine scale (Hamada et al. 2014).

A.4.2 Cultural and Paleontological Resources

In addition to ecological and physical resources, remote sensing has application to cultural and paleontological resource monitoring. Traditional monitoring requires survey teams to walk within sensitive archaeological and paleontological sites to accurately measure impacts and site condition. Repeated field inspections may introduce their own impacts in the form of vehicle and foot traffic. Survey teams could increase trailing and surface compaction and damage cryptogrammic crusts, and this could increase erosion. Repeated field inspections may also draw unwanted attention to sensitive resources, creating the potential for looting, vandalism, or other visitor damage. Land managers are increasingly looking for ways to evaluate resources in situ without causing additional damage.

As described in Section 3, remote-sensing techniques can detect the subtle changes in the physical characteristic of landforms, making them particularly valuable for assessing and monitoring cultural and paleontological resources. Techniques used for producing photogrammetric data, such as LIDAR, satellite imagery, structure-from-motion (SfM) and aerial photography with unmanned aircraft systems, have been have been used successfully in identifying and evaluating fossil sites on public land in Colorado, Wyoming, and Utah (Anemone et al. 2011; Matthews et al. 2014 a,b) and archaeological sites throughout the world (Hesse 2015; Savage et al. 2012; Di Iorio et al. 2010; Hadjimitsis et al. 2013; Lasaponara and Masini 2010; Corns and Shaw 2009; Collins et al. 2008, 2009; Jahjah et al. 2007). These approaches can be applied to other arid environments to detect impacts on resources from large-scale looting, erosion episodes, and industrial sprawl.

Researchers using remote sensing data at different spatial and temporal resolutions have been able to monitor and assess damage by off-road vehicle use to Nasca geoglyphs in southern Peru (Hesse 2015), archaeological looting to a ceremonial center in Cahuachi, Peru (Lasaponara and Masini 2010) and have even been able to identify the geomorphic agents responsible for erosion and accretion at archaeological sites in the Grand Canyon (Collins, Brown, and Fairley 2008; Colline, Minasian, and Kayen 2009). Remote sensing has also been used to interpret and monitor large landscapes in England (Crutchley 2009; English Heritage 2010) and Croatia (Popovic 2013). Satellite imagery has been used to identify locations of potential fossiliferous strata in Kazakhstan (Malakhov et al. 2009) and to capture three-dimensional data on dinosaur track sites and other in situ paleontological resources on BLM and other public lands (Matthews et al. 2014; Matthews, Noble, and Breithaupt 2014; Wegweiser et al. 2014).

Section 4 describes how the Riverside East SEZ LTMS will apply remote sensing to monitoring changes in soil erosion (Section 4.1) and channel erosion (Section 4.2.3). All these changes have the potential to affect the cultural and paleontological resources at the Riverside East SEZ. Thus, monitoring activity described in Section 4 will also be used to monitor physical disturbances at cultural and paleontological resource areas. Ecological resource monitoring (Section 4.4 and Section 4.5) data will be used to assess impacts on culturally significant ecological resources.

A.5 Limitations and the Evolving Nature of Remote Sensing

Overall, the existing literature suggests remote-sensing methods can provide data on key ecological, physical, and cultural indicators. However, certain limitations are also evident (Table A-3). First, to accurately quantify resource indicators, the resource of interest must be visually distinct if manual or semi-automated image analysis is used to extract resource information from remotely sensed images. In the case of automated image analysis, different resource types must be spectrally separable from background, and different target types must have unique spectral signatures (Friedl et al. 2001).

Second, the accuracy of detection and quantification of resources change over time may differ between images collected in separate years because of seasonal differences in vegetation phenology, atmospheric conditions, and sun angle between images (Table A-3). Variation in environmental conditions at the time the image was taken can significantly confound change analysis if the image analysis algorithm is not robust to variation in environmental conditions. Thus, image-processing algorithms must be able to reliably detect changes in targets, elements, and parameters across images collected at different time periods. Also when detecting and quantifying resource changes over time, images collected from multiple years have to be spatially aligned at high precision because any positional misalignment or offset of the images will appear as changes although no change occurred in real world.

