BLM

Best Management Practices for

Reducing Visual Impacts of Renewable Energy Facilities

on BLM-Administered Lands

First Edition - 2013

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Wyoming State Office
P.O. Box 1828
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In Reply Refer To:
(930)

Dear Reader:

The Bureau of Land Management (BLM) manages vast stretches of public lands giving the BLM a leading role in fulfilling the Nation's goals for a new energy economy based on utility-scale production of renewable energy, including wind, solar, and geothermal energy.

The BLM must ensure that renewable energy developments on BLM-administered lands meet all applicable environmental laws and regulations, including the National Environmental Policy Act of 1969 and the Federal Land Policy and Management Act of 1976. As part of this task, the BLM requires that visual design considerations be incorporated into all surface-disturbing activities, including renewable energy construction, operation, and decommissioning.

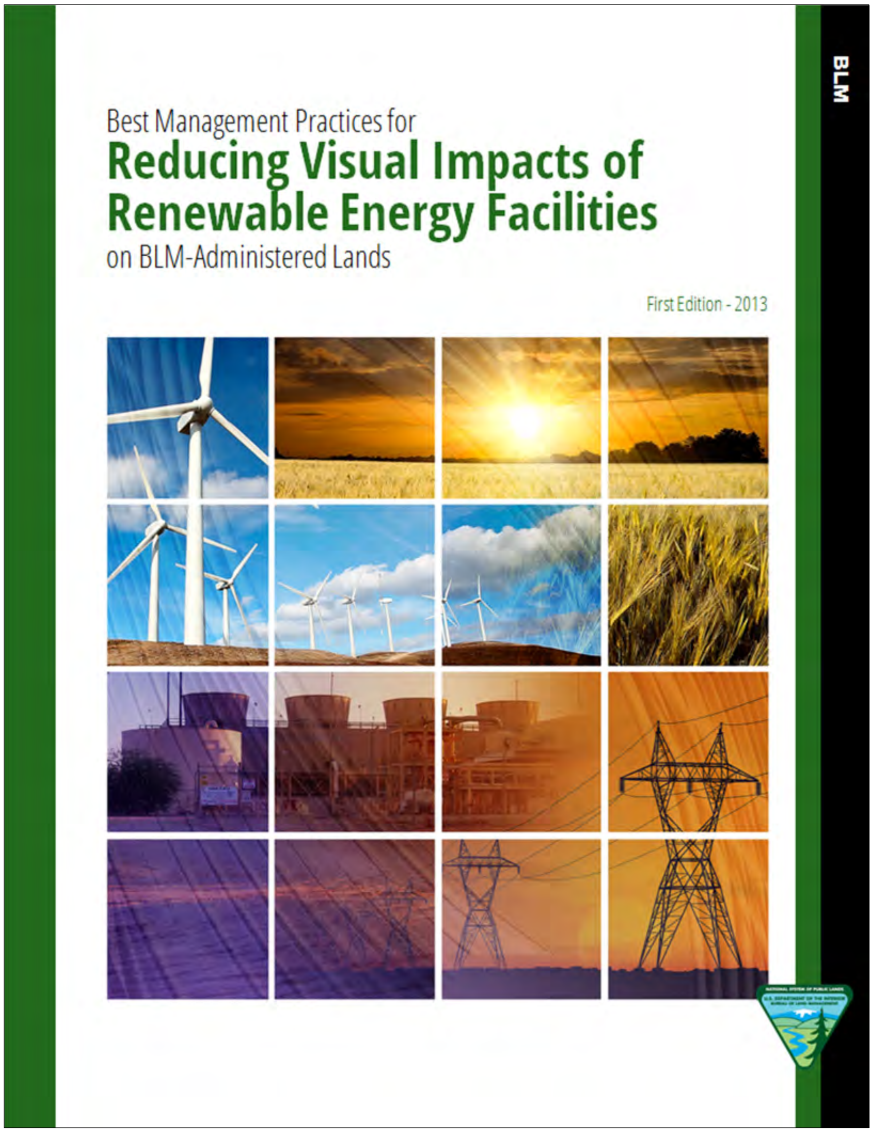
In light of the increasing use of BLM-administered lands for large-scale renewable energy projects, the BLM presents this publication, entitled *Best Management Practices for Reducing Visual Impacts of Renewable Energy Facilities on BLM-Administered Lands*. The publication presents 122 best management practices (BMPs) to avoid or reduce potential visual impacts associated with siting, designing, constructing, operating, and decommissioning utility-scale renewable energy generation facilities, including wind, solar, and geothermal facilities. The publication includes BMPs for avoiding and reducing visual impacts associated with the energy generation components of a facility, such as wind turbines or solar energy collectors, and includes many BMPs for reducing visual impacts associated with ancillary components, such as electric transmission, roads, and structures.

The BMP publication provides individual BLM District and Field Offices, industry, and other stakeholders with proven, effective, and vetted BMPs to address a wide range of potential visual impacts from renewable energy facilities throughout the project lifecycle. The BMPs presented are designed to provide for safe and efficient operations while minimizing undesirable impacts on visual resources. Proactively incorporating visual BMPs into project planning and development typically results in a more efficient review process, greater stakeholder acceptance of proposed projects, and in many cases, reduced remediation costs. Their effective use helps the BLM fulfill its mandate to preserve scenic resources for future generations.

Feedback and questions regarding this publication are welcomed. If you have suggestions or questions, or need additional information, please contact Sherry Lahti at 307-775-6484.

Sincerely,

Donald A. Simpson
State Director



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1 Introduction

1.1 Purpose and Need

The Energy Policy Act of 2005 (EPACT) established several key goals for achieving a move from non-renewable energy sources to clean energy sources. It contains provisions to encourage or facilitate the use and development of utility-scale renewable energy resources for electricity production. Investment in these programs will assist in getting new technologies to market, provide a clean baseload of power, accelerate the clean energy economy, create and revitalize local economies, and help advance long-term energy independence (DOE 2010). The U.S. Department of the Interior (DOI) has issued permits for more than 10,000 megawatts (MW) of renewable energy on public lands and in offshore waters as of the end of 2012 (DOI 2012).

The DOI's Bureau of Land Management (BLM) has a key role in implementing EPACT, because the BLM manages more than 245 million surface acres and 700 million subsurface acres of mineral estate for multiple uses, including energy development. Over 20.6 million acres of public land have wind potential in 11 western states, and 22 million acres of public land within six states have solar potential. In addition, the BLM has delegated authority for leasing 249 million acres of public lands with geothermal potential, including over 100 million acres of National Forest lands (BLM 2010).

The BLM faces increasing interest in the use of BLM-administered public lands for utility-scale renewable energy development. As renewable energy projects are proposed throughout the western United States, the

BLM evaluates and processes the applications for rights-of-way (ROWs) and use of public land for these projects. The BLM must ensure that these developments meet all applicable environmental laws and regulations, including the National Environmental Policy Act of 1969 (NEPA) and the Federal Land Policy and Management Act of 1976 (FLPMA).

The BLM's responsibility to manage the scenic resources of the public lands is established by FLPMA and NEPA as follows:

- FLPMA requires that "the public lands be managed in a manner that will protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resource, and archeological values" and stipulates that "The Secretary shall prepare and maintain on a continuing basis an inventory of all public lands and their resource and other values (including, but not limited to, outdoor recreation and scenic values…)." The act prohibits unnecessary or undue degradation of public lands, and makes protecting a range of environmental values, including scenic values, an explicit criterion that must be applied throughout the BLM's land management activities.
- A stated goal of NEPA is to "assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings." NEPA requires the development of procedures to ensure that environmental values are given appropriate consideration in decision-making processes in which a federal agency is involved (Ross 1979).

To comply with these Acts, the BLM requires that visual design considerations be incorporated into all surface-disturbing activities, including construction, operation, and decommissioning of renewable energy facilities. Design considerations are evaluated through assessments of visual resources, which include all natural and cultural features of the environment that have the potential to be seen (Grinde and Kopf 1986).

It is the BLM's mission to sustain the health, diversity, and productivity of public lands for the use and enjoyment of present and future generations. These practices are supported by the establishment of district and field office resource management plans (RMPs). RMPs are comprehensive management documents that determine how the BLM will manage the public lands within the boundaries of a particular field office or district. Decisions made within the RMP provide direction for the actions of the agency. RMPs are developed with the consideration and involvement of the public.

As part of the RMP, management objectives are established for visual resources on all lands included in the RMP. Management decisions in the RMP must consider the value of visual resources, along with other important resources and agency objectives. Management decisions regarding visual resources are framed as Visual Resource Management Classes (VRM) I through IV, with VRM Class I having the greatest degree of protection and VRM Class IV having the least.

The use of best management practices (BMPs) to avoid or reduce the visual impacts of development is a key component in the BLM's fulfillment of its scenic resource management requirements while meeting its goals to facilitate renewable energy development on

BLM-administered lands. The BLM and the U.S. Forest Service previously developed standards and guidelines for oil and gas development (DOI and USDA 2007) that include measures to reduce the visual impacts of these types of facilities, and the BLM has developed specific guidance for reducing the visual impacts of oil and gas development (BLM 2006). Now, in response to the increasing use of BLM-administered lands for large-scale renewable energy projects, the BLM presents *Best Management Practices for Reducing Visual Impacts of Renewable Energy Facilities on BLM-Administered Lands* (hereafter referred to as the "BMP publication"). The BMP publication presents 122 BMPs to avoid or reduce potential visual impacts associated with the siting, design, construction, operation, and decommissioning of utility-scale renewable energy generation facilities, including wind, solar, and geothermal facilities.

The BMP publication includes BMPs for avoiding and reducing visual impacts associated with the energy generation components of a facility, such as wind turbines or solar energy collectors, and includes many BMPs for reducing visual impacts associated with ancillary components, such as electric transmission, roads, and structures. However, visual impact mitigation is only partly partly addressed by considering *what* is built; mitigation must also address *where* a facility is built, and *how* it is built, operated, and decommissioned. Planning phase activities, such as facility siting and design, and selection of structural materials and coatings, are critical to effective visual impact mitigation, as are "on-the-ground" activities, such as recontouring and revegetating disturbed areas. Consequently, a large part of this BMP publication is devoted to BMPs for key activities that typically have a major effect on the visual impacts associated with facility development, including project siting and design, mitigation planning, structure design and materials selection, materials surface treatments, lighting practices, and soils and vegetation management.

The BMP publication provides BLM staff, industry, and other stakeholders with proven, effective, and vetted BMPs to address a wide range of potential visual impacts from renewable energy facilities throughout the project lifecycle. The BMP publication is intended for use by the BLM's visual resource management staff, and other staff including, but not limited to, recreational planners, landscape architects, project managers, realty specialists, and cultural resource specialists. The BMP publication can be used to provide guidance for specific projects or as a general information source for strategies to mitigate impacts on visual resources on BLM-administered lands. The BMPs were compiled from a variety of sources, including guidance documents developed by various federal and state agencies; existing environmental analyses, including programmatic and project-specific environmental impact statements and assessments; professional practice literature; consultations with landscape architects, engineers, and renewable energy professionals; and field observations of existing renewable energy facilities and facilities under construction.

The BMPs presented are proven measures designed to provide for safe and efficient operations while minimizing undesirable impacts on visual resources. As noted in the BMP descriptions, many visual BMPs also benefit other valued resources, such as wildlife habitat, biodiversity, and water quality. The best outcomes are achieved when BMPs are considered and implemented as early as possible; the proactive incorporation of visual BMPs into project planning and development typically results in a more efficient review process, greater stakeholder acceptance of proposed projects, and in many cases, reduced remediation costs. Their effective use helps the BLM manage and preserve scenic resources on public lands for the enjoyment of present and future generations.

1.2 How to Use the Renewable Energy Visual BMP Publication

This BMP publication is divided into two main parts. The first part (Chapters 1 and 2) provides an introduction to the BMP publication and to key visual resource concepts within the context of utility-scale energy development on BLM lands. It includes an abbreviated discussion of the BLM visual resource management (VRM) system, a description of terminology associated with visual resources, a discussion of viewsheds, and an explanation of factors that affect the overall visibility of large-scale facilities.

The second part (Chapters 3–6) presents information about the visual characteristics of renewable energy facilities and BMPs for avoiding or reducing visual impacts from the facilities. Chapters 3–5 present the visual characteristics and BMPs for wind energy facilities, solar energy facilities, and geothermal facilities respectively. Chapter 6 presents BMPs for "common elements," which include ancillary facilities common to utility-scale energy facilities as well as the design, construction, operation, and decommissioning activities common to large-scale energy development projects.

The common element BMPs presented in Chapter 6 for ancillary facilities include BMPs for electric transmission systems, roads and other surfaces, structures, and signs. The common element BMPs for design, construction, operation, and decommissioning activities include the following:

- Visual impact analysis and mitigation planning;
- Facility siting and design;
- Structure design and materials selection;
- Materials surface treatments;
- Lighting design and operation;
- Avoiding unnecessary disturbance;
- Soil management and erosion control;
- Vegetation management;
- Interim and long-term reclamation; and
- "Good housekeeping" practices.

These activities provide the framework for organizing the common element BMPs. Chapter 6 is divided into 10 subsections, each of which presents BMPs specific to the activities listed above.

A relatively large number of elements and activities are common to most large-scale facilities, and there are a variety of methods for mitigating impacts associated with these elements. As a result, there are almost 100 common-element BMPs in the BMP publication. It should be a valuable source of BMPs to address visual impacts for almost any large-scale energy development that occurs on BLM-administered lands.

Each discussion of a BMP generally includes the following information:

- The BMP title;

- Project phase(s) during which the BMP is implemented;
- Description of the BMP;
- Notes—supplementary information about the BMP (e.g., the benefits of implementing the BMP, details about the mechanism by which the BMP actually reduces visual contrasts, or technical details about implementation);
- Limitations, where applicable, including important restrictions, caveats, or considerations that should be taken into account when considering implementation of the BMP; and
- Photos or diagrams that show examples of poor practices that worsen visual contrasts, the results of successful application of the BMP, and/or "how to" images that show the BMP being implemented in a real situation.

Other useful features include tables at the beginning of each BMP topic listing the BMP titles and indicating the appropriate project phases for each BMP; a list of recommended additional reading materials; a glossary of technical terms used; and an acronym list.

Readers are cautioned that the BMP publication is not prescriptive in nature, as not every BMP in the BMP publication is appropriate for every project. Some BMPs simply do not apply in all landscapes (e.g., color treating exposed rock faces might not be applicable for a wind farm sited in flat grasslands). In some cases, site conditions might preclude the application of particular BMPs or render the BMPs ineffective; for example, transplanting native vegetation may not be a viable option where suitable stock for transplanting does not exist. There may also be conflicts between visual BMPs and concerns for safety or other valued resources; for example, additional lighting may be needed for safety reasons, or building a screening landform might interfere with water drainage. There may be technical reasons why a particular BMP cannot be implemented; for example, applying paint or a coating to a piece of equipment may interfere with its functionality. And finally, there may be cost-benefit concerns that might make some visual BMPs impractical or inadvisable in a given situation; changing a transmission line route may result in lower visual impacts, but if an alternative route adds length to the transmission line, makes getting approval difficult, or results in significant project delays, it could be prohibitively expensive and might only be justifiable if the proposed route would result in major impacts on a highly sensitive landscape. Similarly, moving or eliminating a large number of wind turbines because of visual or other potential impacts could seriously affect the financial viability of a proposed project, and should only be undertaken after ensuring that the nature and severity of the potential impacts justifies implementing the BMP, and of course after exploring other means to reduce the impacts to an acceptable level.

Fortunately, there are many highly effective visual BMPs that are not particularly expensive or difficult to implement, particularly if incorporated early in the development process; these include successful revegetation, recontouring to match existing terrain characteristics, or painting facility components to blend with the landscape background. Except in special circumstances, such practices should always be implemented where possible. Other visual BMPs also have benefits to other resources (e.g., successful revegetation could have beneficial effects on wildlife habitat, water quality, and air quality) that more than justify the costs.

Choosing appropriate visual BMPs for a particular renewable energy project is not as simple as copying the list of BMPs from the BMP publication and requiring a developer to implement them all. Careful consideration must be given to the nature of the project and the site, and to how site- and project-specific conditions may affect the technical feasibility of BMPs under consideration. Potential effects on other important resources, the project's operations, and the project's viability that may result from implementing the BMPs must also be considered. Early and frequent consultation with the developer, other resource specialists, and potentially affected stakeholders will help ensure that visual BMPs are applied where they are needed, where they are effective, where the costs of implementing them are appropriately weighed against the benefits, and where they do not adversely affect safety or other important environmental resources.

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2 Visual Resources

2.1 An Overview of the BLM Visual Resource Management (VRM) System

The BLM's VRM system provides a framework for managing visual resources on BLM- administered lands. Included in this system is a mechanism for identifying visual resource values on BLM-administered lands, minimizing the impacts of surface-disturbing activities on visual resources, and maintaining the scenic value of tracts of land for the future. The VRM system involves the following:

- Inventorying scenic values of BLM-administered lands through the Visual Resource Inventory (VRI) process;
- Assigning VRM classes that establish VRM objectives for these BLM-administered lands;
- Evaluating proposed activities to determine their impact on VRI values and whether or not they conform to the established management objectives through the Visual Contrast Rating process; and
- Updating the VRI to reflect the changed conditions.

These processes are summarized below.

2.1.1 Visual Resource Inventory

The BLM's VRI is a systematic process for:

- Assessing and rating the inherent scenic quality of a particular tract of land, through the Scenic Quality Rating process;

- Measuring the public concern for the scenic quality of the tract, through the Sensitivity Level Analysis; and
- Classifying the distance from which the landscape is most commonly viewed, through delineation of distance zones.

Based on the outcome of the VRI, BLM-administered lands are assigned to one of four VRI classes. VRI Class I lands have the greatest relative visual values, and VRI Class IV lands have the lowest relative visual values.The Scenic Quality Rating process, the Sensitivity Level Analysis, and the Distance Zone delineation process are discussed in more detail below.

2.1.1.1 Scenic Quality Rating

Within the VRI process, public lands are evaluated with regard to their scenic quality, defined as the visual appeal of a particular tract of land (BLM 1986a). Scenic quality is determined systematically by (1) dividing the landscape into Scenic Quality Rating Units (SQRUs) based on conspicuous changes in physiography or land use, and (2) ranking scenic quality within each SQRU based on the assessment of seven key factors: landform, vegetation, water, color, adjacent scenery, scarcity, and cultural modifications. The ratings are made in the field by trained observers who evaluate the landscape view from inventory observation points, which are either important viewpoints or points with views that are representative of the SQRU. Based on the outcome of this assessment, lands within each SQRU are assigned a scenic value rating of A (high scenic value), B (moderate scenic value), or C (low scenic value). Generally, those areas with the most variety and most harmonious composition have the highest scenic value ratings, while areas with less variety and greater levels of disturbance from human activities have the lowest scenic value ratings.

