ANL/EVS-19/1

Compensatory Mitigation and Comprehensive Mitigation Planning for Solar Energy Development in the United States

Environmental Science Division

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Compensatory Mitigation and Comprehensive Mitigation Planning for Solar Energy Development in the United States

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March 2019

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

GENERAL ACRONYMS AND ABBREVIATIONS

ACE	Army Corps of Engineers
ACEC	Area of Critical Environmental Concern
ACHP	Advisory Council on Historic Preservation
AGFD	Arizona Game and Fish Department
AMP	Advanced Mitigation Program
BLM	Bureau of Land Management
BMP	best management practices
CDFG	California Department of Fish and Game
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFCP	California Farmland Conservancy Program
CFR	Code of Federal Regulations
CM	compensatory mitigation
CMP	Compensatory Mitigation Policy
CSP	concentrating solar power
CWA	Clean Water Act
DOD	Department of Defense
DOI	Department of the Interior
DSIRE	Database of State Incentives for Renewables & Efficiency
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FCA	Federal Conservation Act (Maryland)
FWS	Fish and Wildlife Service
HCP	habitat conservation plan
IDEA	Impact-Directed Environmental Accounts
IM	Instructional Memorandum
LTMM	long-term management and maintenance

MDNR	Maryland Department of Natural Resources
MEPA	Massachusetts Environmental Policy Act
MOA	memorandum of agreement
NEPA	National Environmental Policy Act
NFWF	National Fish and Wildlife Foundation
NHPA	National Historic Preservation Act
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NREL	National Renewable Energy Laboratory
PA	programmatic agreement
PT	power tower
PV	photovoltaic
RAMP	Reginal Advance Mitigation Planning
REAT	Renewable Energy Action Team
RCIS	Regional Conservation Investment Strategies
RIBITS	Regulatory In-lieu Fee and Banking Information Tracking System
ROD	Record of Decision
SEIA	Solar Energy Industries Association
SEZ	solar energy zone
SHPO	state historic preservation officer
THPO	tribal historic preservation officer
USDA	U.S. Department of Agriculture

UNITS OF MEASURE

acre	acre
ft	foot (feet)
ft^2	square foot (feet)
GWh	gigawatt hour
mi	mile(s)
MW	megawatt(s)
MWh	megawatt hour
yr	year

EXECUTIVE SUMMARY

Compensatory mitigation (CM) generally refers to compensating for (or offsetting) remaining impacts of a project after all appropriate and practicable avoidance and minimization measures have been applied. The use of CM to offset some of the adverse impacts of development can be an effective means of allowing permitting to proceed expeditiously and also of gaining support for development from affected communities and/or conservation groups.

This report provides an overview of CM used to compensate for unavoidable adverse impacts at solar energy facilities. The report discusses the types of CM actions taken, as well as the methods used to satisfy CM requirements. It also addresses recent changes in CM requirements from the Department of the Interior. The goal of the report is to provide a comprehensive background on how CM has been applied to existing solar energy projects and how it may be applied in the future based on federal, state, and local requirements and policies. Using best available data, we present CM requirements and costs for solar energy facilities that vary in size, geographical location, and resources affected in order to better understand the variability in CM costs. In general, higher CM costs have been associated with

- CM requirements under the Clean Water Act (CWA) and Endangered Species Act (ESA);
- Land acquisition, preservation, and/or restoration methods;
- Large solar energy facility nameplate capacity (MW); and
- Solar energy facilities located in states that have additional state-specific CM requirements.

In addition to facility capacity, the higher cost CM scenarios are driven by federal or state law and policies. Understanding when CM is required and how CM is applied at the project level can help provide solar energy developers with greater cost certainty and may also help to lower costs through identifying and implementing additional avoidance and minimization measures during project development. Considering innovative mitigation projects during the project planning process may also lower costs and decrease permitting burdens and/or increase project public acceptance.

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1 INTRODUCTION

Compensatory mitigation (CM) generally refers to compensating for (or offsetting) remaining impacts of a project after all appropriate and practicable avoidance and minimization measures have been applied. There can be some variation in the definition depending on the regulatory driver for specific CM actions. CM actions may be required by federal or state laws and regulations or through county stipulations applied during the project planning process, or they may be voluntary. Good project siting, site preparation practices, and on-site best management practices (BMPs) can avoid many impacts (and thus avoid the need for CM and associated costs). However, when there are requirements to compensate for residual impacts, the costs to utility-scale solar energy developers can be significant. In addition, identifying the mitigation actions and locations that will be acceptable to permitting agencies can be a lengthy process, resulting in costly construction delays. Better information on CM requirements and costs could help solar energy developers work with regulators to establish protective and timely CM requirements, and would allow them to anticipate and plan for the associated costs. Knowing the requirements in advance may also help to lower the costs through identifying innovative mitigation options with multiple benefits.

To date, the types of required CM for utility-scale solar energy facilities and associated costs have not been analyzed and reported on across the industry. This report

- Provides background on CM requirements under federal laws and policies and state laws.
- Describes CM methods, and suggests how CM costs might be affected by the type of resource affected, as well as the solar energy facility capacity, technology, and location.
- Details efforts in 2016 and 2017 to identify, assemble, and analyze data on CM requirements and costs for solar energy development, and presents results.
- Describes recent Bureau of Land Management (BLM) guidance on CM for proposed projects on public lands (BLM 2018b), and the impacts of the new guidance on previous BLM efforts to develop regional mitigation strategies.
- Proposes BMPs that could be implemented to reduce costs or add cost certainty for mitigating impacts from solar energy development.
- Provides additional resources to interested industry stakeholders and policymakers.

1.1 BACKGROUND ON CM REQUIREMENTS UNDER FEDERAL LAWS AND POLICIES

The foundation of requirements to offset or compensate for the residual impacts of utility-scale solar energy development is included in federal laws to offset loss of wetlands (Section 404 of the CWA of 1972), to offset impacts on endangered species and their habitats (the ESA of 1973, as amended), and to take into account effects on historic properties (National Historic Preservation Act [NHPA] of 1966). In addition, for projects on or connected with public lands, regulations under the National Environmental Policy Act (NEPA) of 1969 require the consideration of mitigation across a wide range of impacts through a mitigation hierarchy: first avoiding and minimizing impacts where possible, and then compensating for impacts by replacing or providing substitute resources or environments (Part 1508.2 of Title 40 of the Code of Federal Regulations [40 CFR 1508.2]). Additional discussion on the federal authorities to utilize CM under these laws has recently been published (Wilkinson et al. 2019).

1.1.1 CM Requirements under the CWA

With the passage of the CWA in 1972, any action that would involve filling a wetland or disturbing a wetland or stream requires a federal permit. If the impact on wetlands or streams cannot be avoided, CM for lost wetlands or stream functions is required under Section 404 (EPA 2018) (see Figure 1-1). The two main goals of the Section 404 program are to restore the integrity of the nation's waters and to ensure that there be "no net loss" of wetland and stream area and functions (ELI and LTA 2012). The program is administered by the U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers (ACE).

CM to aid in achieving the CWA goals is conducted through purchase of credits from approved mitigation banks, payment to an approved in-lieu fee program, or permittee-responsible mitigation (listed in order of preference of the administering agencies). To address problems identified with in-lieu fee programs (e.g., not meeting standards for wetlands replacement, timeliness, or durability [ELI 2006]), new regulations known as the CM Rule were jointly promulgated by the EPA and the ACE in 2008 (40 CFR 230). The CM Rule requires all forms of mitigation utilized for CM to meet an equivalent set of standards based on better science, increased public participation, and innovative market-based tools (ACE and EPA 2008). Of the four methods for CM (establishment, restoration, enhancement, or preservation of aquatic sites), the permitting agencies have expressed a preference for restoration, because restoration provides a net increase in area and function of the watershed (ELI and LTA 2012). The CM Rule also instructed the EPA and ACE to take a more regional watershed approach to stream assessment and restoration projects related to CM requirements (EPA 2012). A goal of this newer approach includes placing stream reach-scale restoration projects into a watershed context and development of goals and objectives at both the broad (watershed) and narrow (restoration project-specific) level. A recent review discusses policy changes and progress in CM practice since the 2008 CM Rule, and opportunities for improvement (Hough and Harrington 2019).