Third, certain cover types are difficult to analyze for temporal changes because they are not spectrally distinct (Table A-3). For example, using visual image analysis, Karl et al. (2014) found that VHSR imagery could be used to monitor change in woody vegetation and nonvegetated land cover types, but not small herbaceous vegetation. Argonne is currently investigating the ability of automated land cover analysis methods to detect changes in vegetation communities at the Riverside East SEZ using high-resolution images taken at different time periods.

Thus, there are uncertainties inherent in the application of remote sensing to long-term monitoring. For example, Karl et al. (2012) identified weaknesses specifically in regard to the application of remote-sensing methods to AIM core indicators. They found that dense vegetation with small canopy gaps (<50 cm) were not accurately quantified using semi-automated remote-sensing methods. Also, the VLSA imagery is collected at fine spatial resolution, and a large number of images may be needed for large areas, which can be expensive (Karl et al. 2012). Also, they found difficulty distinguishing between litter and bare ground and between litter and senescent vegetation.

Overall, methods for quantifying certain resource indicators using remote sensing are still in a state of development. For example, although the results of Potter and Li (2014) in mapping BSCs in the Riverside East SEZ show promise, the results have yet to be field validated. Potter and Li (2014) used the Biological Soil Crust Index (BSCI) developed by Chen (2005), which is used for lichen-dominated BSC communities. However, BSCs in the Riverside East SEZ are dominated by cyanobacteria as well as lichens (Belnap et al. 2001). Consequently, the CI developed by Karnieli (1997) for cyanobacterial BSCs may provide more accurate identification in the Riverside East SEZ, in theory. However, biological soil crusts are sparsely distributed in the SEZ compared to other surface types (e.g., exposed soil, rock fragment, shrub, and tree). Because of this, the study conducted at Argonne showed that neither index yielded satisfactory accuracy for mapping biological soil crust (Hamada and Rollins, 2015). A more localized, fine-scale remote sensing method would require for accurately mapping biological soil crust in the SEZ. More research is needed to determine which of these indices, or some combination of them, is best suited for the Riverside East SEZ.

Table A-3 Advantages and Limitations of Remote-Sensing Approaches

Advantages	Limitations
Spatially continuous data collection	Indirect measurements of features and phenomena
Simultaneous data collection on multiple resources	Spatial sampling unit (i.e., pixel size) may not match resource of interest.
Nonintrusive data collection	Assumption of spectral uniqueness of target
Semi-automated, systematic data processing	Mixture of target and background within a pixel
Potential to provide data on historical conditions	Accuracy sensitive to variation of sky conditions during image collection
Relatively low cost for frequent data collection over large area	Skilled labor and specialized software required
Data complement field-based data	Many image analysis algorithms are still in development.
Repeatability over time and transferability across space	

Despite the promising utility of remote sensing, its use does not eliminate the need for field-based measurements. In fact, the effective use of remote-sensing requires rigorous calibration and validation that use field-based data. To reliably detect and identify features and quantify parameters, it is likely that a combination of approaches is needed to provide comprehensive and meaningful information for long-term environmental monitoring (Hamada et al. 2011).

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APPENDIX B: GLOSSARY OF VISUAL RESOURCE TERMS

Contrast
Opposition or unlikeness of different forms, lines, colors, or textures in a landscape.

Cultural modification
Any human-caused change in the land form, water form, vegetation, or the addition of a structure that creates a visual contrast in the basic elements (form, line, color, texture) of the naturalistic character of a landscape.

Glare
The sensation produced by luminance within the visual field that is sufficiently greater than the luminance to which the eyes are adapted that causes annoyance, discomfort, or loss in visual performance and visibility.

Key observation point (KOP)
A point at a use area or a potential use area, or a series of points or a segment on a travel route, where there may be views of a management activity. KOPs are typically used as viewpoints for assessing potential visual impacts resulting from a proposed management activity.