This colorful and varied BLM landscape has very high scenic quality. (Credit: BLM.)

2.1.1.2 Sensitivity Level Analysis

Visual sensitivity is defined as a measure of public concern for scenic quality (BLM 1986a). Sensitivity is determined by evaluating the types and numbers of potential viewers of a specified area (this area is referred to as a Sensitivity Level Rating Unit or SLRU), the level of public interest in the SLRU, adjacent land uses, and the presence of special areas. The Sensitivity Level Analysis (SLA) is completed in two steps: (1) delineation of SLRUs, and (2) rating visual sensitivity within each SLRU. SLRUs represent geographic areas where public sensitivity to change of the visual resources is shared among constituents.

Determining the level of sensitivity requires familiarity with the tracts of lands being evaluated, and with the people who use them. Sensitivity is generally determined by BLM staff most familiar with the users of the areas, and can be supplemented by direct input from other agencies, interest groups/stakeholders, and the general public.

Sensitivity levels are described as high, medium, or low within the VRI process. Scenic byways, wilderness areas, and lands adjacent to national parks are examples of lands that often have high sensitivity.

Landscapes viewed from scenic overlooks may have increased visual sensitivity. (Credit: BLM.)

2.1.1.3 Distance Zone Delineation

Within the VRI process, distance zones are assigned based on the distance of lands from places such as highways, waterways, trails, or other key locations. They include the following:

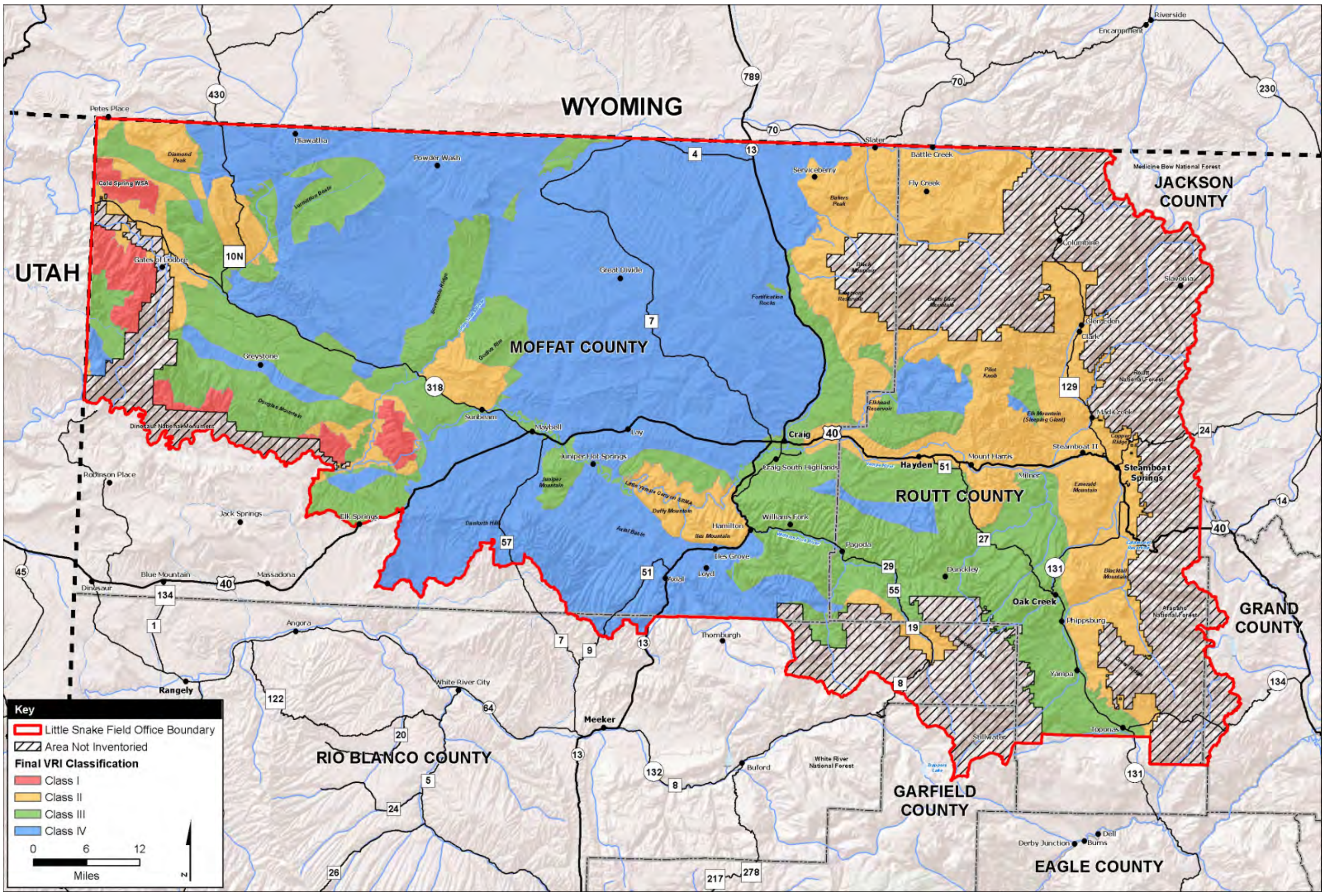
- **Foreground-middle ground**—This zone includes visible areas from 0 to 5 mi.
- **Background**—This zone includes visible areas from 5 to 15 mi.
- **Seldom seen**—This zone includes lands visible beyond 15 mi or lands hidden from view from key locations.

These distance zones are for use in conducting VRIs only. While distance is an important factor in the perception of visual contrast in the landscape (see Section 2.2.4), BLM distance zones are not used in visual contrast or impact analyses, or to identify appropriate mitigation. The effects of distance are highly dependent on the size and other characteristics of the facility and the landscape, and must be incorporated into the contrast and impact analyses and mitigation efforts on a case-by-case basis.

2.1.1.4 VRI Class Determination

The VRI class for the tract of land being inventoried is determined by consulting a matrix that incorporates all possible values for scenic quality rating, the sensitivity rating, and the distance zone. For example, the matrix indicates that an area with a scenic quality rating of B, with a high sensitivity level rating, that falls within the background distance zone as viewed from travel routes and other key locations, would be assigned a VRI class of III, indicating moderate relative visual values.

It should be noted that a typical BLM VRI contains valuable information about the inventoried lands in addition to the VRI classes, including representative photos, maps, and supporting text. This information is useful for a variety of purposes related to VRM and planning, for example, plan amendments and RMP planning-level decisions, landscape setting descriptions, and viewer sensitivity analyses.



VRI classes for Little Snake Field Office in Colorado. (Credit: Logan Simpson Design, Inc.)

2.1.2 The RMP and Visual Resource Management Classes

The RMP establishes how the public lands will be used and allocated for different purposes; it is developed with public participation and collaboration. RMP decisions establish goals and objectives for resource management (desired outcomes) and the measures needed to achieve these goals and objectives (management actions and allowable uses). The visual values reflected in the VRI classes are considered in establishing goals and objectives for resource management, and when management actions and allowable uses are determined for the lands in the RMP, VRM classes are designated for the lands that reflect these management actions and allowable uses.

The VRI class values reflect the quality of the visual resource, but they are not the sole determinant of how the visual resources on the lands are to be managed; the BLM manages lands for a variety of purposes, and preservation of scenic values is only one of many factors to consider in determining land management objectives. The VRI class values inform the VRM class determination made in the RMP; they are the basic measure of the quality of the visual resource, which must be considered when determining VRM objectives in the RMP process, and should be discussed when describing the visual impacts of a proposed surface-disturbing action.

VRI classes are not intended to automatically become VRM class designations. Management classes are determined through careful analyses of other resource values, and other potential land uses and demands. The VRM class determination is based on a full assessment that evaluates the VRI in concert with needed resource uses and desirable future outcomes. The VRM class designations may be different than the VRI classes assigned in the inventory and should reflect a balance between protection of visual values and meeting America's energy and other land use or commodity needs.

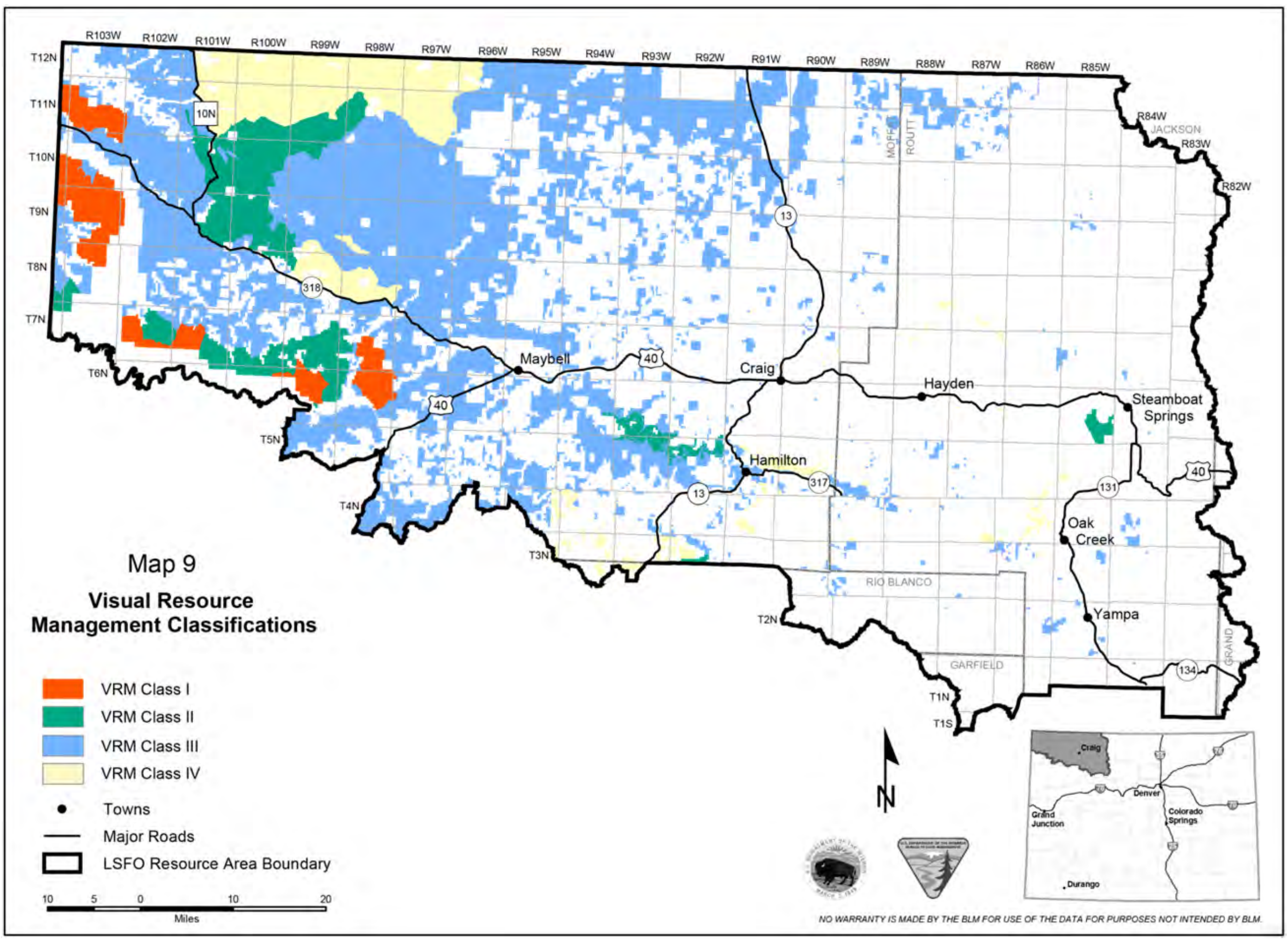
The VRM classes set VRM objectives for lands in each class, as well as the level of visual change in the landscape character that is allowed as a result of proposed management activities. The objectives and allowed levels of change for each of the four VRM classes are as follows:

- **Class I Objective:** To preserve the existing character of the landscape. **Allowed Level of Change:** This class provides for natural ecological changes; however, it does not preclude very limited management activity. The level of change to the characteristic landscape should be very low and must not attract attention.
- **Class II Objective:** To retain the existing character of the landscape. **Allowed Level of Change:** The level of change to the characteristic landscape should be low. Management activities may be seen, but should not attract the attention of the casual observer. Any changes must repeat the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.
- **Class III Objective:** To partially retain the existing character of the landscape. **Allowed Level of Change:** The level of change to the characteristic landscape should be moderate. Management activities may attract attention, but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape.
- **Class IV Objective:** To provide for management activities which require major modification of the existing character of the landscape. **Allowed Level of Change:** The level of change to the characteristic landscape can be high. Management activities may dominate the view and may be the major focus of viewer attention. However, the impact of these activities should be minimized through careful siting, minimal disturbance, and repeating the basic elements of form, line, color, and texture within the existing setting.

Once the VRM class is determined for a tract of BLM-administered land in the RMP, BLM policy requires that proposed management activities, such as constructing and operating a utility-scale renewable energy facility on that tract, must meet the requirements of the VRM class. Disclosure of impacts to the visual values of the project area and conformance with the VRM class requirements is determined through the Visual Contrast Rating (VCR) process (see below) during NEPA analysis. If the VCR process determines that the project conforms to the VRM class objectives and the project is allowed, a concerted effort must still be made to reduce the visual contrasts, even if the proposed project meets the VRM class objectives. If the VCR determines that, as proposed, the project will not conform to the VRM class objectives, additional visual impact mitigation must be implemented until the project does comply with the VRM class requirements. If additional mitigation will not result in the project meeting VRM class requirements, the project is not permitted, or the VRM class for the project area must be changed through an amendment to the RMP.

2.1.3 Visual Contrast Rating

VCR determines whether the potential visual impacts from proposed surface-disturbing activities will meet the VRM class objectives and allowable level of change established for the area, or if design adjustments or additional mitigation will be required. Contrast analysis also is used as the basis for conducting impact assessment to characterize impacts to visual resources (i.e., the landscape) and potential viewers. These impacts and viewers may or may not be on BLM-administered lands; in compliance with NEPA and FLPMA, BLM is required to disclose impacts on visual



VRM classes for Little Snake Field Office in Colorado. (Credit: BLM.)

resources regardless of whether the affected lands are public or private, or are managed by BLM, and regardless of whether potential viewers are located on BLM-administered or other lands. Contrast analysis is also used to identify opportunities for avoidance or mitigation of impacts.

The VCR involves a systematic comparison of the landscape's visual characteristics before and after the project is implemented, as seen from key observation points (KOPs), using the basic design elements of form, line, color, and texture. The BLM defines KOPs as "the most critical viewpoints," such as points or a series of points on a travel route, or at a use area or a potential use area (BLM 1986b).

The following steps are included within the BLM contrast rating process:

(1) **Obtain a project description**—The level of detail required for this step varies by individual project. This information usually can be obtained from a project developer or proponent. Typically, a preliminary Plan of Development (POD) is submitted with the ROW application. However, details such as exact layout of facilities, roads, and transmission lines are not identified, and therefore meeting with the project proponent is warranted. Assesing the impacts of renewable energy facilities is strongly dependant on the location of the components of the project. Details about the main components and ancillary facilities are therefore necessary to identify and characterize contrast and associated impacts.

(2) **Describe the VRM objectives**—For each field office or region, the RMP includes the VRM objectives for lands included in the RMP, usually in a GIS-generated map with polygons labeled with the applicable VRM classes. From this is drawn the existing VRM objective for the parcel or parcels in which the proposed project would be located.

(3) **Select KOPs**—Viewpoints are selected from which to evaluate the visual contrast that would be created if the proposed project were built. KOPs should represent either a typical view from a sensitive viewing location or the range of impacts associated with the project. These locations are usually located on commonly travelled routes from which the project would be visible, or other likely observation points. KOPs typically are selected through a consultation process with the BLM, and, in some cases, interested stakeholders and the public.

(4) **Prepare visual impact simulations**—Visual simulations are spatially accurate and realistic visualizations (typically computer-generated photomontages) of the project and surrounding landscape that are used to depict the overall appearance of a proposed project. Simulations depict views of the project from selected KOPs. Simulations help the BLM and other stakeholders visualize and respond to development proposals. They are also used to evaluate the effectiveness of mitigation measures and BMPs to address visual impact issues.

(5) **Complete the contrast rating form**—The BLM provides a worksheet (Form 8400-4) with which to conduct and record visual contrast ratings for views from the KOPs selected for the VCR.

The worksheet guides the evaluation and allows for multiple observers to evaluate a potential project. Contrast ratings are made by comparing the basic elements of form, line, color, and texture of the existing landscape with the proposed development, using the simulation to guide the assessment of expected future conditions. Factors to be considered when assessing visual contrast from the proposed facility include distance, angle of observation, length of time the project is in view, relative size or scale, season of use, lighting conditions, recovery time, spatial relationships, atmospheric conditions, and motion. These factors are considered in greater detail in Section 2.2.

The results of the VCR for each KOP include a determination of the level of visual contrast associated with the project for each of the four design elements. One of four levels of contrast (i.e., none, weak, moderate, and strong) is assigned for each of the design elements. The contrast assessment is used as the basis for determining whether or not the proposed project complies with the VRM objectives and allowable levels of change assigned to the area in the RMP. If it is determined that the project will not conform to the VRM class requirements, the VCR also specifies mitigation that will be required to meet the VRM class requirements, if compliance could be achieved through mitigation. Regardless of compliance with VRM class objectives, the VCR is used to identify appropriate impact avoidance and mitigation measures that should be implemented.

Additional information on the VRM system can be found in the following BLM documents:

- BLM Handbook 8400, *Visual Resource Management*;
- BLM Manual H-8410-1, *Visual Resource Inventory*;
- BLM Handbook H-8431-1, *Visual Resource Contrast Rating*;
- Information Bulletin No. 98-135;
- Instruction Memorandum No. 98-164; and
- Instruction Memorandum 2009-167.

Additional information on the RMP process can be found in the BLM Land Use Planning Handbook H-1601-1.

2.2 Visual Contrast and Visibility Factors

At a very basic level, visual impacts can be defined as changes to the scenic attributes of the landscape brought about by the introduction of visual contrasts, and the associated changes in the human visual experience of the landscape. Visual impacts on the visual experience of the landscape can be positive or negative. If viewers feel that the visual contrasts generated by a change to the visible elements of the landscape improve its visual qualities, the impact is positive. If viewers feel that the contrasts detract from the scenic quality of a landscape rather than improve it, the impacts are negative.

The concepts of *visual contrast* and *visual impact* are central to understanding how renewable energy facilities and other types of developments affect visual resources on BLM-administered lands.