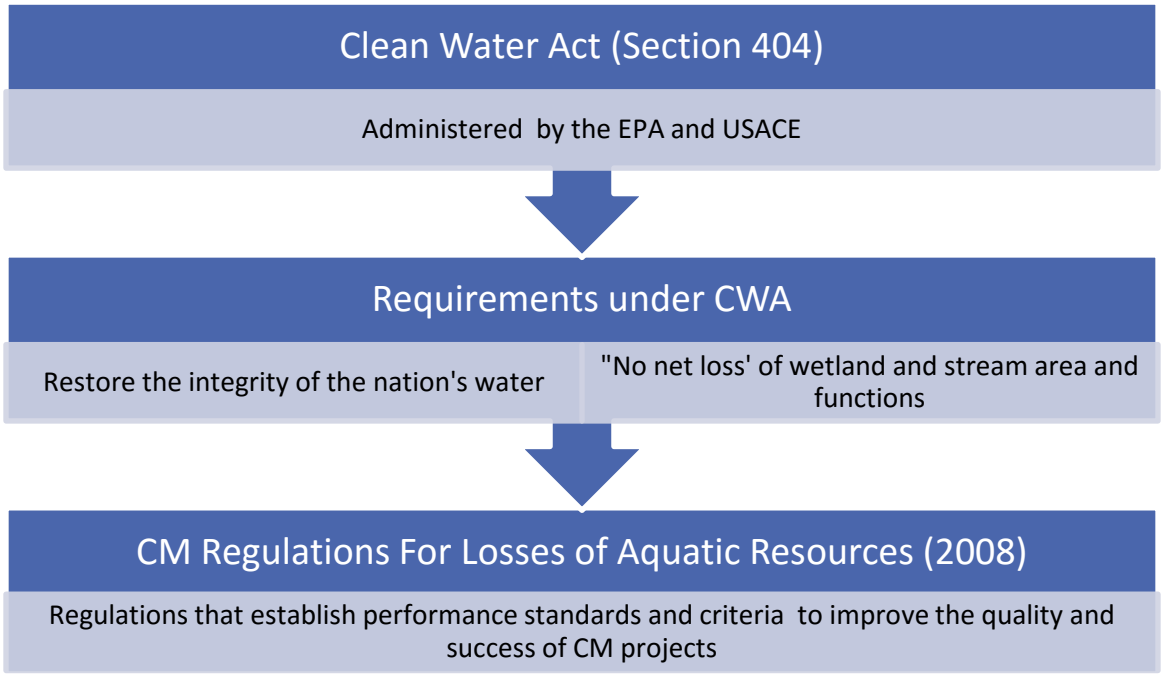

FIGURE 1-1 CM Requirements under the CWA

1.1.2 CM Requirements under the ESA

The ESA, administered by the U.S. Fish and Wildlife Service (FWS), requires replacement of lost habitat for protected species in order to prevent net loss of habitat (FWS 2011) (see Figure 1-2). The ESA requires that the "incidental take" (unintentional killing or capturing) of listed species be permitted through the design and implementation of a habitat conservation plan (HCP) that minimizes and mitigates harm to the affected species. In an HCP, CM measures are identified when it is found that loss of habitat for listed species cannot be avoided for a specific development project. County-wide or regional HCPs take a broader landscape approach to identifying appropriate CM locations and actions (FWS 2012). CM actions specified in HCPs include (but are not limited to) payment into an established conservation fund or bank, preservation of existing habitat (via acquisition or conservation easement), enhancement or restoration of degraded or former habitat, establishment of buffer areas around existing habitats, modifications of land-use practices, and restrictions on access (FWS 2011). The FWS published an ESA CM policy in December 2016 that included a goal of net conservation gain for CM, and recommended a regional planning approach in implementing CM for endangered species (FWS 2016). In July 2018 the FWS rescinded the 2016 ESA CM policy (Federal Register Vol 83, No 146, p. 16472), stating that the FWS does not have authority to require net conservation gain. This action generally reinstated all previous policies and guidance documents that were superseded by the 2016 ESA CM policy.

While the resources protected under the CWA and the ESA differ (i.e., wetlands and jurisdictional waters of the United States under the CWA versus certain listed species and their habitat under the ESA), the CM goals, mechanisms, and approach are similar (see Figure 1-3).

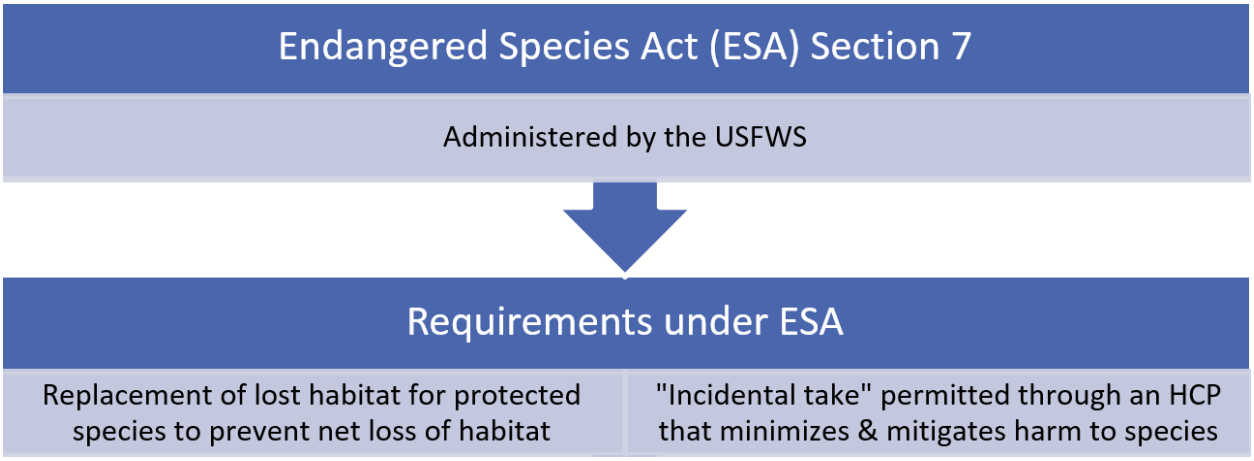

FIGURE 1-2 CM Requirements under the ESA

CM Regulations for Losses of Aquatic Resources (40CFR230; 2008)	ESA Requirements	Both
•Regulations require CM to meet standards based on better science, increased public participation, and innovative market tools.	• Requires Habitat Conservation Plans to compensate for incidental take, providing partnerships with private land-owners to conserve ecosystems	•Mitigation mechanisms include permittee-responsible mitigation, mitigation/conservation banking, and in-lieu fee programs. •Regional approach to mitigation. •Goal of "no net loss".

FIGURE 1-3 CM under CWA and ESA

1.1.3 CM Requirements under the NHPA

The NHPA applies to federal undertakings and undertakings that are federally permitted or funded. The regulations implementing Section 106 of the NHPA, codified at 36 CFR 800, define the process for identifying historic properties that are listed on or eligible for the National Register of Historic Places and for determining whether an undertaking will adversely affect those properties. These regulations also establish the process for engaging in consultation to avoid, reduce, or mitigate any adverse effect on the historic property. Consultation can include government-to-government consultation between federal agencies and American Indian Tribal Governments and engagement with the Advisory Council on Historic Preservation (ACHP), State Historic Preservation Officers (SHPOs), Tribal Historic Preservations Officers (THPOs), and other interest groups or organizations that may assist in the management of historic properties.

The regulations implementing Section 106 of the NHPA (36 CFR 800) do not define specific mitigation measures to compensate for adverse effects on historic properties and instead call for the lead agency and consulting parties to "develop and evaluate alternatives or modifications to the undertaking that could avoid, minimize, or mitigate adverse effects on historic properties" (36 CFR 800.6). Compensatory measures are a way to mitigate adversely affected properties and can be discussed in consultation, planned for in separate documents, and attached to memorandum of agreement (MOA) and programmatic agreement (PA) proceedings. Examples of CM of historic properties can include but are not limited to the designation of an off-site historic conservation, research, or preservation area; survey of a previously unsurveyed area; or distribution of funds to a local historic conservation group.

1.1.4 CM under the NEPA

For solar energy projects connected to federal actions (e.g., on or connected with public lands, or receiving federal loan guarantees), regulations under NEPA require the consideration of mitigation across a wide range of impacts using the mitigation hierarchy, including CM after avoidance and minimization measures have been applied (40 CFR 1508.2). NEPA provides a potential mechanism for considering CM for resources and values that are not addressed under CWA, ESA, or NHPA, including impacts on lands with special designations such as wilderness areas, recreational values, subsistence hunting resources, visual resources, socioeconomics, and environmental justice. For example, a BLM Record of Decision (ROD) for permitting of oil and gas development activities on public lands in Alaska required CM for impacts on subsistence resources and activities, cultural resources, and environmental justice (BLM 2015). However, inclusion of CM requirements in BLM RODs for projects on public lands has become more unlikely under newer policy and guidance (see section on federal policies below).

1.1.5 Federal CM Policies

The Departments of Defense (DOD), Interior (DOI), and Agriculture (USDA), as well as the EPA and the National Oceanic and Atmospheric Administration (NOAA), were required to develop agency-specific approaches for CM through a 2015 Presidential Memo (White House 2015). The 2015 Presidential Memo was rescinded in March 2017 through Executive Order (EO) 13783 (Executive Office of the President 2017). The policies of these federal agencies related to CM have seen varying degrees of change subsequent to EO 13783. For example, EPA and ACE policies for CM under the CWA do not appear to have changed substantially (supported by the fact that as of March 2019 the only changes made to the CM guidance available on the CWA CM website [EPA 2018] were adding links to a December 2016 *Handbook on Coral Reef Impacts: Avoidance, Minimization, and Compensatory Mitigation and Restoration* [USCRTF 2016]), and to information on Compensatory Mitigation in Alaska. DOD and NOAA policies for Natural Resource Damage Assessment (NRDA), similar to CM requirements) also have not changed substantially; for example, the policy on preparing integrated NRDA plans, updated in 2017, still includes CM as an option for mitigating damage to natural resources (DOD 2017, 2018; NOAA 2016). No changes in the USDA Natural Resources Conservation Service (NRCS) policies for mitigation banking have been announced (USDA 2019).

EO 13783 has resulted in substantial changes to policies for DOI agencies. In July 2018, the FWS withdrew the ESA Compensatory Mitigation Policy (CMP) (published in December 2016), specifically rescinding the CMP goal of net conservation gain. However, essentially all policies and guidance documents that were superseded by the 2016 ESA CMP were reinstated, such that overall, long-standing FWS policies requiring CM for loss of habitat for ESA-listed species remain in effect. The BLM also issued an Instruction Memorandum (IM 2018-093) in July 2018 stating that CM requirements for the use of public lands are not permissible, and that the BLM must refrain from authorizing any activity that causes unnecessary or undue degradation pursuant to Section 302(b) of the Federal Land Policy and Management Act (BLM 2018a). IM 2018-093 also rescinded BLM's *Mitigation Handbook* (BLM 2016c). IM 2019-018, issued in December 2018, superseded IM 2018-093 (BLM 2018b). The two IMs are very similar, but IM 2019-018 states more explicitly that CM that is in compliance with State requirements or other federal requirements is applicable for projects (solar or other) on BLM-administered lands.