Landscape
The expanse of visible scenery including landforms, waterforms, vegetation, and human-made elements such as roads and structures. Also the traits, patterns, and structure of a specific geographic area including its physical environment, its biological composition, and its anthropogenic or social patterns.

Light clutter
Excessive groupings of light sources.

Light pollution
Any adverse effect of human-made lighting, such as excessive illumination of night skies by artificial light. Light pollution is an undesirable consequence of outdoor lighting that includes such effects as skyglow, light trespass, and glare.

Light spill
An undesirable condition in which light is cast where it is not wanted. Also referred to as light trespass.

Night sky impact
An interference with enjoyment of dark night skies or an effect on nocturnal wildlife resulting from light pollution.

Reflectivity
The fraction of radiant energy that is reflected from a surface.

Scenic quality
A measure of the intrinsic beauty of landform, water form, or vegetation in the landscape, as well as any visible human additions or alterations to the landscape.

Scenic quality rating
An assessment of scenic quality. In the BLM VRI process, public lands are given an A, B, or C rating based on the apparent scenic quality, which is determined by using seven key factors: landform, vegetation, water, color, adjacent scenery, scarcity, and cultural modifications.

Scenic value
The importance of a landscape based on human perception of the intrinsic beauty of landform, water form, and vegetation in the landscape, as well as any visible human additions or alterations to the landscape.

Screening
A visual barrier consisting of earth, vegetation, structures, or other materials intended to block a particular view, or the actual blocking of a view through the use of a visual barrier.

Sensitivity level (analysis)
A measurement (e.g., high, medium, and low) of public concern for the maintenance of scenic quality. In the BLM VRI process, sensitivity is determined by evaluating the types and numbers of users who visit a specified area, the level of public interest in the area, adjacent land uses, and the presence of special areas.

Simulation
A pictorial representation of a proposed project in its landscape setting, used to visualize the project before it is built, typically in order to determine its potential visual contrasts and associated visual impacts.

Sky glow
Brightening of the night sky caused by outdoor lighting and natural atmospheric and celestial factors.

Viewpoint
A point from which a landscape is viewed. Also a point from which a landscape view is analyzed and/or evaluated.

Viewshed
The total landscape seen or potentially seen from a point, or from all or a logical part of a travel route, use area, or water body.

Visual contrast
Opposition or unlikeness of different forms, lines, colors, or textures in a landscape.

Visual impact
Any modification in landforms, water bodies, or vegetation, or any introduction of structures or other human-made visual elements, that negatively or positively affects the visual character or quality of a landscape through the introduction of visual contrasts in the basic elements of form, line, color, and texture.

Visual impact mitigation
Actions taken to avoid, eliminate, or reduce potential adverse impacts on scenic resources.

Visual resource
Any objects (human-made and natural, moving and stationary) and features such as landforms and water bodies that are visible on a landscape.

Visual resource inventory (VRI)
A BLM process for inventorying scenic resources on BLM-administered lands that provides BLM managers with a means for determining relative visual values. A VRI consists of a scenic quality evaluation, sensitivity level analysis, and delineation of distance zones. Based on these three factors, BLM-administered lands are placed into one of four visual resource inventory classes.

Visual resource inventory (VRI) classes
Classes assigned to public lands based on the results from the VRI. They do not establish management direction and should not be used as a basis for constraining or limiting surface-disturbing activities. Inventory classes are informational and provide the basis for considering visual values in the RMP process. There are four classes (I, II, III, and IV), with VRI Class I lands having the greatest relative visual values and VRI Class IV lands having the lowest relative visual values.

Visual resource management (VRM)
The planning, design, and implementation of management objectives for maintaining scenic values and visual quality.

Visual resource management (VRM) classes
Scenic resource management objectives assigned to BLM-administered lands in the RMP process, which prescribe the amount of change allowed in the characteristic landscape. All actions proposed during the RMP process that would result in surface disturbances must consider the importance of the visual values and the impacts of the project on these values. Management decisions in the RMP must reflect the value of visual resources. The value of the visual resource may be the driving force for some management decisions. There are four VRM classes (I, II, III, and IV).

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