- *Visual contrast* is a change in what is seen by the observer. For example, if wind turbines are introduced to a natural-appearing landscape, the tall shapes of the towers, and their white color, long vertical lines, smooth textures, blade motion, and blinking lights at night are all visual contrasts that can be seen by people and can change the scenic quality of the landscape.

- *Visual impact* includes both the change to the visual qualities of the landscape resulting from the introduction of visual contrasts, and the resulting change to the human visual experience of the landscape. Continuing with the wind energy example above, the introduction of contrasts from wind turbines may change the VRI scenic quality rating of an undisturbed and highly scenic area from an A to a B; this change in scenic quality constitutes a part of the visual impact from the project. The presence of the wind facility may also change the visual experience of persons who view the project area; this constitutes another dimension of the visual impact of the facility. Some viewers may think that the addition of wind turbines improves the view, perhaps because it adds visual interest to an otherwise static view. For these people, the visual impact of the wind turbines is positive. Other viewers may feel that the wind turbines add visual clutter or block the view of mountains they enjoy looking at. For these viewers, the visual impact of the wind turbines is negative.

Broadly speaking, visual impact assessment includes:

(1) determination of the extent and nature of the visual contrasts caused by a project;
(2) prediction of the effects of the contrasts on the landscape's visual qualities;
(3) prediction of viewers' emotional responses to the observed contrasts, as seen by likely viewers from likely viewpoints; and
(4) identification of measures to avoid or reduce the visual contrasts associated with the proposed project.

2.2.1 Visual Contrast

The BLM's VCR process focuses on the systematic assessment of visual contrast. While the VRI process recognizes that cultural modifications (manmade elements visible in the landscape) may sometimes positively affect scenic quality, the VCR process identifies the sources and levels of visual contrast from a proposed project. The BLM's visual impact mitigation approach seeks to reduce the visible contrasts from the project or to avoid the contrasts altogether; this may be accomplished, for example, by moving the entire project or its visible elements, or by screening the project from view. Because of this, a good understanding of the sources of visual contrast and the factors that affect the perception of visual contrast in the landscape is important not only to visual impact assessment, but also to the identification of appropriate visual impact mitigation.

In the VRM system, contrast is described as the differences in the four basic design elements of form, line, color, and texture between the proposed project and the surrounding landscape. Additional information about these elements is presented in BLM VRM Manual Handbook H-8431-1 (BLM 1986b); however, they are summarized as follows:

Form: The mass or shape of an object or of objects that appear unified. Two types are recognized:

- Two-Dimensional Shape—the presence of an area or areas that contrast in color and/or texture with adjacent areas, creating a two-dimensional shape in the landscape.
- Three-Dimensional Mass—the volume of a landform, natural object, or manmade structure in the landscape.

Examples of forms commonly encountered in natural-appearing BLM landscapes are masses of mountains, valley floors or plains, or large masses of similar-appearing vegetation, such as an expanse of shrubs in a landscape dominated by grasslands. Forms can also be manmade; they can include buildings, or the large rectangular block of a solar collector array at a solar energy facility.

Geometry is noted as a sub-element of form; forms in the landscape can approach a standard geometrical figure of two or three dimensions (e.g., square, circle, triangle, cube, sphere, cone). Solar collector arrays often appear as rectangles, parallelograms, or ellipses as viewed from elevated viewpoints. Forms can have irregular geometry, and those found in natural settings (e.g., those of mountains, lakes, or vegetation patches) usually do.

The massive forms of mountain ridges are an important element in this BLM landscape. (Credit: Robert Sullivan, Argonne National Laboratory.)

Line: The path, real or imagined, that the eye follows when perceiving abrupt differences in form, color, or texture or when objects are aligned in a one-dimensional sequence. Line is usually evident as the edge of shapes or masses in the landscape. Three main types of line are recognized: edges, bands, and silhouette lines.

- **Edge—**The boundaries along which contrasting areas are related and joined together; the outline of a two-dimensional shape on the land surface. There are several types of edges:
  - o *Butt Edge*—the simple sharp edge between two contrasting areas.
  - o *Digitate Edge*—the complex indented edge between two interlocking and contrasting areas.
  - o *Transitional Edge*—the presence of one or more band(s) connecting two contrasting areas, forming a transitional stage between the two.
  - o *Diffuse Edge*—soft edge formed by a gradation between two contrasting areas.

- **Band**—contrasting linear form with two roughly parallel edges dividing an area in two.
- **Silhouette-line**—the outline of a mass seen against a backdrop. The skyline is the silhouette-line of the land against the sky.

Boldness, complexity, and orientation are sub-elements of the line feature. Boldness refers to the visual strength of the line; complexity refers to the degree of simplicity or intricacy of a line; and orientation refers to the overall relationship of the line to the (horizontal) axis of the landscape or to compass bearings.

Examples of lines commonly encountered in natural-appearing BLM landscapes are the horizon line; lines of stratified layers of topography (e.g., successive ridges); the lines of mountains or ridges against the sky; strata in rock formations; streams; and the edges of vegetation masses. Like forms, lines in the landscape can be manmade, and manmade lines in BLM landscapes are quite common; they include fences, transmission towers and conductors, wind turbine towers, the edges of solar arrays, and the pipelines of geothermal plants.

Because wind, solar, and geothermal facilities typically have many butt edge, straight line, straight edged, or curved components (e.g., turbine towers, steam pipes, solar panels, mirrors, heliostats, or electricity conductors), line contrast from these facilities can be very strong if the lines are bold, especially when the orientation of the lines introduced by the facility are perpendicular to the predominant natural line. This situation is common for wind energy facilities, which often introduce strong vertical lines into strongly horizontal landscapes, such as the plains and valley floors common on BLM landscapes.

Wind turbines create strong vertical line contrasts in flat landscapes with strong horizon lines. (Dunlap Ranch Wind Energy Project near Medicine Bow, Wyoming. Credit: Robert Sullivan, Argonne National Laboratory.)

Color: The property of reflecting light of a particular intensity and wavelength (or mixture of wavelengths) to which the eye is sensitive. Color is the major visual property of surfaces.

Sub-elements of the color feature include hue, value, and chroma:

- **Hue**—aspect of color we know by particular names (e.g., red, blue, orange), and that is determined by the particular wavelengths of light emitted or reflected from an object.

- **Value**—lightness or darkness of the color, which is caused by the intensity of light being reflected, and ranges from black to white.
- **Chroma**—degree of color saturation or brilliance, determined by the mixture of light rays emitted or reflected from an object. It is the degree of grayness in a color, ranging from pure (high chroma) to dull (low chroma).

Colors common to many BLM landscapes, particularly in the desert southwest and intermountain west, are the colors of vegetation, rock, and soil, which tend toward muted (low chroma) greens, browns, and grays. Soil color varies widely, but soils are often light tan, red, or gray, and in desert or rocky areas with scant vegetation soil can be an important contributor to landscape color. Brighter colors, such as the colors of flowers, are present but tend to be ephemeral. Water is generally rare, but may be locally plentiful. The color of water ranges from brown to green to blue, but it can be white when water is cascading. Blue skies are common overhead, but skies are generally very pale blue to light gray at or near the horizon, except at sunrise and sunset. Night skies away from cities tend to be dark, in some places exceptionally dark. Manmade elements, of course, can be any color, but in many BLM landscapes, manmade elements are relatively uncommon and tend to be widely spaced. They are often constructed of wood or metal, with galvanized metal surfaces common, and they can sometimes be highly reflective.

Depending on the technology, solar facilities use thousands, or even hundreds of thousands, of mirrored surfaces that in some instances are sources of glinting (a brief flash of light) or glare (light bright enough to cause annoyance or discomfort). When glinting and glare are absent, the mirrors or heliostats may reflect the sky, clouds, or, at certain angles, even the ground or surrounding vegetation. Modern wind turbines are always white, which often contrasts strongly with the surrounding natural colors. Geothermal facilities can be any color, but if their sometimes-extensive pipeline networks are not painted or coated to match the backdrop, their surfaces may be highly reflective.

Reflections of the blue sky in this solar parabolic trough facility's mirrors causes strong color contrast with the surrounding vegetation. (Nevada Solar One near Boulder City, Nevada. Credit: Robert Sullivan, Argonne National Laboratory.)

Texture: The aggregation of small forms or color mixtures into a continuous surface pattern; the aggregated parts are small enough that they do not appear as discrete objects in the visible landscape. Two types of texture are recognized:

- **Color Mixture (mottling)**—intrinsic surface color contrasts of very small scale, which may be due to hue, chroma, or value, alone or in combination.
- **Light and Shade**—the color contrast, particularly in value, created by differences in lighting on a varied surface or repeated forms. It consists of the repetition of a lit side, a shaded side, and the shadow cast.

Sub-elements of texture include grain, regularity, and internal contrast. Grain refers to the relative dimensions of the surface variations, ranging from large (coarse texture, e.g., coniferous forest) to small (fine texture, e.g., grassland). Regularity refers to the degree of uniform recurrence and symmetrical arrangement of the surface variation. Internal contrast refers to the degree of contrast in colors or values creating the texture. Perception of texture is highly dependent on distance; a texture that appears coarse at short distances may appear as a fine texture at longer distances and will appear to be smooth at even longer distances.

Naturally occurring textures include those of vegetation, soils, and rocks. Vegetation and soil textures are often predominantly color mixtures, but light and shade textures are often important components of the coarser textures of rocky areas and mountains. The individual structures of renewable energy facilities often have monotone, smooth surfaces that lack texture even at very close viewing distances; however, light and shade textures may be important contrast sources from longer distances. They may be seen as the interplay of shadows and lit surfaces from complex piping and other elements of a power block at a thermal plant, or from thousands of visually overlapping sunlit solar collectors and the shadows they cast on the ground.

The power block, collector array, and buildings of this solar parabolic trough facility introduce a variety of non-natural textures to this landscape. (Nevada Solar One near Boulder City, Nevada. Credit: Robert Sullivan, Argonne National Laboratory.)

2.2.2 Visibility Factors

In many BLM landscapes, utility-scale wind, solar, and geothermal energy facilities may create strong visual contrasts with scenic settings. This is particularly true for wind and solar facilities, because these projects cover very large areas, and the structures involved can be very tall and/or highly reflective. All three technologies involve structures with distinctly manmade geometry that may contrast strongly with natural-appearing backgrounds when lighting conditions and viewing angles are suitable, and viewers are within a certain distance of the facility. However, at other times, even when viewed from the same location, the facilities may be invisible; they may be visible but hard to distinguish from the background; or they may be plainly visible but appear substantially different than they have appeared at other times. The visibility of an object in a landscape setting, and its apparent visual characteristics for any given view, are the result of a complex interplay between the observer, the observed object, and various factors that affect visual perception, referred to as *visibility factors*. After introducing the concept of the *viewshed*, the area of the landscape seen from a particular location, the remainder of this chapter is devoted to describing visibility factors and how they affect the visibility and apparent visual contrast associated with objects in the landscape, including renewable energy facilities.

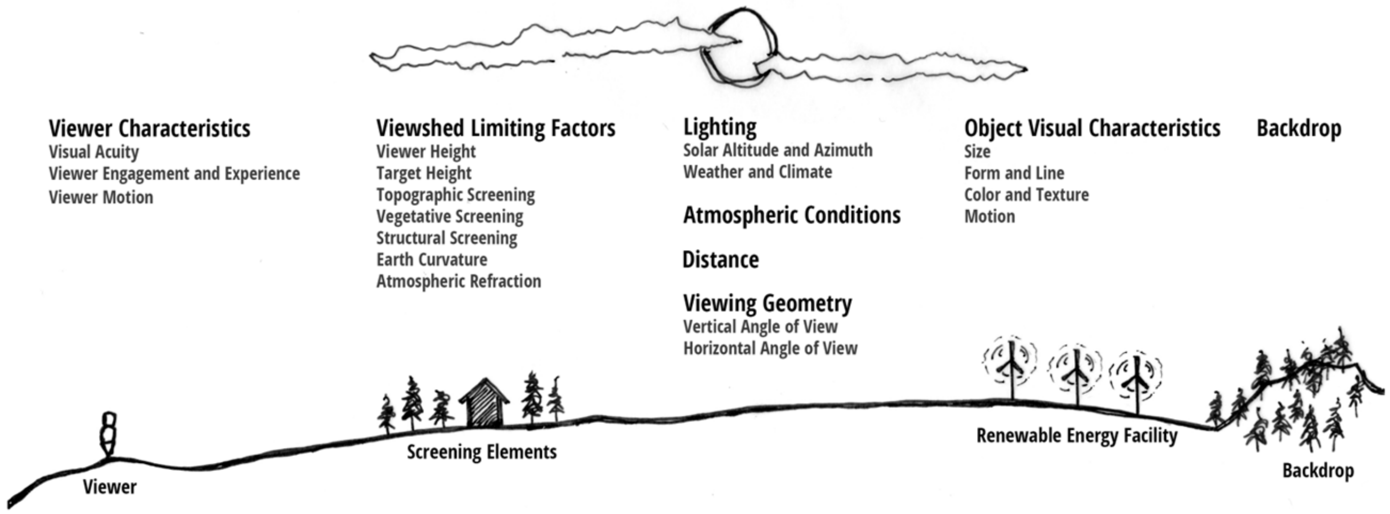
2.2.2.1 Viewsheds

A viewshed is the typical unit of study for a visual impact assessment. A viewshed is the total landscape that can be seen from a particular location, which could be a point, such as a scenic overlook; a line, such a travel route; or an area, such as a lake. Most visual impact assessments begin with a *viewshed analysis*, a spatial analysis conducted using various computer software programs such as a geographic information system (GIS). These programs analyze the land surface around the point, line, or area of interest to determine which part of the landscape would be visible from that location, and which part of the landscape would be screened from view, based on elevation data and data on screening elements such as vegetation or structures, if available. The user sets the maximum distance from the viewshed origin (the viewpoint from which visibility is being determined), as well as other controls (discussed below). The output of the viewshed analysis is usually a *viewshed map*, a map that indicates which areas around the viewpoint are visible and which are not. More specialized viewshed analyses are sometimes conducted; these may include composite viewsheds that indicate visibility of areas from multiple KOPs, or viewsheds that indicate the height of an object at a given location that could be concealed from view of a KOP.

2.2.2.2 Viewshed Limiting Factors

Several factors determine the spatial extent of the viewshed from a given viewpoint, within the maximum distance of analysis set by the user; these factors are here referred to as *viewshed limiting factors*, because they define the spatial limits of the viewshed. They include the following:

- **Topography:** Obviously, terrain such as a ridge or hill may block the view from a particular location; in hilly or mountainous areas, topography has a major effect on the shape and size of the viewshed. The elevation data used in the viewshed analysis provide information used in the analysis to determine topographic screening.
- **Vegetation:** Vegetation, typically trees, may screen views fully or partially, especially close to the viewpoint. In many but not all BLM landscapes, vegetation tall enough to screen views is sparse or absent; however, where it is present and of sufficient density to block views, it can affect the size and shape of the viewshed. Specialized elevation data may be required to account for vegetation height in a viewshed analysis, unless a standard vegetation height can be calculated and incorporated into the viewshed analysis. In areas with deciduous vegetation, seasonal leaf drop may affect the extent of screening. Views may be screened less effectively when leaves are shed.



Schematic Diagram of Visibility Factors that Affect Visual Perception of Landscape Elements (Credit: Lindsey Utter, Argonne National Laboratory)

- **Structures:** Manmade structures may also screen views fully or partially, especially if they are close to the viewpoint. Similarly to vegetation, specialized elevation data may be required to account for structure height in a viewshed analysis, unless the location and height of each structure can be incorporated into the viewshed analysis.
- **Viewer height:** The eyes of a standing adult are generally between 5 and 6 ft above the ground surface, so viewers see more than they would if their eyes were at ground level; this height must be added to the viewpoint elevation to obtain an accurate result from the viewshed analysis. If the viewpoint is further elevated (e.g. the viewpoint is at the top of a building), then the heights of both the viewer and the structure must both be accounted for in the viewshed analysis. Viewer height is a typical input setting for a viewshed analysis.
- **Target height:** Tall objects may project above topographic or other screening, and if a viewshed analysis is being run to determine visibility of a particular type of object (e.g., a wind turbine), the height of the object must be accounted for in the viewshed analysis. Target height is a typical input setting for a viewshed analysis. The components of the proposed energy facility should be considered when determining the target height to be used for viewshed analysis. Solar facility component height varies widely depending on the solar technology employed. Wind turbines also vary in height, and the viewshed analysis must account for the blade tip height in addition to the hub height.
- **Earth curvature:** The curvature of the earth's surface will affect viewshed results at long distances; if earth curvature is not accounted for in the viewshed calculation, objects at longer distances will be indicated as visible when in fact the curvature of the earth would have caused them to drop partially or completely below the horizon. Earth curvature

Solar photovoltaic facilities and the solar collector array of parabolic trough facilities have relatively low profiles and may be fully or partially screened by desert vegetation in flat landscapes where viewpoints are not elevated. (Solar Energy Generating System [SEGS] III–VII parabolic trough facilities, Kramer Junction, California. Credit: Robert Sullivan, Argonne National Laboratory.)

incorporation is a typical setting for a viewshed analysis. It should be noted that for large structures, such as renewable energy facilities that may be visible for very long distances (25 mi or more for wind and solar facilities), earth curvature can substantially reduce structure visibility, and it is important that it be accounted for in visibility analyses.

- **Atmospheric refraction:** Light rays passing through the atmosphere over long distances are bent downward due to the variation in air density as a function of altitude, which causes objects to appear slightly higher than they actually are. The effect is opposite from that of earth curvature, but much smaller in magnitude. Atmospheric refraction incorporation is a typical setting for a viewshed analysis.

If the above factors are accounted for in a properly run viewshed analysis with accurate input data, the result will be a viewshed map that shows the limits of the theoretically visible area around a viewpoint (within the radius set by the user); however, this does not mean that any object within the viewshed will actually be visible at any given time. The actual visibility of an object would depend on the viewer's eyesight, and on the object's size, shape, color, reflectivity, and orientation to the viewer; the lighting that falls on the object; and the presence of haze, among other factors. These factors are described below.

2.2.2.3 Viewer Characteristics

Characteristics of the viewer affect the perception of contrast and the ability to discern objects in the landscape. *Visual acuity* is the acuteness or clarity of vision. *Visual engagement and experience* refer to how closely the viewer is looking at the landscape, whether they are looking for a particular object or type of object, and their familiarity with the type of object. *Viewer motion* may change the aspect of the viewed facility, but it can also limit the duration of views.