BLM's IM 2019-018 now supersedes decisions related to CM for solar energy development that are subject to BLM's Solar Energy Program, established in 2012 through the ROD for Solar Energy Development in Six Southwestern States (BLM 2012). The BLM has authorized more than 20 utility-scale solar energy projects on public lands in three states (Arizona, California, and Nevada). Through the 2012 ROD, the BLM also identified 19 solar energy zones (SEZs, areas preferred for solar energy development) in six states and committed to the creation of regional CM strategies for the SEZs. Regional CM strategies were previously completed by the BLM for eight of the SEZs (BLM 2014, 2016a,b, 2017a), and development of regional mitigation strategies had begun for four additional zones (BLM 2017b,c). The regional CM strategies included recommended per-acre CM fees for SEZs based on unavoidable impacts on vegetation communities and associated ecosystem services (see Section 2.5). Some of the strategies also recognized potential unavoidable adverse impacts on cultural resources, visual resources, and lands with special designations, but left the determination of any associated CM fees to future project-specific NEPA evaluations. Under IM 2019-018, the BLM now may not require CM as a condition for project approvals. However, the BLM may consider voluntary CM by project developers as a means to reach a Finding of No Significant Impact. In addition, the IM does not affect CM required by federal laws (e.g., the CWA and ESA) and does not affect CM required under state laws. Thus, CM for impacts on wetlands and ESA species and CM under state laws are still required for solar energy projects on public lands. Voluntary CM for other impacts of solar energy projects on public lands has also not been precluded by IM 2019-018.

1.2 BACKGROUND ON CM REQUIREMENTS UNDER STATE LAW

A number of states have environmental planning laws similar to NEPA and require environmental reviews for state or local government projects or for private actions of businesses or individuals (see Figure 1-4) (DOE 2017). Of the states with NEPA-like regulations, those that have granted permits for larger (defined here as 15 MW or more) solar energy development projects as of 2016 include California, Georgia, Hawaii, Maryland, Massachusetts, New Jersey,

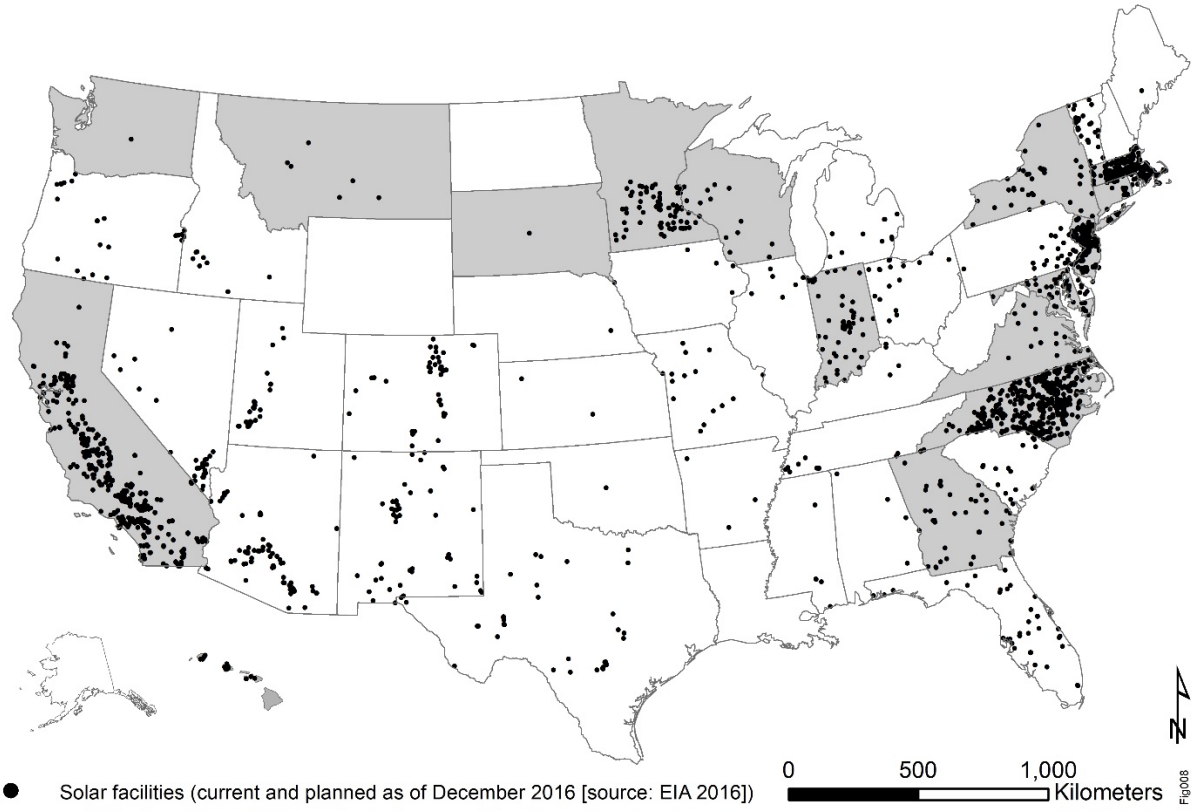

FIGURE 1-4 States with Environmental Review Statutes

New York, North Carolina, and Washington. States may require CM for other resources in addition to the resources for which CM is required under CWA, ESA, and NHPA.

Examples of states that have additional laws or programs that could result in CM requirements for solar energy facilities include the following:

- *Maryland.* Projects subject to Maryland's Forest Conservation Act (FCA) require a Forest Conservation Plan, which describes project disturbance and how existing forested and sensitive areas will be protected, including CM requirements (MDNR 2004). The Maryland Department of Natural Resources (MDNR) Forest Service administers the FCA, but the law is implemented at the county level. CM can include on-site reforestation, off-site reforestation on state-owned or other publicly owned land in the county and watershed in which the construction activity is located, or the use of forest mitigation bank credits in the watershed in which the construction activity is located (Maryland Natural Resources Code Ann. § 5-103 2013).

- *California.* CM may be required for projects seeking permits if there are impacts on endangered, threatened, and candidate plant and animal species under the California Endangered Species Act (CESA) (CDFG 2010). The Senate Bill 34 Advanced Mitigation Program (AMP) provides a mechanism

for implementing CM for impacts from large-scale renewable energy projects at the state level (California Senate Bill 34 2010; CDFG 2010). The program is administered through the California Department of Fish and Game (CDFG), which uses in-lieu fees provided by developers to acquire and restore habitat as mitigation for project impacts. The mitigation actions covered by the AMP include land acquisition through purchase of mitigation lands or conservation easements, habitat restoration, and habitat enhancement. CM may also be required for the development of solar energy projects subject to the California Environmental Quality Act (CEQA), including CM for agricultural lands.

- *Massachusetts*. Mitigation for agricultural lands is authorized through EO 193 and is applied through individual project review under the Massachusetts Environmental Policy Act (MEPA) (Kurtzman and Roberston-DuBois 2016). The Massachusetts Endangered Species Act requires CM for projects seeking permits if they have an impact on state-listed species (MA NHESP 2019).

- *New Jersey.* The No Net Loss Reforestation Act has implemented an acreage-based mitigation program that applies to state-funded construction projects (NJ DEP 2017).

- *Vermont.* Land Use and Development Act criterion 9(B) allows the Agency of Agriculture, Food & Markets to review projects that may have an impact on agricultural lands and could require CM depending on the quality of the agricultural soils (Vermont Agency of Agriculture 2017).

This list is not all-inclusive but is intended to characterize the variety of state laws that could result in CM requirements for solar energy development. A comprehensive review of mitigation requirements under all state laws is not provided in this report. Instead, in Section 2.4.4 we examine the State of Maryland and the State of California as case studies to provide an example of how laws and regulations regarding CM requirements and implementation vary by location. California and Maryland were selected for the following reasons:

- *Geographical location*. The two states are located in different geographical regions, and development of a solar energy project would have an impact on different resources in each state.

- *Solar energy generation*. Both California and Maryland have granted permits for solar energy facilities with greater than 15-MW capacities.

- *State laws with CM requirements.* Both states have laws that require CM for projects in their respective states.

2 CM METHODS AND STRUCTURES

2.1 CM METHODS

A number of methods can be used to implement CM. The method(s) selected at the project level can vary depending on the entity issuing the permit, the preferences of the developer, the project location, or the resource(s) affected by project development. Table 2-1 provides a comparison of CM methods.

- *Land acquisition, preservation, and/or restoration.* These are the most common CM methods. Private land may be purchased (if suitable and available) and then preserved or restored to compensate for the specific resources affected at the solar energy development site. Public lands (federal or state) may also be used for preservation and/or restoration. For effective CM, the timeframe for preservation should be at least as long as the duration of the project impacts, but often the area preserved is established in perpetuity.

- *Study of a resource to identify mitigation needs.* Funding for study of a resource may be required as CM when the impact on a resource from solar energy development is unknown and further information is required.

- *Other CM methods.* These CM methods may include contributing monetary funds for the improvement of various resources affected, typically in the same region as the solar energy development facility. These other CM methods may be required by the permitting agency to comply with federal or state regulations or agreed to voluntarily by the developer. If CM methods are required, the entity issuing the permit would specify the methods during the project planning phase. Additional CM methods may include compensating for the additional strain that development may place on local community services (e.g., police and fire departments, schools) or providing outreach and educational materials about sensitive cultural, ecological, or other resources; such CM actions are typically voluntarily agreed to by project developers, as they do not have a federal legal basis.

2.1.1 Land Acquisition, Preservation, and Restoration

Land acquisition, preservation, and/or restoration are the most common CM methods and are typically used to comply with requirements under the CWA Section 404 administered by the EPA and with requirements of the ESA administered by the FWS (ACE and EPA 2008; FWS 2011). Regulations jointly promulgated by the EPA and the ACE in 2008 define CM under the CWA as the restoration, establishment, enhancement, and/or preservation of wetlands, streams, and other aquatic resources to offset unavoidable adverse impacts that remain after all appropriate and practicable steps have been taken to avoid and minimize those adverse impacts (EPA 2012). Such actions have been used to mitigate for unavoidable adverse impacts on water resources that arise from the development of large-scale solar energy facilities.