- **Visual acuity:** Visual acuity is the ability to discern visual details and is a physical limitation of the human vision system. It is dependent on the sharpness of the retinal focus within the eye, the sensitivity of the nervous elements, and the interpretative faculty of the brain. It varies between individuals and decreases with age, but generally can be corrected with eyeglasses, contact lenses, or surgery, or by other means.
- **Viewer engagement and experience:** Human vision has many similarities to a camera, but unlike a camera, the human vision system is not a passive recorder of the scene in front of the lens. Seeing is an active process that involves scanning the landscape to pick out recognizable objects from the background, to look for patterns, and in general, to organize and make sense of the jumble of forms, lines, colors, and textures presented to the eye. While much of this activity happens without conscious effort by the viewer, viewers who are consciously and actively focusing on the landscape will normally be better able to discern particular objects, particularly if they know what they are looking for, and especially if they have previous visual experience with the object, such that they have a mental "template" to help them predict the forms, lines, colors, and textures they should be looking for as they scan the view. Viewers who are not focusing on the view, not actively scanning the scene in front of them, and not trying to identify a known type of object may be less likely to see a given facility unless it is so large or eye-catching as to be hard to miss.
- **Viewer motion:** If the viewer is moving through the landscape, the visual experience differs from that of a static viewer in important ways. If the viewer is moving directly toward or away from the facility, the general aspect of the facility will not change, but its apparent size will, and the level of contrast it creates will change similarly. If the viewer is moving perpendicular to the line of sight to the facility (i.e., the facility is moving across the field of view), visual parallax will make the facility seem to move across its visual backdrop. If the backdrop is not uniform, and if the viewer is sufficiently close to the facility, the contrast from the facility may change dynamically as the color and texture of the backdrop change. The portions of the facility in view may change as well. Viewer motion will also tend to decrease the duration of views of the facility, particularly if the motion is perpendicular to the line of sight to the facility rather than toward the facility. Decreased view duration will decrease the likelihood that the facility is noticed and decrease the overall perception of contrast.

Viewers who are consciously and actively focusing on the landscape are likely to notice more details. (Credit: BLM.)

2.2.2.4 Distance

Distance affects the apparent size and degree of contrast between an object and its surroundings (Saratoga Associates 2008). In general, visual contrasts are greater when objects are seen at close range. If other visibility factors are held constant, the greater the distance, the less detail is observable and the more difficult it will be for an observer to distinguish individual features (Landscape Institute 2002).

Viewing distance has a large effect on visual contrast. Wind turbines viewed from a distance of 2 mi (top) and 5 mi (bottom). (Cedar Creek Wind Farm, near Grover, Colorado. Credit: Robert Sullivan, Argonne National Laboratory.)

BLM-sponsored research has shown that in clear, dry air, under favorable but not uncommon lighting conditions and viewing geometry, wind turbines can often be visible at distances exceeding 25 mi, and occasionally beyond 35 mi (Sullivan et al. 2012a). Very limited research is available about the visual characteristics of solar facilities; however, a small thin-film PV facility was repeatedly observed at a distance of 22 mi, viewed from the north. Because this perspective did not include the south-facing sunlit PV panels, it is assumed that a larger, sunlit facility might be visible at longer distances (Sullivan et al. 2012b). At any given time and location, the maximum distance at which a facility might be seen, and the degree of visual contrast observed at a particular distance may vary widely, and depends on a complex interaction of the visibility factors discussed below.

2.2.2.5 Viewing Geometry

Viewing geometry refers to the spatial relationship of viewer to the viewed object (e.g., a renewable energy facility), including the *vertical angle of view* and the *horizontal angle of view*. The vertical angle of view refers to the viewer's elevation with respect to the viewed object: whether the viewer is elevated with respect to the facility and therefore looking downward at it, lower in elevation than the facility and therefore looking upward at it, or level with the facility and looking across it. The horizontal angle of view refers to the compass direction of the view from the viewer to the object.

Both the vertical and horizontal angle of view may have important effects on facility visibility and contrast levels. Because of the large areas typically covered by renewable energy facilities, particularly wind and solar facilities, views from elevated viewpoints often include the top surfaces of the structures in the facility, causing it to occupy more of the field of view, and making the full areal extent and the regular geometry of the facility more apparent. For solar facilities, elevated views tend to show more of the often highly reflective solar arrays, which can greatly increase visual contrast, especially if glare or glinting occurs.

The horizontal angle of view determines which side of the facility is in view, and the angle of surfaces with respect to the viewer (for example, whether wind turbine blade motion is seen face-on, where it can be quite noticeable, or seen from the side, where it may be nearly invisible). The horizontal angle of view also interacts with the solar azimuth (see Section 2.2.2.7 below) to determine whether the object is frontlit (the side facing the viewer is fully illuminated by light coming from behind the viewer), backlit (the side facing the viewer is fully shaded because the object is between the viewer and the light source), or sidelit (the side facing the viewer is partly illuminated and partly shaded because the light is falling more or less perpendicular to the line of sight between the viewer and the object).

Movement of the viewer during the act of viewing a facility, as when viewing from an automobile on the highway or while walking down a trail, causes the viewing geometry to change, which can have dramatic effects on visibility and visual contrast. As rapidly changing viewing geometry changes the orientation of the line of sight to reflective surfaces, bright flashes of light, abrupt changes in apparent color, and abrupt changes in the patterns of light and shadows may result. For moving viewers, the visual experience of wind facilities and especially solar facilities tends to be very dynamic, with major changes in the appearance of the facilities sometimes occurring over short periods of time or with small changes in viewer position.

Views of the Silver State North solar PV facility, near Primm, Nevada from ground level (top photo) and from an elevated viewpoint (bottom photo). Views from elevated viewpoints often include the top surfaces of the structures in the facility, causing it to occupy more of the field of view, and making the full areal extent and the regular geometry of the facility more apparent. Credit: Robert Sullivan, Argonne National Laboratory.)

2.2.2.6 Background/Backdrop

Objects that stand out against the visual background typically command a viewer's attention. The ability to see or detect an object is heavily influenced by the contrast between the object and its background or backdrop (Sprawls 1995). As contrast between an object and its background is reduced, the ability to distinguish the object from the background diminishes. When the contrast becomes too small, the object will no longer be visible as separate from its background.

The backdrop against which the structures of a renewable energy facility are viewed affects their visibility. The degree to which visibility is affected depends on the color and textures of the structures and the backdrop, and the lighting falling on both (see Section 2.2.2.4). Light-colored or sunlit structures viewed against backdrops of dark vegetation or rock will show strong contrasts that can greatly extend their visibility, while dark or shaded structures against the same backdrop may nearly disappear. Conversely, dark or shaded structures against light backdrops such as white or light gray clouds, pale blue skies, snow-covered slopes, or expanses of dried grasses may cause strong contrasts, while light-colored or sunlit structures may be difficult to discern against these backdrops.

Because of their height, the visual backdrop of wind turbines may have a particularly large effect on their visibility. The strong vertical, stark white lines of sunlit turbines against dark mountain ridges or dark clouds may be especially conspicuous, while backlit turbines, geothermal facilities, and especially low-height solar facilities (e.g., PV facilities), may be substantially less visible. It should be noted that sunlit water vapor plumes at facilities that use thermal power technology may stand out strongly against dark backdrops.

The texture or visual complexity of an object's backdrop may also affect the visibility of the object. While, in general, it is harder to distinguish objects against visually complex backgrounds, the flat, textureless surfaces of some manmade facilities can contrast strongly with visually complex, highly textured natural backgrounds, although texture effects tend to become less important at long distances.

2.2.2.7 Lighting

Objects are visible when light bounces (i.e., reflects) off their surfaces and is redirected into an observer's eye (Hyslop 2009). The intensity and distribution of lighting has a profound effect on the apparent color of objects and their backgrounds. The angle of sunlight falling on an object may result in shadows that greatly increase its apparent contrast with the background. Sunlight can cause glare from solar mirrors and glinting from wind turbine blades, and can cause dramatic increases or decreases in facility visibility as it interacts with clouds. Lighting's effects on visibility are complex and interact with other visibility factors, such as atmospheric conditions, and the surface characteristics of structures. A number of variables affect the strength, quality, and distribution of lighting and determine its effects on the visibility of renewable energy facilities; these are discussed below.

- S**olar altitude and azimuth—**The solar altitude is the angle of the sun above the horizon. Solar altitude affects the overall visibility of a renewable energy facility by altering the amount and position of light on an object, and in some instances by casting shadows onto the object and the ground that can substantially increase or decrease visual contrast. At higher sun angles,

The complex interaction of viewing geometry, lighting, and visual backdrop may have large effects on facility visibility and contrast levels. Viewing distance ranges from 6 mi for top photo to 10 mi for bottom photo. (Dunlap Ranch Wind Energy Project near Medicine Bow, Wyoming. Credit: Robert Sullivan, Argonne National Laboratory.)

light may be cast more on the tops of structures, which can increase the brightness and contrast of the facility as seen from elevated viewpoints. At higher sun angles, shadows are diminished, and the landscape can take on a more washed-out appearance, with lower levels of contrast for more distant objects. Of course, the horizontal angle of sunlight (the solar azimuth) also alters the amount and position of light on an object, interacting with the viewing geometry to determine whether structures in the landscape are frontlit, backlit, or sidelit. Whether an object is frontlit, backlit, or sidelit can greatly increase or diminish its visibility, depending, in part, on the visual backdrop against which it is viewed. In general, backlighting from the sun will silhouette objects, making their contours prominent, but concealing surface detail. Frontlighting reveals surface detail, texture, and color differences and causes objects to contrast more strongly with darker backdrops. As discussed below, solar altitude and azimuth vary both during the course of the day and seasonally, sometimes causing facilities to vary dramatically in appearance and contrast at different times of day and at different times of year.

Time of day—As the sun rises in the east, passes through the meridian at noon, and sets in the west, it will cause facilities to the east or west of viewers to switch from being backlit to frontlit or vice versa during the course of the day. Both conditions may result in high contrast with the visual backdrop, either because the backlit objects are silhouetted against the brightly sunlit background or frontlit objects are viewed against the darker sky (or a ground backdrop) opposite the sun. Objects will typically be sidelit from the south during the middle parts of the day, but the high-angle sunlight strikes vertically oriented objects (e.g., wind turbines) obliquely and with diminished shadows, so contrast is somewhat lower.

Facilities south or north of viewers may be sidelit at the beginning and end of the day, depending upon the season (see below). For viewers north of a facility, the facility will likely be backlit in the middle part of the day, but because the sun will be at a relatively high angle the contrast will generally be less than if it were directly behind the object. For viewers south of a facility, it will generally be frontlit in the middle of the day, but again, because the sun will be at a relatively high angle, the contrast will often be less than if the sun were more directly behind the viewer.

In addition, renewable energy facilities are lighted in the evening, although the nature and amount of lighting varies widely. This lighting will increase the visibility of the facilities during the evening hours. For instance, wind turbines and solar power towers would be lighted at night for air navigation safety, typically with red, slowly flashing lights. These lights can be visible for very long distances, and although they are not extremely bright, they can be conspicuous in dark night skies, particularly as a result of the flashing.

Seasonal variation— In the northern hemisphere during the fall and winter, the sun is in the southern sky the entire day; in the spring and summer, the sun rises and sets in the northern sky but is in the southern sky most of the day. At the beginning of spring and fall, the sun rises and sets near due east and due west. It is only in spring and summer, in the early morning and late afternoon, that the sun is located in the northern sky for a significant portion of the day. This means that throughout the year, except for the early mornings and late afternoons in spring and summer, a facility will appear completely or mostly frontlit to viewers south of the facility. It will be fully illuminated, with little shadowing evident. If the backdrop is light, contrast may be low. If the backdrop is dark, contrast may be high. Viewers north of a facility will almost always see the facility components completely or mostly backlit (shaded), and in winter, with the sun low in the southern sky, components with a sky backdrop may be silhouetted and show strong contrasts. If the backdrop is dark, the components may be difficult to discern. Viewers to the east or west of a facility will tend to see the facility more sidelit in winter than in summer.

There are other seasonal aspects to lighting that are important: the sun is at a lower angle in the winter months, and is consequently weaker, which reduces the overall contrast levels somewhat. Of course, day length is much shorter in winter than in summer, so night sky contrasts are a much greater percentage of the overall visual contrast generated by the facility on a daily basis. In some locations, there are seasonal variations in weather that change the average percentage of cloud cover and humidity, both of which will affect perceived visual contrast. Finally, in some regions, the change of season may be accompanied by large changes to the color of visual backdrops for facilities, caused by greening of vegetation in the spring, the drying of vegetation as summer progresses, changes in leaf color and leaf drop in the autumn, and snowfall in winter.

- **Weather and Climate**—Local weather can greatly affect the visibility and appearance of facilities, primarily by changing the amount and quality of sunlight falling on the facility. A cloud passing in front of the sun changes the light on both the facility and the backdrop, and often causes a sudden drop in contrast that may make distant facilities difficult to see. When the sun "pops out" from behind a cloud, there may a rapid increase in contrast and consequently visibility. Thus in some circumstances, weather adds a dynamic quality to the viewing experience. Light diffused through clouds and fog also can decrease contrast substantially (San Diego County 2003).

Weather-induced lighting changes can have dramatic effects on the contrast levels associated with wind turbines, and especially for solar facilities that utilize mirrors or heliostats. White wind turbines may appear to be starkly white in bright sunlight, but a medium or even a dark gray when shaded. When sunlit and shaded turbines are side by side, the contrast between them can be striking. Because solar mirrors and heliostats typically reflect the sky above them, they will assume the hue, value, and chroma of the blue sky or clouds, if present, and thus they can appear to be a solid blue, a dull gray, a brilliant white, a dappled blue and white, or even green as they reflect nearby vegetation, and their appearance may change rapidly and dramatically as clouds pass by.

Climate will also affect facility visibility and contrast. Regions with sunnier skies and dryer air will, on average, experience higher levels of visual contrast and longer visibility distances for renewable energy facilities than will regions with less sunny skies and higher humidity levels.

A passing cloud has shaded the two foreground wind turbines, causing a dramatic change in apparent color. (Cedar Creek Wind Farm, near Grover, Colorado. Credit: Robert Sullivan, Argonne National Laboratory.)

Viewed from the west, a dark cloud backdrop behind wind turbines illuminated by late afternoon sun results in very high visual contrast. (Cedar Creek Wind Farm, near Grover, Colorado. Credit: Robert Sullivan, Argonne National Laboratory.)

Winter brings lower light levels, and different colors and textures, to the landscape. (Wind farms near Peetz, Colorado. Credit: Robert Sullivan, Argonne National Laboratory.)

2.2.2.8 Atmospheric Conditions

Water vapor (humidity) and particulate matter (dust, air pollution, and other particles) within the air affect visibility in multiple ways. Particulate matter scatters and absorbs light coming from an object, which diminishes contrast and subdues colors. The nature and degree of these effects depends on particle type and density, distance between the viewer and viewed object, and lighting conditions, among other things. Atmospheric conditions may affect an object's visibility through alterations of sharpness, brightness, and color, and can have a substantial effect on project visibility, especially at longer distances. On humid days with high levels of dust or pollutants, distant facilities may not be visible at all, or may be much harder to see, with substantially lower contrast and indistinct structure edges.

Atmospheric haze may substantially reduce visual contrast of facilities. (Ivanpah SEGS solar power towers, under construction, Ivanpah Valley, California. Credit: Robert Sullivan, Argonne National Laboratory.)

2.2.2.9 Object Visual Characteristics

The inherent visual characteristics of the viewed object (e.g., a renewable energy facility) will obviously affect its visibility and the level of visual contrast it creates. The facility and structure size; the scale relative to other objects in view; the form, line, surface colors, and textures of the facility components; and any visible motion of the facility components will all affect the facility's apparent visual contrast.

- **Size:** Other things being equal, larger facilities with larger structures will obviously show increased visual contrasts relative to smaller facilities. Depending on the distance and the amount of the facility in view, a large wind facility can cover a significant portion of the horizontal field of view, even at long distances. Solar facilities, while generally smaller in size, are still quite large objects relative to what humans normally encounter, and can occupy a substantial portion of the field of view at distances of several miles. Wind turbines and power towers are likely to be much taller than most other objects in BLM landscapes and may seem out of scale with nearby objects in some situations, which may tend to focus visual attention on them.
- **Form and Line (Geometry):** As noted in Section 2.2.1, because wind, solar, and geothermal facilities typically have many rectilinear or regularly curved components, they may contrast strongly with the forms and lines of predominantly natural landscapes.
- **Surface Color and Texture:** The color and surface texture of facility components can make them stand out or blend in with the visual backdrop. Darker colors tend to "recede" from the viewer, and lighter colors to "advance," so that lighter colors may appear to be closer to the viewer than darker background elements, and may stand out against the background. Wind turbines effectively must be painted white for

safety reasons. The mirrored surface of solar collectors and the collecting surfaces of PV panels cannot be painted for performance reasons. Some other facility components cannot be painted for safety or technical reasons, but many facility components could be painted to better match the surroundings, substantially decreasing their visibility and contrast. Where structures cannot be painted or coated to reduce their color contrast, the color contrast may attract visual attention. Most facility components have smooth surfaces that may be highly reflective without special coatings to dull the finish, and if these components cause glinting or glare, the glinting or glare may greatly increase their visibility at long distances, causing them to be strong sources of visual contrast.

- **Motion:** Motion is a strong attractant of visual attention, and facilities with moving components or other sources of visible motion are more likely to attract attention. An obvious example is the motion of wind turbines; the blade motion may strongly attract visual attention and has been shown to be visible at distances greater than 25 mi in clear air with good viewing conditions (Sullivan et al. 2012a). The mirrors of parabolic trough facilities, the heliostats of power towers, and in some cases the panels of PV facilities will track the daily course of the sun, and thus slowly move. This movement is generally too slow to notice, but it can affect contrast levels and change the appearance of the facility. Water vapor plumes from steam turbine generators or gas boilers are also sources of visual contrast associated with motion. In some lighting situations, especially if viewed against dark vegetation or mountain ridges, the plumes can be visible for miles, and their color and movement will attract visual attention and substantially increase the visual contrast associated with the facility.

Glare from reflected sunlight on a solar Compact Linear Fresnel Reflector mirror. (Kimberlina Solar Thermal Energy Plant near Bakersfield, California. Credit: Robert Sullivan, Argonne National Laboratory.)

The polished surfaces of black photovoltaic solar panels are highly reflective. (Copper Mountain Solar Facility, near Boulder City, Nevada. Credit: Robert Sullivan, Argonne National Laboratory.)

Sunlit white wind turbines may contrast strongly with blue skies and may be visible for long distances in open landscapes. (Wind energy project near Medicine Bow, Wyoming. Credit: Robert Sullivan, Argonne National Laboratory.)

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3 Wind

Introduction

The following sections provide a discussion of the general stages of utility-scale wind farm development, as well as a summary of visual contrast sources and effects by project phase.

Facility Life Cycle

In general, the development of a wind farm consists of six stages, including planning/preliminary siting, site evaluation, design/engineering, construction, operations, and decommissioning. The following discussion includes only the phases that involve onsite activities that would lead to significant visual contrasts: site evaluation, construction, operations, and decommissioning and reclamation.