TABLE 2-1 Comparison of Mitigation Methods[a]

	Land Acquisition, Preservation, or Enhancement	Study of a Resource to Identify Mitigation Needs	Other CM Methods
Regulatory or policy basis for CM?	Yes • CWA Section 404 • ESA Section 7 • Various state laws	Sometimes • NEPA and state regulations • Generally determined by the entity issuing permit (i.e., county planning office or state land management agency) or entered into voluntarily	Sometimes • NEPA and state regulations • Generally determined by the entity issuing permit (i.e., county planning office or state land management agency) or entered into voluntarily.
Resources addressed by CM	• Species • Vegetation • Water/riparian habitat • Other land types	• Air quality (e.g., study of dust palliatives) • Cultural resources • Habitat connectivity • Soil/erosion • Species	• Cultural, ecological • Predator management • Social services
Cost components	• Purchasing land and/or obtaining easements/leases for sufficient timeframe • Habitat restoration and enhancement activities • Monitoring • Administration and contingency fees	At the discretion of entity issuing permit and/or developer; dependent on the resource being affected	At the discretion of entity issuing permit and/or developer; dependent on the resource being affected

[a] Categories based on CM data collected for this report; some cases may exist in which differing CM methods apply for different resources (e.g., land acquisition/enhancement may be used to mitigate for air quality or habitat connectivity impacts).

Either private lands or public lands may be used for land acquisition and preservation. For private lands, a developer may purchase the land and then provide for long-term preservation of the land, most often through obtaining a conservation easement. Public lands (federal or state) may also be used for preservation and/or restoration, if the managing agency consents to long-term use as a mitigation site and is willing to limit other uses through leasing or easements. Public lands that are managed for preservation should be managed to prevent the decline of resources. For habitat restoration or enhancement, after acquisition a developer would restore or enhance a disturbed area, ideally with native vegetation, to compensate for the loss of vegetation and habitat from solar energy development. Both the 2008 CM regulations under the CWA and the ESA allow for habitat preservation and/or restoration for mitigating impacts and emphasize a regional approach that includes assurances of long-term protection of compensation sites, financial assurances, and identification of the parties responsible for specific project tasks.

Mitigation ratios may be used to adjust for the relative quality of the affected site versus that of the mitigation project location, relying on function and condition assessments for the affected resource, rather than simply the size of the area being affected (ACE and EPA 2008). If the resource being affected is of a high value (i.e., critical habitat for a species or a high-functioning wetland), a more than one-to-one acreage replacement ratio may be necessary to achieve functional equivalence between the impact and mitigation sites. Mitigation ratios may also be greater than one-to-one to address uncertainty of mitigation success or to compensate for the length of time it takes to establish a restored site (ACE and EPA 2008). Although no examples were located in the project documents reviewed, mitigation ratios might also be set at

less than one-to-one in instances in which the affected resource area is of lower quality than the corresponding resource in the mitigation location.

Most of the large-scale solar energy projects that have required CM also required some form of land acquisition, preservation, and/or enhancement to mitigate for unavoidable adverse impacts. Examples of resources that solar energy facilities have been required to compensate for using land acquisition, preservation, and/or restoration are shown in Figure 2-1. Based on assessments performed under the BLM Solar Energy Program and NEPA, it is also possible that these CM methods could be used to compensate for impacts on other resources, for example, cultural, recreational, visual, subsistence hunting, and/or socioeconomic resources.

2.1.2 Funding for Resource Studies to Identify Mitigation Needs

In some cases, CM has consisted of provision of funds that contribute to further study of a resource in order to identify the best actions to protect that resource. The impact on a resource may be unknown or might not be easily mitigated through land or habitat compensation. Examples of such resource studies include the following:

- Study of a species that supports state or federal agency decision-making related to the long-term management and conservation of the species;
- Study of the effectiveness of dust palliatives and/or their impacts on the environment;
- Ethnographic studies;
- Analysis of methods to mitigate the loss of soils; and
- Study of habitat connectivity potential for a species.

2.1.3 Other CM Methods

Additional CM actions that serve to mitigate for unavoidable adverse impacts and have been implemented for some solar energy projects include the following:

- Funding for predator management (i.e., raven management to mitigate for potential impacts on desert tortoise);
- Monetary compensation to offset impacts on social services incurred as a direct result of development of the solar energy facility, such as
  - Law enforcement,
  - Local school districts, and
  - Emergency services; and
- Funding for outreach materials and activities to educate the public about sensitive resources.

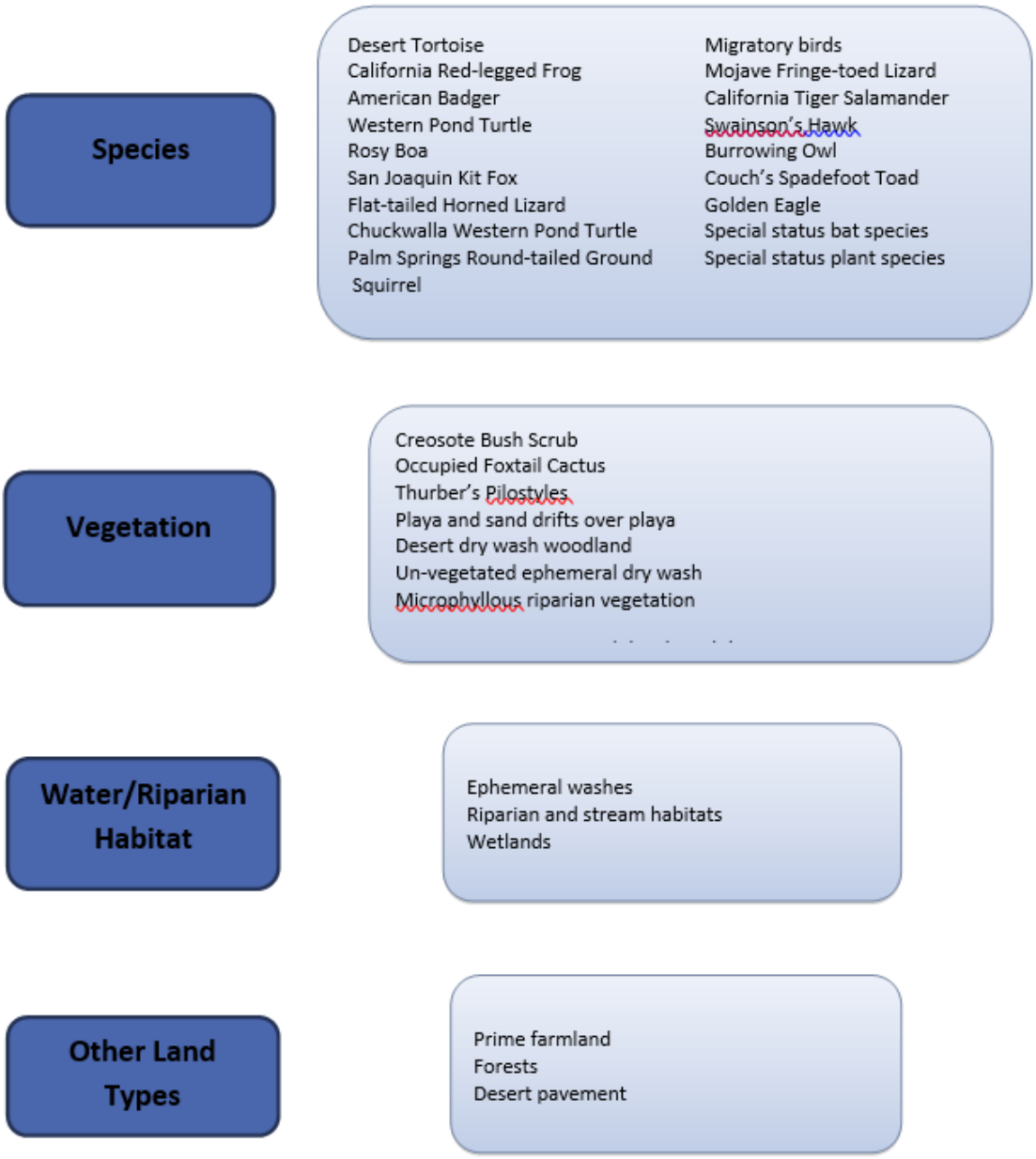

FIGURE 2-1 Examples of Resources for which Land Acquisition and Preservation or Enhancement CM Methods Have Been Applied

2.2 CM STRUCTURES

The CM structures discussed in this section apply only to the traditional CM methods of land acquisition, preservation, and/or restoration. CM structures can provide solar energy developers with the flexibility to implement CM required for project development. The common structures are in-lieu fee programs, mitigation banking and conservation banking, and permittee-responsible CM.

2.2.1 In-Lieu Fee Programs

An in-lieu fee program is a form of "third-party" compensation because a third party is responsible for the implementation and success of the CM. If a project developer/applicant chooses to implement CM for a project through an in-lieu fee program, the applicant would make a payment for land acquisition, preservation, and/or restoration activities to a governmental or nonprofit natural resources management program sponsor. The program sponsor would not usually undertake CM projects until after payments are received (ACE 2017). The program sponsor also generally has a previously established agreement with regulatory agencies to use in-lieu fee payments collected from permit applicants (USACE undated). According to the Regulatory In-lieu Fee and Banking Information Tracking System (RIBITS), which was developed and is maintained by the ACE with support from the EPA and FWS, as of 2016 there were a total of 84 approved in-lieu fee programs and 1,095 in-lieu fee sites across 26 states (ACE 2017). RIBITS tracks only in-lieu fee and banking information for CM required by federal law in compliance with CWA Section 404 and FWS Section 7, and therefore does not include banks or in-lieu fee programs established to comply with state laws.

2.2.2 Mitigation Banking and Conservation Banking

Mitigation banking and conservation banking are also considered "third-party" compensation. Unlike in-lieu fee programs, mitigation and conservation banks are areas where natural resources are conserved and managed in perpetuity and are generally established prior to payments from a developer/permit applicant. Existing mitigation banks have been used to mitigate for impacts on wetlands, streams, riparian areas, or other aquatic resources. Conservation banks are permanently protected lands managed for species that are endangered, threatened, candidates for listing, or otherwise species-at-risk (FWS 2012). Mitigation and conservation banks may be established through restoration or preservation of existing habitat, habitat enhancement, or habitat establishment. The value of a mitigation or conservation bank is determined by quantifying the resource functions restored, preserved, enhanced, or established in terms of "credits," which can be purchased by permit applicants to meet their requirements for CM (ACE undated). According to RIBITS, in 2016 there were 1,759 mitigation banks across 41 states and 167 conservation banks across 13 states (ACE 2017).