Site Evaluation Phase

Before a wind farm can be planned and built, the wind regime at a potential site must be characterized precisely. Meteorological monitoring towers, which vary in height, are installed to transmit data on weather conditions and wind speed, direction, and shear on a continuous basis to a remote monitoring facility. The data is used as the basis for a "micrositing" strategy that places turbines on the site in locations where maximum power production is possible throughout the year.

Construction Phase

Throughout wind energy project construction, the entire project area would be temporarily affected by site preparation activities such as clearing;

construction of access and onsite roads; preparation and use of material and equipment laydown areas; installation of turbine foundations; erection of turbines; construction of the electrical substation, central control facility, and ancillary facilities; and installation of power and signal cables (typically buried or vaulted). Concrete ingredients (sand, aggregate) may also need to be extracted and hauled to the site.

Operations Phase

No land-disturbing activities or associated impacts would normally occur during the operations phase. Routine operations include wind-driven operations of the turbines to produce power, and regular monitoring and maintenance activities to ensure safe and consistent operation. Most monitoring would be done remotely, but maintenance crews would be present on regular shifts. In areas with significant snowfall, roads might be snowplowed in the winter.

Decommissioning and Reclamation Phase

Decommissioning of a wind energy project would include removal of turbines, buildings, concrete pads, and foundations, as well as the excavation and removal of buried components. Underground components would be removed (generally to a depth of at least 3 ft) to ensure an unobstructed root zone for revegetation. More deeply buried components might be abandoned in place. Following removal of site components, site reclamation and revegetation would mitigate some impacts, such as soil erosion, habitat fragmentation, and visual impacts.

Visual Contrast Sources and Effects Summary by Project Phase

Site Evaluation Phase

Typical site evaluation activities include the placement of one or more meteorological towers in or near the proposed wind energy facility to collect one or more years of meteorological data. Meteorological towers are instrumented towers that vary in height and appearance, but generally approximate the hub height of the proposed wind turbine generators. Multiple meteorological towers would be interconnected with data collection and integration equipment, usually contained in an enclosure centrally located between the towers. Meteorological towers are typically metal (galvanized or painted), lattice-type structures; however, composite materials are also used sometimes, as are smooth-skinned materials. Meteorological towers may be guyed or self-supporting; on guyed meteorological towers, guy wires could be visible depending on distance, and depending on the presence of bird diverters.

Aviation warning lights would be required for meteorological towers more than 200 ft (60.9 m) tall; normally these would be red flashing lights (FAA 2007).

Vehicles and workers would be seen during tower construction, and vehicles and workers might occasionally be seen at the tower for maintenance activities, but these activities would be rare.


Meterological tower at Dunlap Ranch Wind Energy Project near Medicine Bow, Wyoming. (Credit: Robert Sullivan, Argonne National Laboratory.)

A meteorological tower in a typical BLM landscape would introduce a vertical line that would contrast with the horizon line. Due to their thin profile and lack of moving parts, meteorological towers generally cause lower visual contrasts than wind turbines and have a shorter radius of visibility. On guyed meteorological towers, guy wires and bird diverters might be visible, depending on viewer distance from the meteorological towers. Some color contrast would also be present, in addition to the FAA-required lighting at night on sufficiently tall towers.

Duration of the visual impacts associated with site characterization meteorological towers would be from 1 to 3 years for a typical project, although some meteorological towers might be retained for the life of the project, or replaced elsewhere on the project site with permanent meteorological towers.

Construction Phase

Construction activities for a wind energy facility are site- and project-dependent; however, construction of a typical facility would normally involve the following major actions with potential visual impacts: building/upgrading roads; grading the site; constructing laydown areas; removing vegetation from construction and laydown areas; transporting towers, turbines, nacelles, and other materials and equipment to the wind energy facility site; assembling and erecting the wind turbine generators; installing permanent meteorological towers (as necessary); constructing ancillary structures (e.g., control building, fences); constructing electrical power conditioning facilities and substations; and installing power-conducting cables and signal cables (typically buried). Additional construction activities may also be necessary at very remote locations or for very large wind energy projects; they may include constructing temporary offices, sanitary facilities, a concrete batching plant, or a transmission line.

Potential visual contrasts that could result from construction activities include contrasts in form, line, color, and texture resulting from vegetation clearing and grading (with associated debris); road building/upgrading; construction and use of staging and laydown areas; wind turbine generator, electric transmission, and support facility construction; vehicular, equipment, and worker presence and activity; dust; and emissions.

Unloading a wind turbine blade. (Milford Wind Corridor project, near Milford, Utah. Credit: BLM.)

Partially erected turbine, with nacelle and hub visible at right center. (Near Peetz, Colorado. Credit: Robert Sullivan, Argonne National Laboratory.)

Construction visual contrasts would vary in frequency and duration throughout the course of construction; there may be periods of intense activity followed by periods with less activity, and associated visual impacts would to some degree vary in accordance with construction activity levels. Construction schedules are project dependent. While many projects might be completed within 1 year, larger projects may take longer and could involve phased development, with construction-related visual impacts therefore lasting longer.

Operations Phase

Visual impacts associated with wind facility operations include the presence of wind turbines, control buildings, and other ancillary structures; movement of the rotor blades; shadow flicker and blade glinting; turbine marker lights and other lighting on control buildings and other ancillary structures; roads; vehicles; and workers conducting maintenance activities.

Wind Turbines

The major visible components of a wind turbine include the following:

Tower: Wind turbine towers typically consist of large, tubular steel pieces that support the nacelle and rotor hub. Heights vary, but as an example, a modern 3.0-MW tower may be nearly 400 ft tall, with a trend toward increasing height.

Nacelle: An enclosure atop the tower that houses the controller, gearbox, generator, and shafts. It typically is equipped with an anemometer and wind vane, which may be visible at short distances.

Rotor: The rotor consists of the blades and the hub.

- Hub: The junction of the blades and the rotor shaft, covered with a protective nose cone.

- Blades: The moving parts of the wind turbine that capture wind energy, typically three in number. Lengths vary, but typically range from 110 to 180 ft, with a trend toward increasing length.

The primary visual impacts associated with wind energy developments would result from the introduction of the numerous vertical lines of wind turbines into the generally strongly horizontal landscapes common to many BLM lands, or the placement of turbines on mesas or ridgelines where they would be "skylined". The visible structures would potentially produce visual contrasts by virtue of their design attributes (form, color, and line) and the reflectivity of their surfaces. In addition, aviation warning lighting could cause large visual contrasts at night.

Vertical line contrast from wind turbines in a strongly horizontal landscape. (Seven Mile Hill Wind Farms, Carbon County, Wyoming. Credit: Robert Sullivan, Argonne National Laboratory.)

For nearby viewers, the very large sizes and strong geometric lines of both the individual turbines and the array of turbines could dominate views, and the large sweep of the moving blades might command visual attention. Structural details could become apparent, and the control buildings and other structures could be visible as well, as could strong specular reflections from the towers and moving

Wind facility at night, with synchronized flashing hazard navigation lighting visible on several turbines. (Cedar Creek Wind Farm, near Grover, Colorado. Credit: Robert Sullivan, Argonne National Laboratory.)

rotor blades (blade glint). For viewers close enough to fall within the cast shadows of the turbines, shadow flicker might be observed.

Ancillary Structures

In addition to visual impacts associated with wind turbines, aboveground ancillary structures (including permanent meteorological towers, control buildings, electrical power conditioning facilities, and substations) would potentially produce visual contrasts by virtue of their design attributes (form, color, line, and texture) and the reflectivity of their surfaces.

Roads

Permanent roads could also contribute to visual impacts during wind facility operations. While some construction access roads would not be needed during operations and would be reclaimed after construction, certain roads would remain, such as

Wind energy facility substation, with meterological tower in background. (Dunlap Ranch Wind Energy Project near Medicine Bow, Wyoming. Credit: Robert Sullivan, Argonne National Laboratory.)

Wind energy facility control building, fences, and parking area. (Dunlap Ranch Wind Energy Project near Medicine Bow, Wyoming. Credit: Robert Sullivan, Argonne National Laboratory.)

onsite roads used for inspection and maintenance and the permanent facility access road. In addition to vegetative clearing, roads may introduce long-term visual contrasts to the landscape, including ground disturbances (e.g., grading and erosion control measures) and contrasts from rock faces exposed by blasting. Temporary visual contrasts could be created by snowplowing of roads in areas with significant snowfall in winter.

Workers, Vehicles, and Equipment

Maintenance activities could potentially cause visual impacts. Vehicles (potentially with associated dust plumes) and technicians would be present at or near wind turbines and other facilities, where they would either work directly on the turbine or associated facilities or remove components for repair and subsequent reinstallation. Towers, nacelles, and rotors may need to be upgraded or replaced. Infrequent outages, disassembly, and repair of equipment may occur. These may produce the appearance of idle or missing rotors, "headless" towers (when nacelles are removed), and lowered towers.

Wind turbine maintenance. (Dunlap Ranch Wind Energy Project near Medicine Bow, Wyoming. Credit: Robert Sullivan, Argonne National Laboratory.)

Magnitude and duration of impacts: The magnitude of the visual contrasts associated with a given wind energy facility during operations would depend on site- and project-specific factors, including the following:

- Distance of the proposed wind energy facility from viewers;
- Weather and lighting conditions;
- Size of the facility (i.e., number of turbines) and turbine spacing;
- Size (including height and rotor span) of the wind turbines;
- Surface treatment of wind turbines, the control building, and other structures (primarily color);
- The use of identifying graphics on nacelles;
- The presence and arrangement of lights on the turbines and other structures; and
- The presence of workers and vehicles for maintenance activities.

These impacts would occur during the entire operational life of the facility.

Decommissioning and Reclamation Phase

Decommissioning of a wind energy project would involve the dismantling and removal of infrastructure associated with each wind turbine, the removal of aboveground and some buried ancillary structures, road redevelopment, temporary fencing, and restoration of the decommissioned site to pre-project conditions. In terms of expected visual impacts, decommissioning activities would be similar to construction activities. However, activities would generally proceed in reverse order from construction and would proceed more quickly than during construction; thus, the associated impacts would last for a shorter time.

Restoration activities would include recontouring, grading, scarifying, seeding and planting, and stabilizing disturbed surfaces. Newly disturbed soils would create a visual contrast that could persist for several seasons before revegetation would begin to disguise past activity. Restoration of vegetation to pre-project conditions may take much longer. Invasive species may colonize recently reclaimed areas. These species may be introduced naturally or in seeds, plants, or soils introduced for intermediate restoration, or by vehicles. Non-native plants that are not locally adapted would likely produce contrasts of color, form, texture, and line.

Similarly to construction, the various decommissioning activities described above require work crews, vehicles, and equipment that would add to visual impacts during decommissioning.

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Wind Energy Facility BMPs and Applicable Project Phases	Siting and Design	Construction	Operations	Decommissioning and Reclamation
3.1 Consider Topography When Siting Wind Turbines (p 44)	●			
3.2 Cluster or Group Turbines to Break up Overly Long Lines of Turbines (p 46)	●			
3.3 Create Visual Order and Unity among Turbine Clusters (p 48)	●			
3.4 Site Wind Turbines to Minimize Shadow Flicker (p 49)	●			
3.5 Relocate Turbines to Avoid Visual Impacts (p 50)	●			
3.6 Use Audio Visual Warning System (AVWS) Technology to Reduce Night Sky Impacts (p 52)	●			
3.7 Create Visual Uniformity in Shape, Color, and Size (p 54)	●			
3.8 Use Fewer, Larger Turbines (p 55)	●			
3.9 Use Non-reflective Coatings on Wind Turbines and Other Facility Components (p 56)	●			
3.10 Prohibit Commercial Messages and Symbols on Wind Turbines (p 57)	●			
3.11 Keep Wind Turbines in Good Repair (p 58)			●	
3.12 Clean Nacelles and Towers (p 59)			●	

3.1 Consider Topography When Siting Wind Turbines

Project Phase: Siting and Design

During the facility design process, wind turbine siting should be sensitive to, and respond to, the surrounding landscape in a visually pleasing way. Avoid major modifications to natural landforms, roads, water bodies, structures, or other characteristic parts of the landscape.

Non-linear turbine configurations are better suited to rolling terrain. (Spanish Fork Wind Farm, Utah. Credit: NREL.)

Linear turbine configuration in flat agricultural landscape. (Big Horn Wind Farm near Bickleton, Washington. Credit: NREL.)

Notes

For example, in rolling landscapes, a less rectilinear and rigid configuration of wind turbines that follows local topography may be appropriate. In flatter, agricultural landscapes with rectilinear patterns of roads and fields, a more geometric or linear wind turbine configuration may be preferred. Where possible, the nacelles should be kept at a constant height relative to the ground. Consideration should be given to the appearance of the project at night, when the aircraft warning lights will create a strong horizontal line above the ground. Computer modeling can be an effective tool to study the relationship between the turbines and topography.

Limitations

Wind farm efficiency (and therefore profitability) depends, in part, on precise turbine siting, based on local topography, the local wind regime, and other technical factors. Micro-siting may reflect concerns for small-scale components of the landscape, both cultural and environmental. Therefore, developers may be reluctant to site turbines in response to potential visual impacts, except where visual values are considered a critical concern.

3.2 Cluster or Group Turbines to Break up Overly Long Lines of Turbines

Project Phase: Siting and Design

During the facility design process, to the extent possible given the terrain of a site, create well-organized clusters or groupings of wind turbines when placed in large numbers; to avoid cluttering, separate overly long lines of turbines, or large arrays, and insert breaks or open zones to create distinct visual units or groups of turbines.

Organized clusters of wind turbines separated by open zones create distinct visual units. The breaks reduce visual clutter and the potentially overwhelming visual presence of turbines. (Seven Mile Hill Wind Farms, Carbon County, Wyoming. Credit: Robert Sullivan, Argonne National Laboratory.)

Notes

When siting large numbers of turbines, developers may be able to relieve visual clutter or a potentially overwhelming visual presence of turbines by clustering turbines to create visual breaks.

Limitations

Because engineering and other technical considerations are the primary drivers for decisions about wind turbine locations, clustering may be impractical in some cases; in other cases, local topography may make clustering ineffective for reducing visual impacts. In some situations, turbine clustering could increase the lengths of the conductors needed to bring current to a central power control facility, which would involve increased cost.

3.3 Create Visual Order and Unity among Turbine Clusters

Project Phase: Siting and Design

The operator should create visual order and unity among clusters of turbines (visual units) to avoid visual disruptions and perceived disorder, disarray, or clutter.

This array of turbines lacks visual order and unity, and appears cluttered. (Wind farm near Peetz, Colorado. Credit: Robert Sullivan, Argonne National Laboratory.)

Notes

Large numbers of turbines in a visually disordered and apparently random array may appear to be visually cluttered and have an overwhelming visual presence.

Limitations

Wind farm efficiency (and therefore profitability) depends, in part, on precise siting of individual turbines and turbine strings, based on local topography, the local wind regime, and other technical factors. As a result, siting flexibility may be constrained, and developers may thus be reluctant to site turbines in response to potential visual impacts, except where visual values are considered a critical concern. In addition, perceived order in the turbine array is partially dependent on viewer location and viewing angle with respect to the turbine array. Furthermore, where multiple, visually overlapping wind facilities are visible from one observation point, some level of perceived disorder or clutter is almost inevitable.

3.4 Site Wind Turbines to Minimize Shadow Flicker

Project Phase: Siting and Design

Wind turbines should be sited properly to eliminate shadow flicker effects on nearby residences or other highly sensitive viewing locations as calculated using appropriate siting software and procedures. If shadow flicker is anticipated, the ROW lease should stipulate that the turbines will not operate over the relatively short time periods where shadow flicker presents an important concern. Accurately determined shadow flicker analyses should be made available to stakeholders in advance of project approval. If wind turbine locations are changed during the siting process, shadow flicker effects should be recalculated and made available to potentially affected stakeholders.

Wind turbine shadow. Tower shadow is the wide vertical shadow at center, blade shadows are visible at left, with the nacelle shadow appearing as a horizontal shadow connecting the tower and blade shadows. Shadow flicker is caused by the moving blade shadows passing across a viewed object. (Seven Mile Hill Wind Farms, Carbon County, Wyoming. Credit: Robert Sullivan, Argonne National Laboratory.)

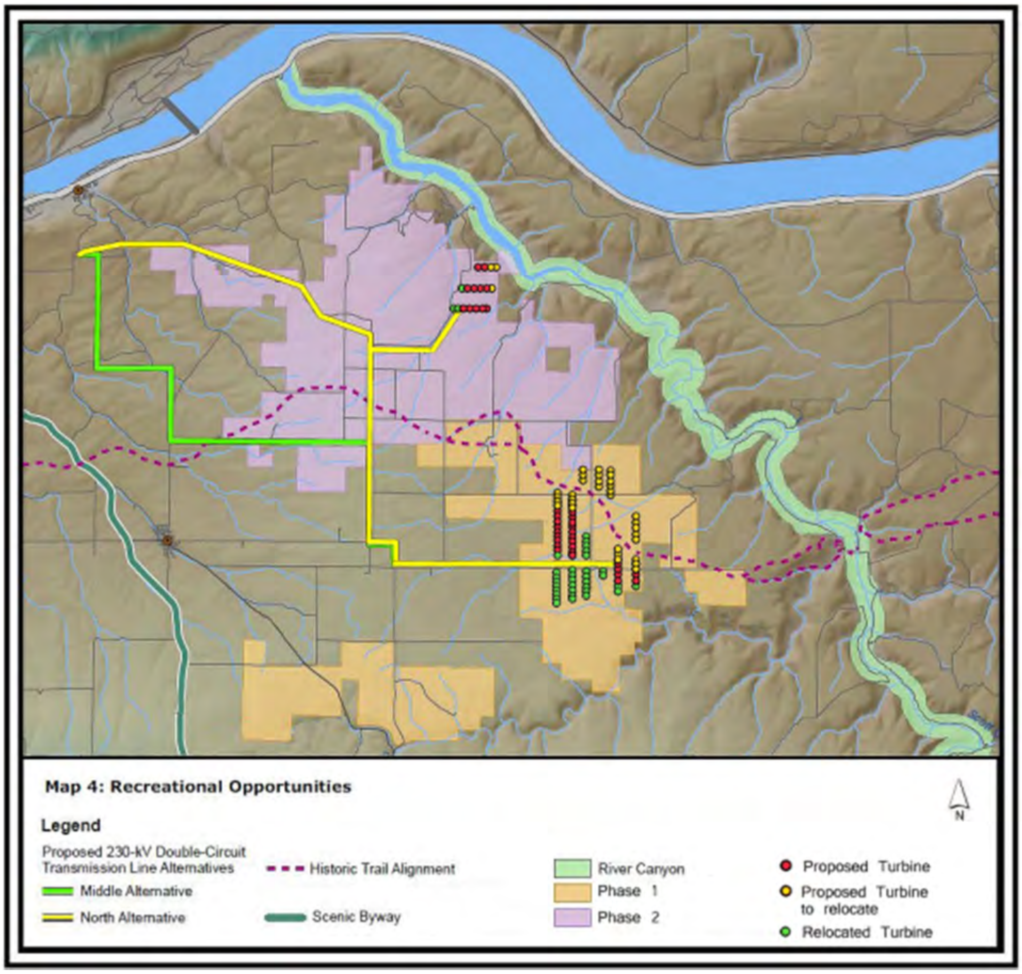
Notes

Because of the relatively short distance and short timeframes in which shadow flicker effects are observed, they are generally not a major concern for wind facilities sited on BLM lands; most wind farms on BLM-administered lands would generally not be close enough to sensitive resource areas to cause significant shadow flicker effects.

3.5 Relocate Turbines to Avoid Visual Impacts

Project Phase: Siting and Design

During the facility design process, move turbines to locations of less impact, for example, to take advantage of screening effects of topography or vegetation. Where possible, relocate turbines to areas that have already been impacted by other development.



Hypothetical turbine relocation map. Turbines near a national historic trail and a wild and scenic river overlook would be relocated. (Credit: BLM.)

Notes

Developers may be able to relocate turbines that pose particular impact concerns for stakeholders.

Limitations

Wind farm efficiency (and therefore profitability) depends, in part, on precise siting of the turbines. Therefore, developers may be reluctant to relocate turbines in response to potential visual impacts, except where visual values are considered a critical concern. Furthermore, landscapes suitable for wind energy development on BLM-administered lands typically lack sufficient topographic relief or vegetation tall enough to screen wind turbines effectively.

3.6 Use Audio Visual Warning System (AVWS) Technology to Reduce Night Sky Impacts

Project Phase: Siting and Design

In order to minimize night-sky impacts from hazard navigation lighting associated with wind facilities, AVWS technology should be employed, when the FAA has approved its use. The use of red or white strobe lighting should be prohibited without BLM approval (which may be given because of conflicting mitigation requirements). Until the FAA approves the use of AVWS, aerial hazard navigation lighting should be limited to the minimum required to meet FAA safety requirements.

FAA-required hazard navigation lighting presents a major unavoidable source of night-sky impacts from utility-scale wind facilities. (Cedar Creek I Wind Farm, near Grover, Colorado. Credit: Robert Sullivan, Argonne National Laboratory.)

Notes

Dark night skies are a highly valued amenity in many parts of the American west. AVWS is a radar-based obstacle avoidance system that activates obstruction lighting and audio signals only when an aircraft is in close proximity to an obstruction on which an AVWS unit is mounted, such as a wind turbine. The obstruction lights and audio warnings are inactive when aircraft are not in proximity to the obstruction. Currently, the FAA may approve use of AVWS on a case-by-case basis. If approved by the FAA for general use, AVWS technology would greatly reduce the night-sky impacts of lighting from tall structures and would also reduce avian mortality. Visual resource impact analysts and developers are encouraged to remain current on the status of FAA approval.

Limitations

As of the publication date, the use of AVWS technology for any structures other than communication towers is under FAA evaluation. In the interim, projects proposing the use of AVWS technology are reviewed on a case-by-case basis until the FAA makes a final determination on suitability. FAA approval of the technology for utility-scale wind projects is anticipated in the near future; however, its use might not be appropriate for all locations (e.g., near airports).

3.7 Create Visual Uniformity in Shape, Color, and Size

Project Phase: Siting and Design

If multiple turbine types are to be used in a single facility, developers should be encouraged to create visual uniformity in the shape and size of blades, nacelles, and towers. Where multiple types are used in a project, similar turbine designs should be grouped together and separated from dissimilar models to lessen the perceived contrasts in height or appearance.

Multiple wind turbine models in close proximity add to the visual clutter in this view. (Tehachapi Pass Wind Farm, Kern County, California. Credit: David Hicks, NREL.)

Notes

Multi-phase wind energy developments may occasionally utilize more than one turbine type. Developers should be encouraged to use turbine designs that are as similar as possible in their visual characteristics, because a uniform appearance is generally more pleasing.

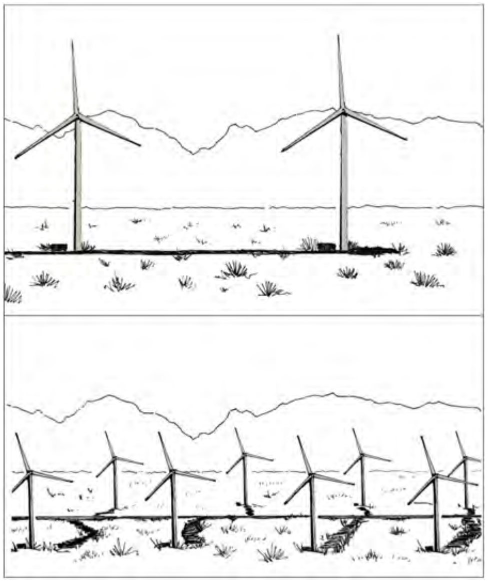
Limitations

Developers would normally be expected to use a single turbine type for a given project; however, because engineering and other technical, cost, and supply considerations drive decisions about wind turbine selection, developers may not always be able to use similar turbines.

3.8 Use Fewer, Larger Turbines

Project Phase: Siting and Design

Downsize the facility by eliminating certain turbines to reduce visual impacts. Use fewer, larger turbines to achieve desired power output in preference to using a greater number of smaller turbines.



In some instances, a few larger turbines may result in a better visual outcome than a greater number of smaller turbines. (Credit: Lindsey Utter, Argonne National Laboratory.)

Notes

In some instances, a few larger turbines may result in a better visual outcome than a greater number of smaller turbines. Developers may be able to eliminate turbines that pose particular impact concerns for stakeholders (e.g., turbines prominently visible from a historic trail or residential area).

Limitations

Because engineering and other technical, cost, and supply considerations drive decisions about wind turbine selection, it may be impractical for developers to use fewer turbines in some cases, based solely on potential visual impacts. Increasing turbine height may increase shadow flicker effects (see BMP 3.4) and could accentuate scale differences between the turbines and elements in the surrounding landscape.

3.9 Use Non-reflective Coatings on Wind Turbines and Other Facility Components

Project Phase: Siting and Design

Where feasible, non-reflective paints and coatings should be used on wind turbines, visible ancillary structures, and other equipment to reduce reflection and glare. Turbines, visible ancillary structures, and other equipment should be painted before or immediately after installation. Uncoated galvanized metallic surfaces should be avoided because they may create a stronger visual contrast.

Blade glinting near hub of turbine at left. These bright flashes from sunlight falling on the reflective surface of the blade have been observed at distances exceeding 15 mi, and can increase turbine visibility considerably. (Cedar Creek 1 Wind Farm, near Grover, Colorado. Credit: Robert Sullivan, Argonne National Laboratory.)

Notes

BLM-sponsored research has shown that wind turbines may be visible for very long distances, and reflections from untreated surfaces can increase visibility and cause blade glinting (brief flashes of reflected light) as the observer moves, or as wind turbine blades move. Using non-reflective paints and coatings reduces glinting and decreases the visual impact of the turbines in the landscape. Certain wind facility ancillary components may be treated with non-reflective coatings or colors selected to blend in with their immediate surroundings, for example, security fencing, substation components, and operations and maintenance buildings.

Limitations

Non-reflective paints and coatings may not be available for some pre-manufactured facility components. Wind turbines are not painted after erection, and the use of radar-absorbing materials on turbines (where applied) may preclude the use of non-reflective coatings. It may be difficult for the wind farm developer to control the appearance of equipment on substations owned by third parties.

3.10 Prohibit Commercial Messages and Symbols on Wind Turbines

Project Phase: Siting and Design

Commercial messages and symbols (such as logos or trademarks) on wind turbines should be prohibited.

Commercial logo on a wind turbine adds to visual contrast. (Happy Jack Wind Farm, Cheyenne, Wyoming. Credit: NREL.)

Notes

Commercial messages and symbols such as logos add to the color contrast of wind turbines, particularly at shorter viewing distances.

3.11 Keep Wind Turbines in Good Repair

Project Phase: Operations

Wind turbines should be well maintained for the duration of the operating permit. Nacelle covers and rotor nose cones should always be in place and undamaged. Inoperative turbines should be repaired, replaced, or removed as quickly as feasible. A clear deliniation of maintenance responsibilities and schedules should be part of the project approval process.

Collapsed wind turbine. (Arlington Wind Farm, Wyoming. Credit: BLM.)

Notes

Inoperative or incomplete turbines could cause viewers to perceive that "wind power does not work" or that it is unreliable. Inoperative turbines disrupt the "visual rhythm" of turning blades within a group of wind turbines. A turbine that is broken or disabled creates a health and safety hazard as well as being disruptive to the visual experience of the casual observer.

Limitations

Inclement weather and other practical considerations, such as poor road conditions or a lack of availability of turbine components or heavy equipment, may prevent immediate repair of inoperable wind turbines.

3.12 Clean Nacelles and Towers

Project Phase: Operations

Nacelles and towers should be cleaned to remove any spilled or leaking fluids and the dirt and dust that would accumulate on them.

Cleaning leaking fluid from a wind turbine. (Credit: TGM Wind Services)

Notes

Cleaning nacelles and towers improves their appearance and reduces the potential for negative public perception of the wind energy facility and the operating company.

4 Solar

Introduction

The following sections provide a discussion of the general stages of utility-scale solar facility development, a summary of visual contrast sources and effects by project phase, and summaries of technology-specific visual impacts.

Facility Life Cycle

In general, the development of a solar facility consists of six stages, including planning/preliminary siting, site evaluation, design/engineering, construction, operation, and decommissioning. The following discussion includes only the phases that involve onsite activities that would lead to significant visual contrasts: site evaluation, construction, operations, and decommissioning and reclamation.

Site Evaluation Phase

During the site evaluation phase, a geotechnical survey would evaluate general surface conditions, subsurface conditions, seismicity, and other geological information required to develop recommendations for the design and construction of project components (e.g., type of foundations required to support the solar collectors). The geotechnical survey would require soil borings.

Onsite monitoring/sampling wells and associated impoundments for well drilling fluids and cuttings may be required if groundwater resources would be used to meet water requirements.

Before a solar development can be planned and built, the solar regime at a potential site must be precisely characterized. Solar monitoring equipment, including solar sensors and a meteorological tower, would be installed to collect data on direct normal insolation and weather conditions.

Construction Phase

The entire solar project area could be affected by site preparation activities such as clearing and grading; construction of access and onsite roads; preparation and use of material and equipment laydown areas; placement of solar collectors; construction of the electrical substation, central control facility, and ancillary facilities; and installation of power and signal cables (typically buried or vaulted).

Concrete ingredients (sand, aggregate) may need to be extracted and hauled to the site.

A refueling station (with diesel and gas storage tanks) would be used during construction.

Construction of a transmission line, and possibly a substation, would be required.

Construction of a gas pipeline might be required for parabolic trough, compact linear Fresnel reflector (CLFR), and power tower solar developments. Water pipelines may also need to be constructed unless onsite wells were drilled to obtain the water needed for plant operations and maintenance.

Ivanpah Solar Energy Generating System power tower under construction. The grayish area at center is a heliostat field for the central tower, one of three towers in the facility. The structure just to the right of the tower base will house the steam turbine generator. (Credit: Robert Sullivan, Argonne National Laboratory.)

Operations Phase

Minimal land-disturbing activities and associated impacts would occur during the operations phase. Routine activities would include operation of the solar facility to produce power, and regular monitoring and maintenance activities to ensure safe and consistent operation.

Mirror washing would be required routinely at some facilities. In most cases, mirror washing would occur during evening hours.

Both on- and offsite maintenance of access roads may be required after rainfall events (e.g., blading and sediment removal from culverts).

Vegetation maintenance would be required within the solar collector field and within the transmission line, gas pipeline, and water pipeline ROWs.

Decommissioning and Reclamation Phase

Decommissioning of a solar energy project could range from mothballing to full removal of equipment and facilities. If the latter were chosen, underground components would be removed to a depth of at least 2 ft to ensure an unobstructed root zone for revegetation. More deeply buried components might be abandoned in place.

Visual Contrast Sources and Effects Summary by Project Phase

Site Evaluation Phase

Potential visual impacts that could result from site evaluation activities include contrasts in form, line, color, and texture resulting from vegetation clearing, if required for site evaluation activities such as meteorological tower construction; the presence of trucks and other vehicles and equipment, with associated occasional, short-duration road traffic and parking, and associated dust; and the presence of workers. If road upgrading or new road construction were required for site characterization activities, visual contrasts might be introduced. Site evaluation visual impacts would generally be temporary; however, impacts due to road construction, erosion, or other landform altering or vegetation clearing in arid environments might be visible for extended periods.

Construction Phase

Potential visual impacts that could result from construction activities include contrasts in form, line, color, and texture resulting from vegetation clearing for the solar field and other areas such as building pads (with associated debris); road building/upgrading; construction and use of staging and laydown areas; solar energy collector and support facility construction; vehicle, equipment, and worker presence and activity; and associated vegetation and ground disturbances, dust, and emissions. If construction-related activities took place at night, there would be night-sky impacts, and some lighting impacts would be expected in any event. Construction visual impacts would vary in frequency and duration throughout the course of construction, which for a utility-scale project may last several years.

Antelope Valley Solar Ranch thin-film PV facility under construction. Fixed (non-tracking) mounts for the PV panels have been installed, and await the panels. Note complete clearing of vegetation and leveling of ground underneath the collectors. (Credit: Robert Sullivan, Argonne National Laboratory.)

Operations Phase

Visual impacts associated with solar facility operations include the presence of the cleared solar field, the presence of the solar collector array and supporting infrastructure, control buildings, and other ancillary buildings and structures; glare, glinting, and other reflections from the solar array and ancillary facilities; lighting on ancillary buildings and structures; roads; vehicles; and workers conducting maintenance activities, which if conducted at night would require lighting.

The operation and maintenance of solar energy projects and associated electricity transmission lines, roads, and ROWs would potentially have substantial long-term visual effects. Some impacts are common to all utility-scale solar energy projects, regardless of solar technology employed; however, the solar energy collectors and associated structures differ in terms of visual impacts. Power tower projects generally have larger visual impacts than the other technologies because of the relatively tall and brightly illuminated receiver towers. Photovoltaic (PV) projects generally have lower visual impacts than the other technologies because of the low profile of the collector arrays and the lower reflectivity of the PV panels compared to the highly reflective mirrors used by the other technologies. However, all utility-scale solar facilities could create strong visual contrasts for nearby viewers. The following discussion includes impacts

Operating solar facilities near Boulder City, Nevada: Nevada Solar One parabolic trough facility at center and right; Copper Mountain thin-film PV facility at left. The large building adjacent to the Copper Mountain facility at left is a natural gas power plant. A large substation is visible behind the facilities. (Credit: Robert Sullivan, Argonne National Laboratory.)

common to the various solar energy technologies, while impacts that are significantly different between the technologies are discussed separately below.

Site operation impacts would generally occur throughout the life of the facility, with some impacts (e.g., impacts resulting from land forming and vegetation clearing) potentially continuing many years beyond the lifetime of the project.

Solar Field Clearing

Visual impacts associated with solar field clearing include the potential loss of vegetative screening, which would result in the opening of views; the exposure of potentially highly contrasting soils; potentially significant changes in form, line, color, and texture for viewers close to the solar field; and potentially significant changes in line and color for viewers with distant views of the solar field. Vegetation removal could result in windblown dust that could create visual contrasts and visible movement of dust clouds, obscure views of nearby landscape features, and degrade general visibility of both day and night skies. It should be noted that complete clearing of vegetation is not required for all solar technologies or projects.

Other cleared areas would include maintenance roads and facility access roads (e.g., electric substations or pump stations). Some support facilities would be surrounded by cleared areas.

Solar Collectors and Support Facilities

Solar energy collectors and some support facilities vary by solar energy technology, and specific descriptions and potential impacts for each technology are discussed below. Operational activities associated with the collectors and support facilities include routine maintenance, such as washing of solar collector surfaces, road and building maintenance, and repairs.

Buildings common to solar energy projects may include a control/administrative building, a warehouse/shop building, a security building or gatehouse, and a fire-water pump building. These structures would normally be constructed of sheet metal, concrete, or cinderblocks and would be expected to range from approximately 20 to 40 ft in height.

Utility-scale solar energy facilities may also include various tanks for water and other chemicals (e.g., gasoline or diesel fuel, potable water). Solar energy projects would normally be fenced around the outside perimeter and might include additional fencing around certain support facilities.

These built structures would introduce complex, rectilinear geometric forms and lines and artificial-looking textures and colors into the landscape, and would likely contrast markedly with natural-appearing landscapes. Most buildings and some tanks would be of sufficient height to protrude above the collector arrays as viewed from outside the facility and would likely contrast with the collector arrays in terms of form, line, and color.

In addition to the collector/reflector arrays, solar facilities would normally include other components that may have reflective surfaces, such as array support structures, steam turbine generator components (for parabolic trough, CLFR, and power tower facilities), piping, fencing, and transmission towers and lines. Under certain viewing conditions,

Ancillary structures at a parabolic trough facility, including substation, administration building, equipment shed, and HTF tank. Steam turbine generator and cooling tower visible behind substation. Solar collector array visible at far right. (Nevada Solar One near Boulder City, Nevada. Credit: Robert Sullivan, Argonne National Laboratory.)

Ancillary structures at a parabolic trough facility, including cooling tower, steam turbine generator, and equipment shed. Note prominent plume. (Nevada Solar One near Boulder City, Nevada. Credit: Robert Sullivan, Argonne National Laboratory.)

these reflective surfaces can give rise to specular reflections (glint and glare) that may be visible to moving observers as spots of intensely bright light on the reflective surface or as flashes of bright light.

Roads

Permanent roads could also contribute to visual impacts during solar facility operations. While some construction access roads would not be needed during operations and would be reclaimed after construction, certain roads would remain, such as onsite roads used for inspection and maintenance and the permanent facility access road. In addition to vegetative clearing, roads may introduce long-term visual contrasts to the landscape, including ground disturbances (e.g., grading and erosion control measures).

Lighting

Solar energy facilities would include exterior lighting around buildings, parking areas, and other work areas. Security and other lighting around and on support structures (e.g., the control building) could contribute to light pollution. Maintenance activities conducted at night, such as mirror or panel washing, might require vehicle-mounted lights, which could also contribute to light pollution. Light pollution impacts associated with utility-scale solar facilities include skyglow, light trespass, and glare.

Power block of operating solar parabolic trough facility. (Nevada Solar One near Boulder City, Nevada. Credit: Marc Sanchez, BLM.)