2.2.3 Permittee-Responsible CM

For permittee-responsible CM, the permittee is responsible for meeting the project's requirements for CM. The CM actions (land acquisition, restoration, preservation, enhancement, or establishment) may be provided at or adjacent to the project site or at another location, usually within the same watershed or region (ACE 2017).

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3 CM PRACTICES AND COSTS

As explained in Section 1.1, the federal regulatory environment is currently the primary driver of CM, directing CM through requirements under the CWA, ESA, NHPA, and NEPA. In some cases, state laws may also require projects to implement CM. At the individual project level, however, CM practices vary across a wide range of methods and can cover many different resources. For some projects, developers put forward voluntary CM actions; in others, CM might be required as a condition of project approval through negotiations with federal regulating agencies and/or state or county planning offices. The following sections synthesize data gathered through document review and industry outreach and suggest how various factors might influence the total cost of CM. Appendix A provides tables summarizing the results of the document review and industry outreach efforts. It includes project-specific information (excluding project identifiers) and provides some baseline but not comprehensive cost estimates for CM actions.

3.1 RESEARCH METHODOLOGY

The methodology for evaluating CM requirements for solar energy facilities with capacities greater than 15 MW included a combination of literature review and outreach to industry and government permitting agencies to develop a database containing implemented CM actions as well as estimates of CM costs. Solar energy facilities operating or under construction within the United States in 2016 were included. Data were collected to

- Identify and categorize various types of CM actions, and
- Identify CM costs associated with specific CM activities, where data were available.

3.1.1 Document Review

Data on CM and associated costs were obtained from publicly available project documents. The Solar Energy Industries Association (SEIA) Major Solar Projects List was used to create a list of solar energy projects larger than 15 MW (SEIA 2016). For those projects, a directed literature review was conducted to obtain documents associated with project development, including

- Environmental impact statements and reports,
- Biological assessments, and
- Permits and mitigation reports required for project development.

Many of the documents obtained were project planning documents, written prior to construction or operation of the solar energy facility, and thus required mitigation may have been modified prior to implementation. In general, project documents with CM data tended to be more publicly available for projects sited on public land (e.g., federal lands managed by the BLM) or

for projects sited on private lands within counties that have extensive experience with solar energy permitting (i.e., Imperial County, California). In total, more than 130 documents were reviewed for 41 solar energy projects across 5 states (of which CM cost data were identified for fewer than 10 solar energy projects; see Appendix A). Other documents reviewed included reports related to CM policies, state and federal regulations, county planning documents, peer-reviewed journal articles, and analyses of in-lieu fee programs and conservation banks used to implement CM activities.

3.1.2 Stakeholder Outreach

A number of targeted outreach measures were conducted to obtain data on CM actions and costs directly through facility developers and agencies or organizations involved in the permitting process, as follows:

- Emails sent to approximately 30 solar industry representatives included a link to a survey requesting information about CM, site preparation, and on-site mitigation.

- For some states that have both solar energy facilities with capacities greater than 15 MW and state regulations that include CM requirements, outreach was conducted to obtain data from county planning departments that have processed solar energy facility permits and to request information on project-related CM and associated costs.

- Webinars were conducted with members of the Large-scale Solar Association, Solar Energy Industry Association, and nongovernmental organizations concerned with solar energy development. These webinars provided background information about this CM project and solicited information related to CM, including cost data.

Follow-up emails were sent and telephone interviews were conducted to attempt to increase response rates. Targeted questions in the survey were meant to solicit information about the causes for the variability in CM costs including technology, location, facility size, and affected resource. The survey outreach and follow-up emails and interviews yielded limited results, particularly with respect to specific CM cost data. However, some information related to CM practices and requirements for larger solar energy facilities was obtained.

3.2 RESOURCES AFFECTED BY SOLAR ENERGY DEVELOPMENT

Section 1 discussed CM methods that have been employed for solar energy development and the associated resources for which CM has been applied. CM requirements are generally higher for projects affecting wetlands, significant cultural resources or specially designated areas, or critical habitat for ESA-designated species. However, insofar as possible, solar energy

developers avoid impacts on these resources through careful siting practices, thus also avoiding associated CM fees.

In general, the most common (and costly) CM actions are land acquisition and preservation and/or restoration associated with impacts on species, vegetation, water and riparian habitat, and land types such as agricultural lands and forests. Implementing mitigation ratios for a particular resource usually further increases the cost of CM as more land is required per acre of disturbance. For example, a solar energy project in California required a 2:1 mitigation ratio for the California red-legged frog, meaning that for every acre of habitat disturbed from project development activities, 2 acres of land needed to be acquired elsewhere to compensate for the habitat disturbance on-site. A less common action is basing the acreage required for CM on affected species population rather than on habitat disturbance. For example, the CDFG has required compensation with a minimum of 6.5 acres of foraging habitat per pair or unpaired burrowing owl to offset the loss of foraging and burrow habitat (CDFG 1995).

If a developer is paying into a mitigation fund to achieve land acquisition and preservation, the mitigation fee is generally calculated to pay the estimated costs for the following (CEC 2010; ELI 2009), including

- Obtaining title or rights to the land,
- Monitoring,
- Protecting the area from further disturbance, and
- Administration fees and contingency fees.

Mitigation actions that include habitat restoration and/or enhancement would incur the additional costs to conduct and monitor those actions.

Nested mitigation, or conducting CM (through acquisition, restoration, and/or preservation) on lands that mitigate for impacts on multiple resources simultaneously, can decrease costs by requiring less mitigation acreage while still providing the required amount of CM (or more for some resources). In cases in which the mitigation lands meet criteria for two or more resources that require greater-than-one mitigation ratios, the highest ratio would apply.

Based on the somewhat limited cost data available for this assessment, Table 3-1 provides a cost comparison between the resource(s) being mitigated and the methods used to satisfy the CM requirement. The table suggests that mitigation methods other than land acquisition, preservation, or restoration (such as funding for resource studies to identify mitigation needs; funding to compensate for additional strain on local social services; funding for outreach and educational materials and activities; and the like) are generally less costly. These mitigation methods typically are assessed and determined at the individual project level based on project-specific impacts, the local environment, and the surrounding community.

TABLE 3-1 Estimated Costs for CM Resources and Methods

Resource	Mitigation Method	Cost per Acre[a]
Special status species (various species)	Land acquisition, preservation, or restoration	$105–$3,668
	Funding for resource studies	$82–$120
	Other (funding for various recovery actions)	$64–$843
Water/riparian habitat	Land acquisition, preservation, or restoration	$3,088
Landscape-level resources	Land acquisition, preservation, or restoration	$1,836
Cultural resources	Funding for resource studies	$1,586
Specially designated area	Land acquisition, preservation, or restoration	$165
Social services	Other methods (e.g., funding for law enforcements, school districts, emergency services, etc.)	$144
Water quality	Funding for resource studies	$36–$41
Soils	Funding for resource studies	$21

[a] Costs summarized from individual project data are presented in Appendix A, Table A-1. In some cases, costs in source documents were not presented as a cost-per-acre fee. For ease of comparison, we have calculated cost per acre for all mitigation actions based on reported facility areas.

3.3 SOLAR ENERGY FACILITY CAPACITY AND SIZE AND CM

For solar energy facilities, facility size (in terms of land area required) and capacity are directly correlated. The amount of power produced from a solar energy facility depends on the amount of infrastructure used to capture sunlight (e.g., the number of solar panels and their relative efficiency at a photovoltaic [PV] facility). A solar energy facility with a large generation capacity requires more infrastructure than a facility with a smaller capacity and therefore requires a larger area. An analysis was conducted by the National Renewable Energy Laboratory (NREL) (Ong et al. 2013) to determine land-use requirements for various solar technologies and system configurations on both a capacity and an electricity-generation basis, and the results are presented in Table 3-2.

Based on the CM data collected for this report, the types of mitigation actions required for solar energy projects do not appear to depend on facility size or capacity, although the *numbe*r of mitigation actions required for larger solar energy facilities may be greater than the number of mitigation actions required for smaller solar energy facilities. For preparation of this report, cost data for CM actions were located only for utility-scale solar energy facilities on public lands (see Table 3-3). From the available cost data for project-specific CM actions, there seems to be some correlation between solar energy facility capacity and the total and per-MW costs of CM. Available cost data indicate a trend of increasing total cost and per-MW cost with increasing solar energy facility capacity (with one exception). The correlation is less consistent between solar energy facility size and CM costs, likely because of inclusion of data for a 110-MW facility that has an unusually large reported size with respect to its capacity (see Table 3-3).

TABLE 3-2 Land-Use Requirements for Solar Energy Facilities by Capacity and Generation

Technology	Size (MW)	Land-Use Requirement	
		Capacity-Weighted Average (acres/MWac)	Generation-Weighted Average (acres/GWh/yr)
Fixed-tilt PV	< 20	7.6	4.4
1-axis tilt PV	< 20	8.7	3.8
Fixed-tilt PV	> 20	7.5	3.7
1-axis tilt PV	> 20	8.3	3.3
Parabolic t**rough**		9.5	3.5
Power tower	> 20	10	3.5

Source: Ong et al. 2013.

TABLE 3-3 Solar Energy Facilities by Capacity, Size, Technology, and CM Cost[a]

Capacity (MW)	Size (acres)	Acres/MW	Technology	Total Cost of CM	Cost per MW	Cost per Acre
110	1,670	15.2	Power tower	$200,000	$1,818	$120
112	594	5.3	PV	$1,614,326	$14,414	$2,718
130	806	6.2	PV	$2,181,274	$16,779	$2,706
200	1,520	7.6	PV	$4,129,759	$20,649	$2,715
250	1,920	7.68	Parabolic trough	$5,356,251	$33,605	$4,376
250	2,427	9.7	PV	$3,099,848	$12,399	$1,277
392	3,500	8.9	Power tower	$11,400,000	$29,082	$3,257

[a] Example facilities are located on public lands in California and Nevada, with cost information provided from public environmental assessment documents.