Workers, Vehicles, and Equipment

Maintenance activities could potentially cause visual impacts. Vehicles (potentially with associated dust plumes) and technicians would be present at or near the solar collector array and other facilities. Mirrors, panels, heliostats, and other components may need to be repaired, upgraded, or replaced, and if mirrors, panels, or heliostats are missing from the array during these activities, they may create noticeable gaps in the array for nearby viewers.

Decommissioning and Reclamation Phase

During decommissioning/reclamation, the immediate visual impacts would be similar to those encountered during construction, but likely of shorter duration. These impacts likely would include road redevelopment, removal of aboveground structures and equipment, the presence of workers and equipment with associated dust and possibly other emissions and litter, and the presence of idle or dismantled equipment, if allowed to remain onsite. Deconstruction activities would involve heavy equipment, support facilities, and possibly lighting. The associated visual impacts would be substantially the same as those in the construction phase, but of shorter duration. Decommissioning likely would be an intermittent or phased activity persisting over extended periods of time and would include the presence of workers, vehicles, and temporary fencing at the worksite.

Restoring a decommissioned site to pre-project conditions would also entail recontouring, grading, scarifying, seeding, and planting, and perhaps stabilizing disturbed surfaces. This might not be possible in all cases; that is, the contours of restored areas might not always be identical to pre-project conditions. In the arid conditions generally found in the BLM-administered lands where utility-scale solar energy development is likely to occur, newly disturbed soils might create visual contrasts that could persist for many seasons before revegetation would begin to disguise past activity.

Technology-Specific Visible Components and Visual Contrasts

Two main types of solar facilities are used for utility-scale solar power production: concentrating solar power (CSP) and PV systems. CSP technologies are those that concentrate the sun's energy to produce heat; the heat then drives either a steam turbine or an external heat engine to produce electricity. Parabolic trough, power tower, and dish engine technologies are three types of CSP technologies discussed in the BMP publication.

In PV systems, the energy of photons in sunlight is converted directly to electricity. The main component of this type of system is the solar panel, which is comprised of a group of individual solar cells. The most common PV technologies used in utility-scale solar facilities are crystalline silicon and thin film.

The following discussion provides a description of the visible components of CSP and PV facilities, based primarily on the characteristics of existing facilities or facilities under construction within the United States.

CSP Systems

CSP systems generally include three types of systems, including **linear concentrators** (e.g., parabolic troughs and CLFR systems), **power towers**, and **dish engines**. These systems use mirrors to convert the sun's energy to heat and then to apply that heat in various ways to produce electricity.

Parabolic trough facilities are the most common type of linear concentrator system and are among the most developed technologies for commercial applications of CSP systems. These facilities require very flat terrain and the solar field for these facilities is typically completely cleared and leveled.

The visible components of parabolic trough facilities include the following features:

- Solar field;
- Power block;
- Cooling system (e.g., cooling water and steam water support systems, including wells, pipelines, filtration, chemical treatment equipment, blowdown and evaporation ponds, zero-discharge facilities, and pumping stations);
- Electrical switchyard and power conditioning facility;
- Thermal storage facilities (if needed); and
- Support buildings (e.g., control building, warehouse, and maintenance facilities).

A parabolic trough solar field typically consists of rows of north-south oriented solar collectors that focus the sun's energy on a central absorber tube containing a heat transfer fluid (HTF). The collectors consist of large curved reflectors; a receiver (in essence a steel tube encased by a glass tube) a few feet above the reflector and oriented parallel to the long axis of the reflector; supporting structures for both the reflector and the receiver; and additional pipes to transport HTF to and from the solar collectors. The height of the trough assembly (including ground clearance) would generally be between 18 and 25 ft. A single-axis tracking system allows the reflectors to tilt from east to west to track the sun's apparent movement across the sky, which result in changes in orientation of the reflectors over the course of a day; the reflectors face east in the morning, upward in the middle of the day, and west in the afternoon.

Pabolic trough assembly at a parabolic trough facility, including large curved reflectors, the HTF tube at the focal point of the reflectors, and the support structure behind and below the reflectors. (Nevada Solar One near Boulder City, Nevada. Credit: Robert Sullivan, Argonne National Laboratory.)

The HTF is heated and then flows to the power block, where its heat is transferred to steam via a heat exchanger; the steam is used to produce electricity via a steam turbine generator (STG). The power block also contains a substation, where electrical equipment is used to condition the power by adjusting its voltage and phase to match existing conditions on the transmission line segment of the power grid to which the facility is connected. Cooling systems include a condenser, which cools spent steam leaving the STG to a liquid state, and a cooling tower, which transfers excess heat from the water to the atmosphere. Water is needed to run the cooling systems, as well as for mirror washing and other maintenance uses on the project sites, and there may be ponds of water for these uses onsite. Reflections and other visual contrasts may be observed from control buildings, STGs, and associated facilities, and plumes from gas boilers and cooling towers may also contribute substantially to observed visual contrasts in some situations. Dry cooling technology may be used at some facilities. Facilities using dry cooling would still have a cooling tower but would have no vapor plume, and would thus avoid that source of potentially large visual contrast.

The reflecting surface of the collector assembly is essentially a mirror and, as such, is highly reflective. Under certain conditions, when viewed from certain angles, specular reflection may result in glinting or glare from collector assembly components. The glint and glare can be observed from viewpoints either perpendicular or parallel to the trough arrays. In some instances, the glare can be bright enough to create strong visual discomfort, such that viewers may be forced to close their eyes, although individuals vary in their sensitivity to glare (Sullivan et al. 2012). The occurrence of glare is highly variable: it may appear and disappear suddenly in some instances, or vary greatly in intensity over a short period of time.

Water vapor plumes at CSP facilities can contribute substantially to overall visual contrasts. (Solar Energy Generating System III-VII, near Kramer Junction, California. Credit: Robert Sullivan, Argonne National Laboratory.)

Close-up photo of parabolic trough mirrors showing glare sources. (Nevada Solar One near Boulder City, Nevada. Credit: Robert Sullivan, Argonne National Laboratory.)

Depending on the angle of mirror tilt, the mirrors may also reflect the sky, clouds, vegetation, soil, and other landscape elements around the facility, which can cause dramatic differences in apparent color of the array (Sullivan et al. 2012).

Reflections from other facility components may cause a variety of other visual effects, such as strong glittering or scintillations that may appear in striking geometrical patterns as they are repeated from the many hundreds or thousands of symmetrically arrayed metal surfaces. Although these reflections are not bright enough to cause discomfort, they may appear as straight lines or grids of light across the entire collector array or large portions of it. They may change dramatically as the observer moves, and in general, they may create striking visual effects that capture and hold an observer's visual attention. These other array components would primarily be metal, and reflectivity of these surfaces could be potentially be lessened through mitigation measures specifying paint or low-reflectivity coatings.

Potential visual contrasts from solar energy projects utilizing **CLFR technology** would be very similar to the impacts expected for parabolic trough systems; however, the solar energy collectors differ in some respects, and the system makes steam directly, rather than using HTF, resulting in some reduction in ancillary facilities. The Fresnel reflectors utilized for CLFR systems are typically lower in height than parabolic trough collectors, so the vertical profile of the reflecting surface array is slightly lower; however, the receiver could be as high as or higher than that for a standard parabolic trough system.

Effects of sun angle and lighting on parabolic trough facility color. The solar collector array can appear black, glittering silver-white, green, gray, or blue, as the mirrors reflect objects around them. (Nevada Solar One near Boulder City, Nevada. Credit: Robert Sullivan, Argonne National Laboratory.)

Symmetric patterns of reflected light from multiple exposed metal surfaces. (Solar Energy Generating System III–VII, near Kramer Junction, California. Credit: Ron Kolpa, Argonne National Laboratory.)

Close-up photo of Kimberlina CLFR facility near Bakersfield, California. Mirrors are the white band running left to right across the photo. The receiver tubes are held well above the mirrors. Ancillary buildings, including STG, are at far right. (Credit: Robert Sullivan, Argonne National Laboratory.)

Power tower facilities include one or more central towers, typically 300 to 700 ft in height, and typically surrounded by a generally circular or semicircular array of flat-plate reflectors called heliostats. The number of heliostats varies by facility, but can number in the thousands to hundreds of thousands. Similarly to parabolic trough systems, the power tower heliostats reflect the sun to heat HTF to eventually boil water, but instead of focusing light onto a tube, the light is focused onto a receiver unit that holds the HTF, located atop the central tower. The heliostats track the sun during the course of the day to keep sunlight focused on the receiver. Power tower facilities have a power block, cooling system,

Torresol Gemmasolar 20-MW power tower facility near Seville, Spain. (Credit: Robert Sullivan, Argonne National Laboratory.)

and other ancillary structures similar to those of the parabolic trough system.

The reflecting surface of the heliostat is essentially a mirror and, as such, is a highly reflective surface. Where visible, heliostats could display highly variable surface color and brightness. Viewed from certain angles, specular reflection might result in glint or glare from these surfaces, particularly from elevated viewpoints. Power tower facilities usually have the heliostats arrayed in a circle around the central tower. Where this heliostat configuration is used, some portion of the heliostat field would face viewers regardless of their direction of view, which could increase the potential for glinting and glare from the heliostats. The heliostat supports would be primarily metal and would also reflect light; however, reflectivity of these surfaces could be lessened through mitigation measures specifying paint or low-reflectivity coatings, and they often would be shaded by the heliostats in any event.

In addition to visual impacts from the tower structure, the sunlight focused on the tower's receiver by the heliostats during normal operations causes the surface of the receiver to appear to glow with sufficient intensity to be visible for long distances; however, the apparent glow is actually diffuse reflected sunlight. The tower receivers can appear brilliantly white at close distances, and the light from relatively small-scale existing facilities has been observed at distances of 25 mi; however, observations

Power tower heliostats on trailer enroute to installation. Heliostat backs are visible on reversed heliostats at front of trailer. Heliostat supports are visible in heliostat reflections and to the right of the trailer. (Credit: Robert Sullivan, Argonne National Laboratory.)

to date have not shown the receiver light to be as intense as the glare observed from parabolic trough facilities (Sullivan et al. 2012).

In addition to heliostat reflections and glare from the receiver, at certain times of the day and from certain angles, the reflection of sunlight on ambient dust particles in the air could sometimes result in the appearance of light streaming diagonally downward and/or upward from the tower in a luminous, transparent, tent-like form.

Glare and reflections from airborne dust particles at Torresol Gemmasolar 20-MW power tower facility near Seville, Spain. (Credit: Robert Sullivan, Argonne National Laboratory.)

Because of the height of the central towers, FAA-compliant aircraft warning lights would be required for power tower receivers (or other structures) 200 ft tall or higher, and may be required in some circumstances for lower height structures (FAA 2007). These lights typically flash white during the day and at twilight and red at night; or alternatively, red or white strobe lights flash during the day and/or at night. In theory, for power towers, daylight lighting might be avoided by painting the tower orange and white according to FAA guidelines; this practice could result in large increases in visual contrast for the tower during the day, but is unlikely.

Dish systems generate electricity through the action of an external engine, rather than steam. These systems usually consist of a parabolic concentrator, a receiver, an external heat engine, and a generator. Sunlight is concentrated onto the receiver, which transfers the heat to a gas contained in a sealed external heat engine. As the gas is heated, the pressure increase drives a piston, thereby powering a generator and producing electricity.

Hundreds or thousands of individual dish engines can be grouped together to form a larger facility. Solar dish engine units superficially resemble backyard satellite dishes but are much larger. The solar dish units are about 40 ft tall. The large surfaces of the dishes may reflect the sky and clouds, potentially creating strong color contrasts with the surrounding landscape, particularly for elevated viewers. Because the dishes are mirrors, they are capable of causing glinting and glare.

Maricopa solar dish facility, Phoenix, Arizona. (Credit: U.S. Department of Energy.)

Dish systems do not use STGs for steam-powered electricity generation, and therefore do not require the variety of buildings, tanks, evaporating ponds, and other facilities associated with STGs, HTFs, and cooling water and steam management. The absence of STGs and related facilities would reduce the visual impacts associated with dish facilities, including potential water vapor plumes from a cooling tower, which would not be present. However, solar dish facilities would normally include an administration building, a maintenance building, a component assembly building, a guardhouse, and other small structures.

PV Systems

PV technologies differ fundamentally from CSP technologies. PV solar facilities do not concentrate sunlight to generate heat to boil water; instead, they convert solar energy directly to electrical current, utilizing panels or modules coated with special materials that can capture photons and convert the energy into electric current. Because PV solar facilities do not require the infrastructure associated with heating, transporting, boiling, and cooling water and other HTFs, generally speaking, they are visually simpler than parabolic trough and power tower facilities, and generally are associated with lower visual contrasts.

PV technologies can be grouped into two types of systems: flat-plate and concentrating photovoltaic (CPV).

Flat-plate PV facilities contain PV panels in rectangular arrays mounted on either simple fixed mounts that tilt the panels southward toward the midday sun or more complex sun-tracking systems that might add somewhat to the visual impact, depending on the technology employed and its configuration. Interspersed regularly among the solar arrays may be inverter boxes that house electrical equipment. Depending on the facility, the inverter boxes may be taller than the panel array, and thus project above it. Depending on their color, they may contrast with the array, and because they are generally spaced at regular intervals throughout the array, this may result in a striking pattern of color contrasts.

Flat plate PV: Crystalline silicon PV panels on tilted single-axis trackers. (Nellis Air Force Base, Nevada. Credit: Robert Sullivan, Argonne National Laboratory.)

CPV systems use concentrating or reflecting optical devices to concentrate sunlight onto high-performance solar cells. These systems incorporate tracking devices. CPV collectors are generally larger and taller than conventional PV panels, and because precise tracking of the sun is essential to obtain the best performance, concentrating PV collectors use more advanced tracking systems that, in some cases, may add to the height and visual complexity of the system.

A utility-scale PV facility may include one or more of the following: an administration building, a maintenance building, a component assembly building, a guardhouse, and other small structures. In some cases, especially for smaller facilities, administration and other buildings may be at offsite locations.

Flat plate PV: Thin-film PV panels on fixed (non-tracking) mounts. (Silver State North Solar Project near Primm, Nevada. Credit: Robert Sullivan, Argonne National Laboratory.)

In general, the low profile of the solar collectors of PV facilities would reduce their visibility (relative to the other solar technologies) when viewed from low viewing angles, especially from longer distances, and they have less associated infrastructure than CSP facilities, which further lowers their vertical profiles. When viewed from elevated positions, more of the facility would be visible, and the regular geometry of the panel arrays would be more apparent, sometimes resulting in substantially larger visual contrasts.

CPV units on dual-axis trackers. (Clark Generating Station, Las Vegas, Nevada. Credit: Robert Sullivan, Argonne National Laboratory.)

Unlike the solar reflectors for CSP technologies, PV panel surfaces are not designed to reflect light and, being significantly less reflective than the mirrored surfaces of the solar collectors for the other technologies, they have reduced potential for glint and glare; however, the panels and other components do reflect light that may result in glinting, glare, and other visual effects that would also vary depending on panel orientation, sun angle, viewing angle, viewer distance, and other visibility factors. In a manner somewhat similar to parabolic trough facilities, PV facilities may vary substantially in their appearance, depending on viewer location and other visibility factors. Sullivan et al. (2012) observed the apparent color of the panels at two different facilities to vary rapidly from black to blue to silvery white, depending on viewer location, as a vehicle was driven past the facilities.

Apparent color changes with differing sun angle and viewing geometry at thin-film PV facility. Note contrasting color of regularly spaced inverter boxes among the panels in the collector array. (Copper Mountain Solar Facility, near Boulder City, Nevada. Credit: Robert Sullivan, Argonne National Laboratory.)

Because they do not use steam to create electricity, PV facilities do not have cooling towers or water vapor plumes, thus avoiding the associated visual contrasts. The lack of a steam turbine generator and associated equipment and infrastructure results in lower lighting levels at night and fewer workers present on average during operations, which also reduces overall visual contrasts.

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Solar Energy Facility BMPs and Applicable Project Phases

	Siting and Design	Construction	Operations	Decommissioning and Reclamation
4.1 Develop a Glint and Glare Assessment, Mitigation, and Monitoring Plan (p 80)	●			
4.2 Use Dry-Cooling Technology for CSP Facilities (p 82)	●			
4.3 Site and Operate Solar Collectors to Avoid Offsite Glare (p 83)	●		●	
4.4 Screen Solar Collectors to Avoid Off-site Glare (p 85)	●			
4.5 Use Color-Treated Solar Collectors and Support Structures (p 87)	●			
4.6 Maintain Color-Treated Surfaces of Solar Collectors (p 89)			●	
4.7 Avoid Complete Removal of Vegetation beneath Solar Collector Array (p 90)		●		
4.8 Prohibit Commercial Messages and Symbols on Solar Power Towers and Solar Collector Arrays (p 92)	●			

4.1 Develop a Glint and Glare Assessment, Mitigation, and Monitoring Plan

Project Phase: Siting and Design

Regardless of the solar technology proposed, a glint and glare assessment, mitigation, and monitoring plan should be prepared that accurately assesses and quantifies potential glint and glare effects and determines the potential health, safety, and visual impacts associated with glint and glare. The assessment should be conducted by qualified individuals using appropriate software and procedures. The assessment results should be made available to the BLM in advance of project approval.