3.4 TECHNOLOGY TYPE AND CM

Cost data are available for four PV, two power tower, and one parabolic trough solar energy facilities. According to the data collected for CM actions and cost, there is no direct correlation between solar energy facility technology and either the cost of CM or the CM actions required for project development. The land requirements analysis presented in Table 3-3 indicates that for the capacity-weighted average, approximately 0.8 to 2.5 more acres/MW are required for facilities using parabolic trough and power tower technologies in comparison with facilities using PV technology. Based on these data, CM actions for solar energy facilities using power tower or parabolic trough technologies would be expected to be somewhat higher than CM costs for facilities of the same capacity using PV technologies. Although the data in Table 3-3 seem to support this correlation, there are too few power tower and parabolic trough facilities represented to support a definitive conclusion.

Concentrating solar power (CSP) technologies, including parabolic trough and power tower, generate thermal energy and require water for cooling. Cooling can be done with water

(wet cooling), air (dry cooling), or a combination of both (hybrid cooling). In addition, the source of water may be surface water or groundwater. Wet cooling provides the most efficient cooling but consumes a large amount of water (about the same amount as coal-fired or nuclear power plants, 500–800 gal/MWh) (DOE 2001). Dry cooling systems are less efficient in comparison with wet cooling but have significantly lower water consumption (SEIA 2017). In arid regions where water is scarce, CM actions to compensate for impacts on water availability and land subsidence could be required. However, no data on CM actions or costs related to water use were located as part of the preparation of this report.

Research is ongoing to better understand the impacts of solar energy development on birds and avian populations, and how the impact differs for the various solar technologies (CWG 2016). Good information on migratory patterns and life-cycle needs may inform siting decisions and help to avoid impacts. Currently, any CM required for avian impacts is identified on a project-specific basis in consultation with regulating entities, including the FWS where it has jurisdiction.

3.5 LOCATION AND CM

CM for individual solar energy facilities varies based on location because of environmental conditions, land ownership, local planning stipulations, and/or state laws.

Environmental conditions. The CM needs for solar energy facilities may differ because of geography, climate, regional landscape, and environmental conditions in the location of the facility. The species and vegetation types affected by solar energy development also vary by location. For example, CM for impacts on wetlands is applicable only where wetlands are present, and generally not in the desert Southwest where many larger solar energy facilities are located, because few wetlands are present.

Land ownership. The ownership of the land (private or public) on which a solar energy facility is located can also influence the CM requirements for solar energy development. CM costs can be higher for projects sited on federal land, since federal agencies have greater NEPA obligations that are not applicable to private parties or state agencies (Sonoran Institute 2011).

Local planning stipulations. CM can vary at the local level, based on local planning requirements or stipulations. CM requirements at the county level are typically implemented on a project-by-project basis and have included CM for impacts on social services (i.e., emergency response and schools), which are generally not required at the state or federal level. Costs for these CM measures will vary. For example, the following anecdotal information on such CM costs was found for facilities permitted at the county level in Imperial County, California:

- 1.5 percent of the cost of a project was subject to sales tax paid to the county and local transportation authority (Imperial County 2017); and

- $50 per acre per year during construction and $20 per acre per year during operations was required for emergency response (Imperial County 2011).

State laws. In some cases, CM may differ because of state laws where the solar energy facility is located (see Section 2.1.2 for overview on state laws requiring CM). These laws may or may not lead to CM requirements for solar energy development, but also can affect solar energy development through siting requirements, selection of technology, or on-site mitigation requirements. For example, solar energy development in states with NEPA-type regulations may incur higher CM costs because of required mitigation (e.g., for state-listed sensitive species). States have also passed laws requiring CM to ensure protection of land-use types (e.g., agricultural lands in California and forests in Maryland and New Jersey). This is particularly relevant for solar energy development because solar energy facilities have significant land-use requirements.

As explained in Section 1.2, the States of California and Maryland provide an opportunity to examine the variation in CM laws at the state level. The case studies are outlined in the text boxes below.

The two case studies, in addition to the state laws listed in Section 2.1.2, highlight the wide variability in state laws, regulations, and policies regarding CM. The States of California and Maryland have CM laws and regulations that differ in the entity administering the CM, the resources mitigated, the types of projects subject to CM, and how the states estimate and apply costs and payment rates (see Table 3-4). However, both states implement the land acquisition, preservation, and/or restoration CM method and allow all three of the mitigation structures discussed in Section 2.3.2 (in-lieu fee, banking, and permittee-responsible CM). While this report does not provide a comprehensive state-by-state record of laws and regulations for CM, it does provide developers and planners examples of how state regulations can influence the cost of solar energy development through state-led CM requirements.

State of California

California Endangered Species Act (CESA): Renewable energy developers may be required to satisfy the mitigation requirements of project impacts on endangered, threatened, and candidate plant and animal species under CESA using CM (CDFG 2010).

SENATE BILL X8 34 (SECTION 2069 OF THE FISH AND GAME CODE): Enacted on March 22, 2010 to provide a mechanism for coordination and collaboration between government agencies (state and federal) and renewable energy developers to facilitate project mitigation actions for large-scale renewable energy projects by creating an in-lieu fee program to streamline CM efforts. The Advance Mitigation Land Acquisition Grants Program (AMP) authorizes CDFG to design and implement mitigation actions, including

- Land acquisition through purchase of mitigation land and conservation easements,
- Habitat preservation,
- Habitat restoration, and
- Habitat enhancement (CDFG 2010).

Estimated Costs of Mitigation for Biological Resources for Use with the Renewable Energy Action Team (REAT)–National Fish and Wildlife Foundation (NFWF) Mitigation Account

Task	Cost[a]
Land acquisition	$1,000 per acre
Level 1 environmental site assessment	$3,000 per parcel
Appraisal	$5,000 per parcel
Initial site work (cleanup, enhancement, restoration)	$250 per acre
Closing and escrow costs	$5,000 per transaction
Biological survey (to determine mitigation value of land)	$5,000 per parcel
Third-p**arty administrative costs**	10% of land acquisition cost
Agency costs (review and determine land donation)	15% of land acquisition cost × 1.17
Subtotal	
Long-term management and maintenance (LTMM) fund	$1,450 per acre
NFWF fees	$12,000
	3% of subtotal
	1% of LTMM
Total	$

[a] in 2010 dollars
Source: CEC 2010.

California Environmental Quality Act (CEQA): Enacted in 1970, CEQA requires state and local agencies to identify the significant environmental impacts of their actions and to avoid or mitigate those impacts, if feasible. CM may be required if impacts cannot be mitigated through avoidance, minimization, or otherwise rectifying, reducing, or eliminating the impacts.

Agricultural Mitigation through CEQA: Created in 1996 under the California Conservation Act of 1965, the California Farmland Conservancy Program (CFCP) allowed permanent agricultural conservation easements as agricultural land conservation options administered by the California Department of Conservation. Mitigation requirements for impacts on farmland are determined as part of a CEQA review, by local ordinances or general plan policies, allowing local jurisdictions (cities and counties) to implement agricultural mitigation programs. These programs can require project developers to partially mitigate for the loss of farmland via in-lieu fees, agricultural mitigation banks, or purchases of conservation easements. Local mitigation fees have frequently been used as a match for CFCP funds toward the purchase of agricultural conservation easements (California Council of Land Trusts 2014; California Department of Conservation 2017).

Regional Advance Mitigation Planning (RAMP): In addition to the AMP, California has implemented RAMP to mitigate unavoidable biological resource impacts from state infrastructure projects (CDWR undated). California has also established the Regional Conservation Investment Strategies Program (RCIS), a voluntary program that consists of regional conservation assessments, regional conservation investment strategies, and mitigation credit agreements (CDFW 2017).

State of Maryland

Forest Conservation Act (FCA) 1990: Requires CM for displaced trees through reforestation in areas that are permanently conserved through conservation easements. Any activity that requires an application for a grading permit or sediment/erosion control plan on areas 40,000 ft^2 (approximately 1 acre) or greater is subject to the FCA and will require a Forest Conservation Plan, which describes the disturbance for the proposed project and how existing forested and sensitive areas will be protected during and after development, including CM requirements (MDNR 2004). The MDNR Forest Service administers the FCA, but the law is implemented at the county level. When construction of a project involves land-clearing or removal of trees, the FCA requires mitigation actions including

- On-site reforestation,
- Off-site reforestation on state-owned or other publicly owned land in the county and watershed in which the construction activity is located, or
- Purchase of forest mitigation bank credits in the watershed in which the construction activity is located (Maryland Natural Resources Code Ann. § 5-103 2013).

The state's 15-year review of the FCA concluded that during the 15-year period 94,600 acres were retained (under long-term protection) and 15,531 acres were planted (MDNR 2007). Of the retained and planted acres, there are 2,139 acres in forest banks (speciesbanking.com 2010).

In April 2009, a Sustainable Forestry Act was passed by the legislature and signed into law. The new law requires a larger in-lieu-fee cost per square foot (from 10 cents to 30 cents), lowers the threshold for projects to fall under FCA jurisdiction (to 20,000 ft^2 from 40,000 ft^2), and has led to the creation of smaller forest mitigation banks (as small as 1 acre) (Levitt and Youngblood 2011).

As of 2010, off-site forest mitigation banking was authorized in five counties (speciesbanking.com 2010). In Frederick County, the Fee-In-Lieu Program payment rates listed in 2014 (Frederick County 2017) were as follows:

- \$0.54/ft^2 for required forest mitigation for projects outside of a state-designated Priority Funding Area, and
- \$0.43/ft^2 for required forest mitigation for projects inside of a state-designated Priority Funding Area.

From 1993 to 2006, Frederick County's Fee-in-Lieu Program has spent a total of \$468,470; \$343,689 of this was spent planting floodplain agricultural lands in the Monocacy Natural Resources Management Area (Frederick County 2006).
An interview with solar industry representatives who have experience with developing practices in Maryland confirmed that to comply with the FCA, a developer can plant additional trees on-site, buy and manage lands off-site, or purchase credits from a conservation bank. The industry representatives estimated costs for a conservation bank to be approximately \$0.50/ft^2, while the cost to purchase other land within the county or planting trees on-site would be 40% to 50% less than the cost of purchasing credits in a conservation bank (White 2017). These costs may vary depending on location within the state and land availability, and other factors such as liability and legal requirements may deter some developers from conducting CM themselves. However, it does suggest that conservation banks are not necessarily the most cost-effective approach to comply with CM requirements.

TABLE 3-4 CM in California and Maryland

Statute	Regulatory Authority	CM Implementation	Resource(s)	Project Type Subject to CM	CM Structure	Cost
California						
CESA	CDFG	CDFG issues permits to authorize the take of species under federal ESA and CESA	Species under the ESA and CESA	Any project subject to CESA	• In-lieu fee • Banking • Permittee • Responsible CM	Costs for acquisition, restoration, biological surveys, administrative and agency costs, LTMM, and sponsor fees.
Senate Bill X8 34	CDFG	CDFG administers the Advance Mitigation Land Acquisition Grants Program	Species under the ESA and CESA	Renewable energy projects	• In-lieu fee • Banking • Permittee-responsible CM	
CEQA	Lead agency for CEQA review	Lead or local agency for CEQA review	Any resource reviewed under CEQA	Any project subject to CEQA	• In-lieu fee • Banking • Permittee-responsible CM	Costs for acquisition, transaction costs, base-line condition reports for the site, escrow costs and title insurance, staff time, and LTMM.
Maryland						
FCA and Sustainable Forestry Act	MDNR	County	Forests	Any area greater than 1 acre that requires a grading permit or erosion control plan	• In-lieu fee • Banking • Permittee-responsible CM	\$0.30–\$0.54 per ft^2 for in lieu fee

4 REGIONAL MITIGATION STRATEGIES

As stated in Section 1.1.5, under its Solar Energy Program established in 2012, the BLM prepared several regional CM strategies for SEZs on public lands (BLM 2014, 2016a,b, 2017). These strategies were prepared in advance of solar energy development in the SEZs in order to strategize for adequate mitigation of impacts, expedite future project schedules, and provide more certainty on mitigation costs to solar energy developers. They included the identification of resources that would likely warrant CM and recommended per-acre CM fees for specific SEZs. In each of the solar regional mitigation strategies, the BLM identified residual impacts on vegetation communities and associated ecosystem services as likely warranting CM, and restoration of similar vegetation was a component of the recommended base mitigation fee. However, for some BLM locations, acquisition of new lands as a part of CM would not be feasible (because most surrounding regional lands are already public lands); in those cases the BLM did not include acquisition as a component of the base fee. BLM also did not include costs for preservation actions as a component of the base mitigation fees, because preservation through land-use planning stipulations is already a part of BLM's existing mission and thus was not considered appropriate to identify as CM. The BLM incorporated mitigation ratios into the base fee calculations to ensure that a sufficient functionally equivalent area would be restored to compensate for the area lost to solar energy development. Most of the recommended fees also included downward adjustment to account for development on previously disturbed lands. All the fees include costs for long-term monitoring of the CM actions and administrative costs. Contingency costs were included to account for potential unforeseen events that would require additional restoration (e.g., fires). For one of the SEZs an additional fee for impacts on an ESA-listed species was also included (i.e., a fee for desert tortoise habitat impacts for the Dry Lake SEZ in Nevada [BLM 2014]).

The recommended CM fees ranged from about $3,200 to $4,600 per acre. Because the regional mitigation strategy documents were not decisions under NEPA, it is not known whether these or any mitigation fees would actually be applicable for future projects in SEZs. The current BLM policy (IM 2019-018) prohibits the BLM from requiring CM as a condition of any project approvals, but does not prohibit voluntary CM by project developers, as long as the BLM does not hold the CM funds.

An auction was held for solar energy development parcels in the Dry Lake SEZ in June 2014. Six parcels representing the entire SEZ developable area were successfully auctioned to three separate developers. The CM fees corresponding to the recommended fee value were to be assessed prior to the start of construction. One of the developers began construction in the spring of 2016, and operations began in December 2017.

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5 BEST MANAGEMENT PRACTICES

Extensive mitigation measures and BMPs for utility-scale solar energy development were developed by federal and state agencies and conservation groups several years ago when large-scale developments were first starting to be permitted in the U.S. desert Southwest. Examples include BMPs developed by the Arizona Game and Fish Department (AGFD 2010); BMPs developed for solar energy development in California (REAT 2010); BMPs consolidated from various sources by the conservation group Utah Wild (Jones 2012); and the required mitigation measures or design features included in the BLM ROD establishing its Solar Energy Program (BLM 2012). These BMPs can be implemented to reduce solar energy development impacts, thereby reducing or eliminating the need for CM for large-scale solar energy facilities. First and foremost of these is careful project siting so that where possible, valuable resources such as critical habitat for protected species, wetlands, important cultural resources, important recreational resources, and areas with other significant utility (e.g., areas used for military activities) are avoided. However, when certain resources cannot be avoided and CM is determined to be necessary, key BMPs to be considered include the following:

- During the environmental review and project planning phase, review federal, state, and local requirements and precedents for CM to identify likely CM needs for the project under development.

- Conduct site surveys as early as possible to identify the specific resources at risk, document the results, and share them with the regulating agency or agencies to support conclusions on resources requiring or not requiring CM.

- As early as possible during project planning, engage with agency permitting staff and other stakeholders if appropriate to discuss CM needs.

- Develop a plan for addressing the identified CM needs and appropriate CM methods and structures (e.g., acquisition and restoration of habitat, payment of an in-lieu fee into a mitigation fund, purchase of credits from a mitigation bank, payment for new social service needs arising as a result of the project).

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6 AVAILABLE RESOURCES

The resources listed in Table 6-1 can be used by policymakers as well as industry stakeholders to better understand CM regulations, policies, costs, and implementation.

TABLE 6-1 Resources Available for CM

Website	Description
RIBITS	RIBITS is an online database developed by the ACE with support from EPA and FWS that provides information on mitigation and conservation banking activities and in-lieu fee programs. It allows the public to access information on individual mitigation banks across the United States. RIBITS provides information for each bank. such as bank type, status, location, service area, credit type and availability, and credit ledgers. RIBITS is also a comprehensive online resource that contains information about mitigation and conservation banks and in-lieu fee programs, including policy guidance, handbooks and white papers, assessment tools, and reports.
NFWF	NFWF's Impact-Directed Environmental Accounts (IDEA) program serves as a manager and trustee for funds arising from legal and regulatory actions involving natural resources and the environment.
RAMP in California	Developed by a coalition of infrastructure and natural resource agencies, nongovernmental organizations, and academic researchers, RAMP provides a comprehensive approach to mitigating unavoidable biological resource impacts potentially caused by state infrastructure projects through preservation or restoration CM measures before infrastructure projects are constructed. The intent is that this approach will be faster, less expensive, and more effective than traditional project-by-project mitigation. The website is includes Links to relevant state, federal websites, Articles, literature, and background information on advanced mitigation, Information on RAMP's structure and contact information for members of the engagement team, and Updates on news information and blog entries.
Database of State Incentives for Renewables & Efficiency (DSIRE)	The DSIRE website is a comprehensive source of information on incentives and policies that support renewable energy and energy efficiency in the United States. DSIRE is operated by the North Carolina Clean Energy Technology Center at North Carolina State University and is funded by the U.S. Department of Energy.

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7 SUMMARY

The use of CM to offset some of the adverse impacts of development can be an effective means of allowing permitting to proceed expeditiously. Although research to date is limited, implementing CM for the unavoidable environmental impacts of energy development may also gain public support for specific energy projects from affected communities and/or conservation groups (Kaplowitz and Kerr 2003; Cohen et al. undated). However, CM costs can add substantially to project development costs, and therefore potential unavoidable impacts and appropriate CM costs should be carefully evaluated during the planning phase for large-scale solar energy facilities.

This report provides an overview of compensatory mitigation used to compensate for unavoidable adverse impacts at solar energy facilities. The report discusses the types of CM actions taken, as well as the methods used to satisfy CM requirements, in order to provide a comprehensive background of how CM has been applied to existing solar energy projects, and how it may be applied in the future, based on federal, state, and local requirements and policies. Using best available data, we have presented CM requirements and costs for solar energy facilities that vary in size, geographical location, and resources affected in order to better understand the variability in CM costs. In general, higher CM costs have been associated with

- CM requirements under the CWA and ESA;
- Land acquisition, preservation, and/or restoration methods;
- Large solar energy facility nameplate capacity (MW); and
- Solar energy facilities located in states that require additional state-specific CM requirements.

In addition to facility capacity, the higher cost CM scenarios are driven by federal or state law and policies. Understanding when CM is required and how CM is applied at the project level can help provide solar energy developers with greater cost certainty and may also help to lower costs through identifying and implementing additional avoidance and minimization measures during project development. Considering innovative mitigation projects during the project planning process may also lower costs and decrease permitting burdens and/or increase project public acceptance.

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8 REFERENCES

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APPENDIX A:

CM PROJECT REQUIREMENTS AND COSTS ESTIMATES

TABLE A-1 CM Requirements for Solar Energy Projects with Available Cost Data

County	State	Project Capacity (MW)	Technology	Acres	Resource	Mitigation Action	Land Type	Cost Data per Acre (if applicable)	Mitigation Ratio (if applicable)	Cost Data Total
Nevada										
Nye County	NV	110	Power tower	1,670	Special status species (kangaroo mouse)	Funding for additional study of a resource	Federal land (BLM)	NA	NA	*$200,000*
Clark County	NV	112	PV	594	Special status species (desert tortoise)	Various (habitat restoration and recovery; monitoring of recovery actions, applied research to promote conservation/ recovery, predator management, public outreach)	Federal land (BLM)	$843	NA	*$500,742*
					Landscape-level resources (loss of creosote-bursage vegetation, special status species habitat, cryptobiotic soil crusts and desert pavement, loss of ecosystem services)	Not determined		$1,836	NA	$1,090,584
					Water quality (palliative impacts on environment/water)	Funding for the additional study of a resource		NA	NA	$23,000
Clark County	NV	200	PV	1,521	Special status species (desert tortoise)	Various (habitat restoration and recovery; monitoring of recovery actions, applied research to promote conservation/ recovery, predator management, public outreach)	Federal land (BLM)	$843	NA	$1,282,203

TABLE A-1 (Cont.)

County	State	Project Capacity (MW)	Technology	Acres	Resource	Mitigation Action	Land Type	Cost Data per Acre (if applicable)	Mitigation Ratio (if applicable)	Cost Data Total
					Landscape-level resources (loss of creosote-bursage vegetation, special status species habitat, cryptobiotic soil crusts and desert pavement, loss of ecosystem services)	Not determined		$1,836	NA	$2,792,556
					Water quality (palliative impacts on environment/water)	Funding for the additional study of a resource		NA	NA	$55,000
Clark County	NV	130	PV	806	Landscape-level resources (loss of creosote-bursage vegetation, special status species habitat, cryptobiotic soil crusts and desert pavement, loss of ecosystem services)	Not determined	Federal land (BLM)	$1,836	NA	$1,479,816
					Special status species (desert tortoise recovery fees)	Various (habitat restoration and recovery; monitoring of recovery actions, applied research to promote conservation/ recovery, predator management, public outreach)		$843	NA	$679,458
					Water quality (palliative impacts on environment/water)	Funding for the additional study of a resource		NA	NA	$22,000
Clark County	NV	250	PV	2,427	Soils (loss of cryptobiotic soils)	Funding for the additional study of a resource	Federal land (BLM)	NA	NA	$50,000
					Special status species (effects of dust palliatives on the health of desert tortoise)	Funding for the additional study of a resource		NA	NA	$100,000

TABLE A-1 (Cont.)

County	State	Project Capacity (MW)	Technology	Acres	Resource	Mitigation Action	Land Type	Cost Data per Acre (if applicable)	Mitigation Ratio (if applicable)	Cost Data Total
					Specially designated areas (proposed Area of Critical Environmental Concern [ACEC])	Habitat restoration funds to restore 400 acres of roads/disturbed area within a proposed ACEC		$1,000	NA	$400,000
					Special status species (study the health and genetics of desert tortoise population)	funding for additional study of a resource		NA	NA	$200,000
					Special status species (desert tortoise)	Remuneration fee		$824	NA	$1,999,848
California										
Riverside County	CA	250	Parabolic trough	1,920	Special status species (desert tortoise)	Habitat acquisition and preservation	Federal land (BLM)	Not given	1,750 acres at 1:1 (outside critical habitat)	$4,263,600
					Special status species (desert tortoise)	Land acquisition and preservation[a]			24 acres at 5:1 (critical habitat)	
					Special status species (desert tortoise through raven management)	Land acquisition		$105	NA	$184,170
					Water/riparian habitat (microphyllous riparian vegetation)	Land acquisition		NA	16 acres at 3:1;	$342,768
					Water/riparian habitat (unvegetated ephemeral dry wash)	Land acquisition		NA	53 acres at 1:1;	
					Water/riparian habitat (unvegetated ephemeral dry wash)	Land acquisition		NA	21 acres at 0.5:1	
					Vegetation (stabilized/partially stabilized sand dunes)	Land acquisition		NA	7.5 acres at 3:1	$422,668
					Special status species (Mojave fringe-toed lizard)	Land acquisition		NA	136 acres at 3:1	

TABLE A-1 (Cont.)

County	State	Project Capacity (MW)	Technology	Acres	Resource	Mitigation Action	Land Type	Cost Data per Acre (if applicable)	Mitigation Ratio (if applicable)	Cost Data Total
					Vegetation (playa and sand drifts over playa)	Land acquisition		NA	38 acres at 3:1	
					Special status species (burrowing owl)	Land acquisition		NA	NA	$143,045
					Cultural resources, mitigation of impacts on buried prehistoric cultural resources discovered during construction	Funding for additional study of a resource			NA	$3,044,885
San Bernardino	CA	392	Power tower	3,500	Special status species, desert tortoise, and state waters	Land acquisition and management	Federal land (BLM)	NA	NA	$11,400,000
Riverside County	CA	485	Trough/PV	4,138	Special status species (desert tortoise)	Other (to reduce predation of ravens on desert tortoise)	Federal land (BLM)	$64	NA	$264,832
					Special status species (desert tortoise)	Other (to reduce predation of ravens on desert tortoise). Applies to transmission lines that are expected to remain after the 20-yr term of a given renewable energy project.		$105	NA	NA

[a] In most cases, land acquisition, restoration, and/or preservation includes the acquisition of land through purchasing easement lands or providing funds through an in-lieu fee program or conservation/mitigation bank.

TABLE A-2 CM Requirements for Solar Energy Projects without Available Cost Data

County	Project Capacity (MW)	Technology	Acres	Land Type	Resource	Mitigation Action	Mitigation Ratio
California							
Riverside	485	PV	4,138	Federal (BLM)	Special status species (desert tortoise)	Land acquisition[a]	3,975 acres at 1:1
					Special status species (burrowing owl)	Land acquisition funding for enhancement and long-term management of the lands	19.5 acres per owl for two owl estimate (39 acres total)
					Special status species (plants)	Acquisition of habitat supporting the species or restoration/enhancement of populations of species; or fund a species distribution study	3:1 for rank 1 plants 2:1 for rank 2 plants
					Special status species (Mojave fringe-toed lizard through sand dune/partially stabilized desert dune habitat)	Land acquisition and habitat improvements and long-term maintenance and management of lands	75 acres at 3:1
					Water/riparian habitat	Land acquisition for land that contains state jurisdictional waters (ephemeral washes)	412 acres at 3:1
					Special status species (Couch's spadefoot toad)	Prepare protection and mitigation plan; land acquisition	NA
Monterey	280	PV	2,900	Private	Special status species (plants)	Land acquisition	1:1
					Special status species (California red-legged frog)	Permanent protection of Cottonwood create that provides important breeding habitat for California red-legged frog	
					Special status species (plants)	Land acquisition (1,070-acre conservation easement to protect grassland species that includes designated critical habitat for red-legged frogs and California tiger salamanders)	
					Special status species (San Joaquin kit fox, golden eagles, California red-legged frog, burrowing owl, sensitive native plants)	Land acquisition (and perpetual conservation of lands)	$10.5 million
					Special status species (San Joaquin kit fox)	Land acquisition	3:1 within final footprint, 2:1 within the SDAs
					Special status species (burrowing owl)	Land acquisition	3:1 within final footprint, 2:1 within the SDAs

TABLE A-2 (Cont.)

County	Project Capacity (MW)	Technology	Acres	Land Type	Resource	Mitigation Action	Mitigation Ratio
					Special status species (western spadefoot toad)	Land acquisition for permanently affected occupied breeding habitat	2:1
					Special status species (California red-legged frog)	Land acquisition, restoration or enhancement of degraded habitat	2:1 if the CM provides suitable breeding habitat, the overall acreage for upland mitigation habitat shall be reduced by two times the acreage of the suitable breeding habitat
					Special status species (California tiger salamander)	Land acquisition	2:1 within 4,925 ft; 1:1 within 4,925–6,125 ft; 0.5:1 within 6,125 ft–1.3 mi from a potential breeding pond.
					Special status species (western pond turtle)	Land acquisition for western pond turtle aquatic habitat	1:1
					Water/riparian habitat	Land acquisition for perennial stream/channel wetlands and associated riparian habitat	3:1 for perennial streams/associated riparian habitat; 2:1 for intermittent streams;1:1 for ephemeral streams
Riverside	550	PV	3,800	Federal land (BLM)	Special status species (Mojave fringe-toed lizard)	Land acquisition	Ranges from 1:1 to 5:1 depending upon (a) species known to be present on site, (b) habitat condition, (c) proximity of known disturbances, (d) vegetation type.
					Vegetation (desert dry wash woodland)	Land acquisition	101 acres at 3:1
					Special status species (desert tortoise)	Land acquisition	2,757 acres at 1:1; 1,214 acres at 2:1; 191 acres at 5:1

TABLE A-2 (Cont.)

County	Project Capacity (MW)	Technology	Acres	Land Type	Resource	Mitigation Action	Mitigation Ratio
					Special status species (burrowing owl)	Land acquisition	2:1 for 6.5 acres per occupied burrow of burrowing owls); 13 acres for each occupied burrow, estimated as two burrows
					Water/riparian habitat (state jurisdictional streambeds)	Land acquisition	302 acres at 3:1
					Vegetation (creosote bush scrub)	Land acquisition	4,072 acres at 1:1
					Vegetation (occupied foxtail cactus habitat)	Land acquisition	2 acres at 1:1
					Special status species (desert kit fox, American badger)	Land acquisition	4,173 acres at 1:1
					Special status species (chuckwalla and rosy boa)	Land acquisition for occupied habitat	149 acres at 1:1
					Wildlife (migratory birds)	Land acquisition for suitable upland shrubland nesting habitat	4,173 acres at 1:1
					Special status species (golden eagles)	Land acquisition suitable foraging habitat	4,173 acres at 1:1
					Special status species (bats)	Land acquisition for suitable or occupied roosting habitat	101 acres for dry wash woodland 149 acres rocky slopes
					Special status species (Palm Springs round-tailed ground squirrel)	Land acquisition	92 acres
					Special status species (Colorado Valley woodrat)	Land acquisition	149 acres
Imperial	175	PV	1,861	Private (active agricultural land)	Special status species (burrowing owl)	Land acquisition	$5,000/acre plus $750 per acre for LTM for 176.7 acres
					Special status species (flat-tailed horned lizard)	Land acquisition	5 acres at 6:1
					Special status species (Thurber's pilostyles)	Land acquisition	NA
					Water/riparian habitat	Land acquisition	6.3 acres at 2:1
Imperial	139	PV	1900	Private	Special status species (burrowing owl)	Land acquisition	NA

TABLE A-2 (Cont.)

County	Project Capacity (MW)	Technology	Acres	Land Type	Resource	Mitigation Action	Mitigation Ratio
					Special status species (flat-tailed horned lizard)	Land acquisition	7.21 acres at 6:1
					Water/riparian habitat	Land acquisition	2:1 for permanent impacts 1:1 for temporary impacts

[a] In most cases, land acquisition, restoration and/or preservation includes the acquisition of land through purchasing easement lands, or providing funds through an in-lieu fee program or conservation/mitigation bank.

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