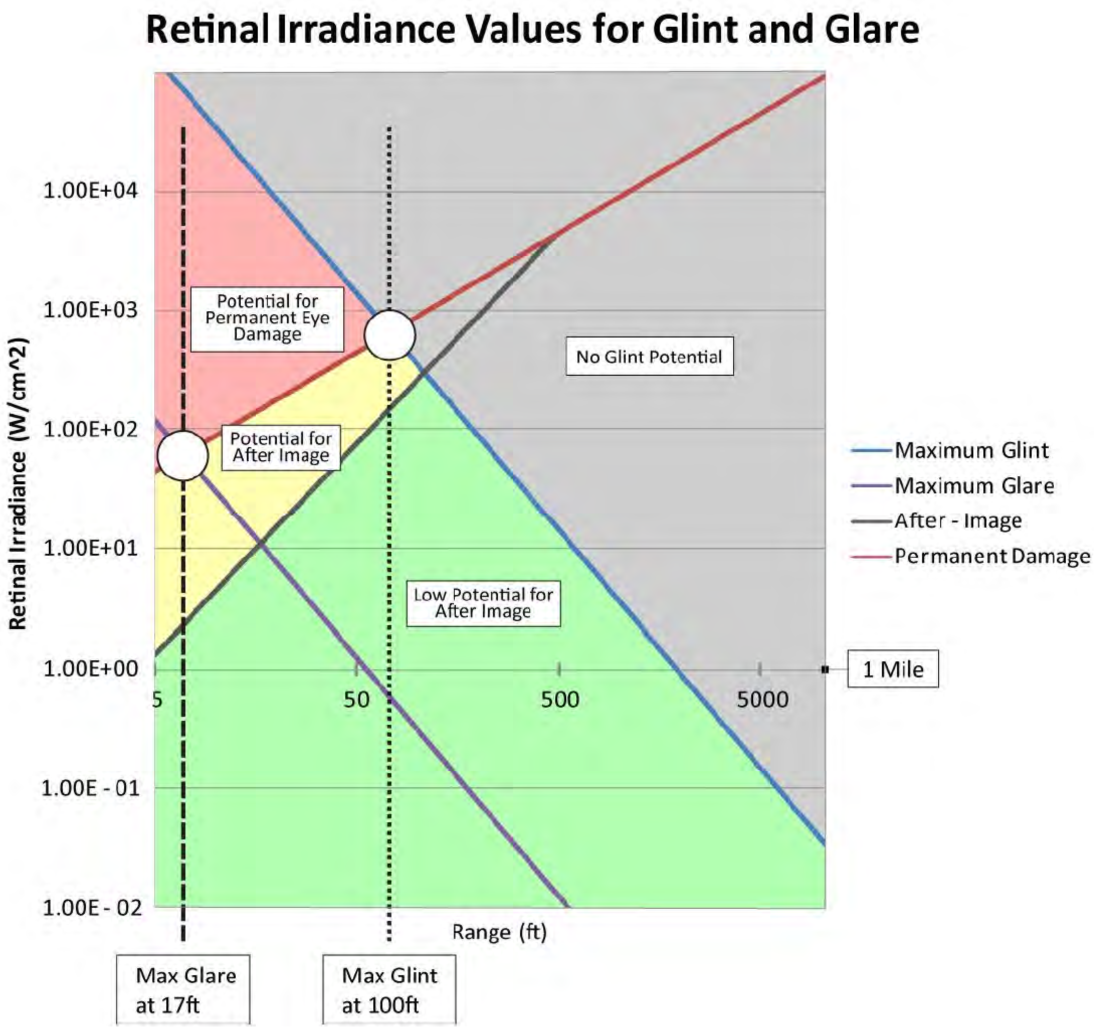


Figure from glint/glare assessment for solar dish facility. (Credit: California Energy Commission.)

Notes

Research sponsored by the BLM and others has shown that utility-scale solar facilities are capable of causing offsite glare that may cause annoyance, discomfort, or in certain circumstances, ocular damage. A glare assessment, mitigation, and monitoring plan should be used to assist site design and operations planning to avoid and reduce significant offsite glare impacts. The glare assessment, mitigation, and monitoring plan may be incorporated as part of other visual assessment and mitigation planning for the project. The FAA may also require this type of assessment if impacts on aircraft pilots or airports are anticipated.

4.2 Use Dry-Cooling Technology for CSP Facilities

Project Phase: Siting and Design

Dry-cooling technology should be used for CSP facilities instead of wet-cooling technology so that visual impacts from water vapor plumes can be avoided.

The Ivanpah Solar Energy Generating System, a CSP power tower facility currently under construction in the Ivanpah Valley in California, will utilize dry-cooling technology. (Credit: Robert Sullivan, Argonne National Laboratory.)

Notes

The operation of thermal concentrating solar power plants (power towers, parabolic troughs, and similar technologies using steam to generate electricity) requires cooling towers. Air-cooled (dry-cooling) systems are preferred in areas where the viewshed is particularly sensitive to the effects of vapor plumes. These types of plumes occur in water-cooled (wet-cooling) systems. A hybrid cooling system would still generate plumes, but less frequently than a wet-cooled system.

Limitations

Dry-cooling systems are less thermally efficient than wet-cooling systems. Compared to wet evaporative cooling systems, they require greater amounts of station power to produce the same amount of cooling capacity, therefore reducing the net power generating capacity of the power plant. Dry cooling is least efficient in hot summer months, when demand is greatest. However, in addition to reducing visible water vapor plumes, dry-cooling systems use far less water than wet-cooling systems, which is an especially important benefit in the generally arid western states. While visual impact considerations would not normally drive a decision regarding the use of wet- or dry-cooling technology, they provide an additional reason to choose dry-cooling technology where it is feasible to do so.

4.3 Site and Operate Solar Collectors to Avoid Offsite Glare

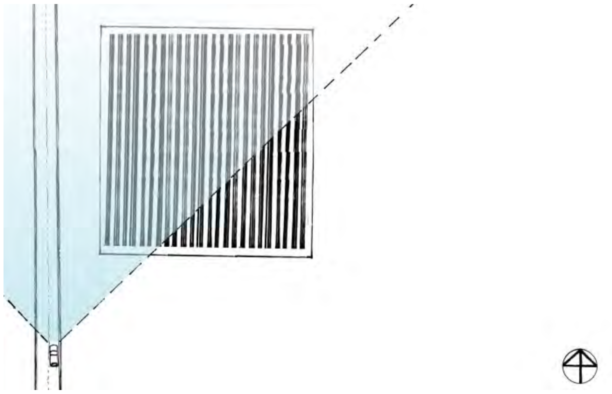
Project Phase: Siting and Design, Operations

Solar facilities should be sited and designed to ensure that glint and glare do not have significant effects on roadway users, nearby residences, commercial areas, or other highly sensitive viewing locations. Mirrors and heliostats should be operated to avoid reflection of high-intensity light (e.g., glare) toward offsite ground receptors.

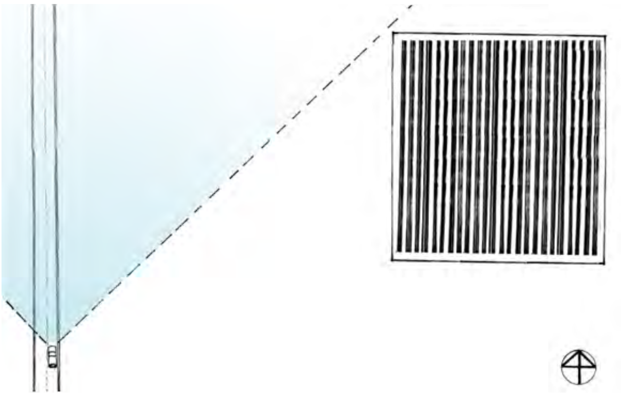
Offsite glare from parabolic trough facility as seen from highway, approximately 1.9 mi from glare spot. (Nevada Solar One facility near Boulder City, Nevada. Credit: Robert Sullivan, Argonne National Laboratory.)

Notes

Research sponsored by the BLM has shown that utility-scale solar facilities are capable of causing offsite glare that may cause annoyance and visual discomfort. Careful siting and operation of solar collectors (e.g., siting the facility away from roads and trails) or turning mirrors away from the sun during time periods when glare impacts are significantly adverse may substantially reduce or avoid visual impacts from offsite glare.



Left: Siting a facility with potential to cause glare close to a roadway may result in glare close to the driver's line of sight at short viewing distances.



Right: Siting a facility with potential to cause glare farther from the roadway keeps glare sources farther away from the driver's line of sight at short viewing distances. (Credit: Lindsey Utter, Argonne National Laboratory.)

Limitations

Some glare from collector arrays is unavoidable. Glare occurrence and intensity is highly technology- and site-specific and varies widely depending on viewer location and various environmental factors. It may be difficult or impossible to avoid at least some offsite glare to ground receptors. However, glare occurrence can be mathematically modeled and is predictable. A glare assessment, mitigation, and monitoring plan (see BMP 4.1) should be used to assist site design and operations planning to reduce and avoid offsite glare impacts. Although turning mirrors can reduce or eliminate glare, this can adversely impact the power generation of the solar facility and could affect the viability of the project.

Offsite glare from 20-MW power tower facility. (Torresol Gemasolar facility near Seville, Spain. Credit: Robert Sullivan, Argonne National Laboratory.)

4.4 Screen Solar Collectors to Avoid Off-site Glare

Project Phase: Siting and Design

Where significant offsite glare is unavoidable, fencing with privacy slats, earthen berms, or vegetative screening materials may be employed.

A fabric-covered screening fence at power tower facility screens the heliostats, but not the receivers. (eSolar Sierra Suntower, Lancaster, California. Credit: Robert Sullivan, Argonne National Laboratory.)

Notes

Research sponsored by the BLM and others has shown that utility-scale solar facilities are capable of causing offsite glare that may cause annoyance, discomfort, or in certain circumstances, ocular damage. Fencing, berms, or vegetation can be used to screen reflecting project elements from offsite views.

Limitations

Fencing and other screening may not be tall enough to block views of the facility from high-elevation viewpoints, such as nearby mountains, and would not likely be able to screen views of power tower receivers. In addition, the introduction of screening elements may itself create negative visual impacts that must be weighed against the benefits of reduced offsite glare. For example, earthen berms and tall screening vegetation may not blend in well with a flat desert landscape containing only low shrubs and grasses. The introduction of screening elements may also cause undesirable shading of the solar collectors.

4.5 Use Color-Treated Solar Collectors and Support Structures

Project Phase: Siting and Design

The backs and support structures for PV panels, heliostats, parabolic trough mirrors, and solar dishes, as well as other facility components that would cause substantial contrasts as seen from sensitive offsite viewing locations, should have non-reflective finish or be color- treated to reduce visual contrast. Select colors from the BLM Standard Environmental Colors Chart CC-001 (see BMP 6.4.6).

Close-up view of experimental application of color-treated trough mirror backs (visible at left and center) at a parabolic trough facility. Untreated mirror backs appear blue. (Nevada Solar One facility near Boulder City, Nevada. Credit: Robert Sullivan, Argonne National Laboratory.)

Notes

BLM-sponsored research has shown that utility-scale solar facilities may be visible for long distances, and that reflections from solar collector support structures and other components, such as PV inverters, often contribute to visual contrasts between the facility and the surrounding landscape. Color treatment or the use of non-reflective materials in place of potentially reflective surfaces may substantially reduce contrasts.

Color-treated trough mirror backs at parabolic trough facility. Color-treated mirror backs appear as a dark band visible at front left of trough field. Untreated mirror backs appear blue. In this case, the color treatment used has the added benefit of strengthening the mirrors, and it improves energy production efficiency during low-energy production seasons. (Nevada Solar One facility near Boulder City, Nevada. Credit: Robert Sullivan, Argonne National Laboratory.)

Limitations

Color treating of facility components is typically done at the time of fabrication. Currently, color treatment of components is not standard practice, and hence requires customization. In addition, the need for treatment is dependent on the visibility of the equipment and the distance and sensitivity of the potential viewers; treatment may not be appropriate in all circumstances.

4.6 Maintain Color-Treated Surfaces of Solar Collectors

Project Phase: Operations

Color-treated surfaces of mirror, dish, and heliostat backs should be kept in good repair.

Notes

Depending on the component and treatment method, treatments could be subject to fading or flaking, and may require re-treatment to maintain proper coloration.

Limitations

Re-treatment may be difficult or impossible for some in-place components, or could require disassembly and offsite transport, which could be prohibitively expensive.

4.7 Avoid Complete Removal of Vegetation beneath Solar Collector Array

Project Phase: Construction

Consistent with safety and operational requirements, complete removal of vegetation beneath solar collectors should be avoided where feasible. Leave low vegetation, or trim to lowest height tolerable for plant survival.

Trimmed vegetation beneath power tower heliostats (facility under construction). (Ivanpah SEGS facility, Ivanpah Valley, California. Credit: Robert Sullivan, Argonne National Laboratory.)

Notes

Often, vegetation beneath solar arrays is completely stripped and the array area may be leveled prior to construction; however, depending on the solar technology employed, these procedures may not be necessary. In some cases, grasses and some low shrubs can be left under the array, or shrubs can be trimmed to shorten them to an acceptable height. If vegetation can safely be left beneath the array and does not interfere with facility construction, operation, or maintenance, strong color contrasts associated with exposed or eroded soils can be reduced, as can texture contrasts caused by vegetation removal. The visual benefits of leaving vegetation underneath arrays varies depending on the height and spacing between solar collectors; it is most effective at reducing visual impacts for more widely spaced and taller collector arrays because there is more space visible underneath and between the collectors. Leaving or replacing vegetation underneath the array has non-visual benefits as well, such as reduced runoff and erosion, and reduced cost for revegetation at the time of decommissioning.

Limitations

Some sites may need leveling (which would require vegetation removal) for facility operation. Leaving vegetation beneath the collector array may increase fire hazards. The vegetation must be low enough not to cause shading or interfere with mirror/panel movement or maintenance activities. Where it is not feasible to leave existing vegetation due to construction, safety, or operational concerns, post-construction revegetation should be considered, consistent with facility operations and safety considerations. Vegetation under collector arrays may need periodic maintenance to maintain an acceptable height.

4.8 Prohibit Commercial Messages and Symbols on Solar Power Towers and Solar Collector Arrays

Project Phase: Siting and Design

Commercial messages and symbols (such as logos or trademarks) on solar power towers and solar collector arrays should be prohibited.

Commercial logo on a solar power tower adds to visual contrast. (Torresol Gemmasolar power tower facility near Seville, Spain. Credit: Robert Sullivan, Argonne National Laboratory.)

Notes

Commercial messages and symbols such as logos add to the color contrast of power towers and collector arrays, particularly at shorter viewing distances.

5 Geothermal

Introduction

The following provides a discussion of the general stages of utility-scale geothermal facility development, and a summary of visual contrast sources and effects by project phase.

Facility Life Cycle

In general, the development of a geothermal facility consists of six stages, including planning, site evaluation, design/engineering, construction, operations, and decommissioning. The following discussion includes only the phases that involve onsite activities that would lead to significant visual contrasts: site evaluation, construction, operations, and decommissioning and reclamation.

Site Evaluation Phase

Before geothermal resources can be developed, various offsite exploratory activities must take place to characterize the development potential of a geothermal reservoir. Once data and surveys have been compiled and analyzed, more invasive activities such as geophysical testing, drilling temperature gradient wells (above the reservoir), drilling holes for explosive charges for seismic exploration, and core drilling take place.

Specific activities affecting the project site include clearing of vegetation and building of roads to increase access to the project site; detonating small charges below the ground surface to create seismic pulses for the seismic surveys; burying cables and sensors as part of the seismic surveys; drilling of wells (typically with truck-mounted rigs); and earth-moving activities to prepare the drilling site. During the exploration and drilling phase, fluids produced during drilling (e.g., drilling mud and groundwater) would be collected by sump or tanker truck and transported to licensed offsite locations for disposal.

Geothermal drilling rig. (Credit: Idaho Department of Water Resources.)

If a site is confirmed as a viable prospect for geothermal development, exploration wells are drilled to test the reservoir. Activities include flow testing of wells, producing geothermal fluids for chemical evaluation, and injecting fluids into a geothermal reservoir. Sumps or pits to hold excess geothermal fluids would also be constructed. Water would be left to evaporate, but remaining sludge would be removed and transported to licensed offsite locations for disposal. Some infrastructure construction may also be required. If a reservoir and geothermal well were determined to be sufficient for development, a wellhead with valves and control equipment would be installed on top of the well casing.

Construction Phase

After the exploration and drilling phase, the project site is prepared for production. The construction phase involves the construction of the geothermal field(s), infrastructure, power plants, and transmission lines. Activities in this phase of development would include the following:

- Clearing, grading, and constructing access roads;
- Clearing, grading, and constructing electrical generation facilities;
- Building facility structures;
- Drilling and developing well fields;
- Installing pipeline systems; and
- Installing meters, substations, and transmission lines.

The construction phase of the development process would result in the greatest area of land disturbance at the geothermal energy project site, although some of the disturbed land would be reclaimed once construction activities end.

Operations Phase

The operations and maintenance phase involves the operation and maintenance of the geothermal field(s)—including drilling additional production and reinjection wells—and the generation of electricity. The types of operations and maintenance activities depend on the size and temperature of the geothermal reservoir. The operations and maintenance phase can last from 10 to 50 years.

Pipelines and cooling towers at operating geothermal plant. (GEM 2/GEM 3 facility near Holtville, California. Credit: Robert Sullivan, Argonne National Laboratory.)

Decommissioning and Reclamation Phase

Once geothermal production ceases, the production wells are abandoned, facility structures and infrastructure are removed, and all the disturbed areas at the project site are reclaimed. Well abandonment involves plugging, capping, and reclaiming the well site. Reclamation includes removing the power plant and all surface equipment and structures, regrading the site and access roads to pre-production contours, and replanting vegetation to facilitate natural restoration.

Visual Contrast Sources and Effects Summary by Project Phase

Site Evaluation Phase

Activities during the resource exploration and drilling phase are temporary and are conducted at a smaller scale than those during the construction, operations and maintenance, and decommissioning and site reclamation phases. The impacts would occur as a result of typical exploration and drilling activities, such as localized ground clearing, vehicular traffic, seismic testing, positioning of equipment, and drilling. Most impacts during the resource exploration and drilling phase would be associated with the development (improving or constructing) of access roads and exploratory and flow-testing wells. Exploration generally includes ground disturbance, but it does not include the direct testing of geothermal resources or the production or utilization of geothermal resources. Activities for commercial facilities usually would be limited to 2–7 acres per facility. The exploration and drilling phase generally takes between 1 and 5 years to complete.

As part of the development of geothermal facilities, drilling is an important activity during exploration and production. During exploration activities for temperature gradient wells, drill rigs can be up to 60 ft in height. A truck-mounted or small rotary rig often is utilized for drilling these types of wells. The drilling rigs are quite visible due to their height and associated equipment. Support equipment consists of water trucks, tanks, supply transport vehicles, and backhoes.

Exploration and drilling activities would have only temporary and minor visual effects, resulting from the presence of drill rigs, workers, vehicles, and other equipment (including lighting for safety); and from vegetation damage, scarring of the terrain, and altering of landforms or contours.

Geothermal drilling rig at night. (Long Valley Exploratory Well near Mammoth Lakes, California. Credit: Sandia National Laboratories.)

Construction Phase

Activities that may cause environmental impacts during construction include site preparation (e.g., clearing and grading); facility construction (e.g., geothermal power plant, pipelines, transmission lines); and vehicular and pedestrian traffic. Impacts would be more extensive than those that would occur in the exploration and drilling phase. The construction phase would require from 50 to 350 acres, depending on the geometry of the geothermal systems and the anticipated size of the power development. Some of this disturbed land would be reclaimed once construction activities end. Construction of a large geothermal development would normally require about 2 to 4 years. A pipeline or transmission line could take several months or more to construct, depending primarily on its length.

Construction activities would have temporary visual effects resulting from the presence of drill rigs, workers, vehicles, and other equipment (including lighting for safety); and from vegetation damage, scarring of the terrain, and altering of landforms or contours.

Operations Phase

The operations and maintenance phase involves the operation and maintenance of the geothermal field(s) and the generation of electricity. Typical activities during the operations and maintenance phase include operation and maintenance of production and injection wells and pipeline systems, operation and maintenance of the power plant, waste management, and maintenance and replacement of facility components.

During utilization, the well field would be developed; roads would be built and/or improved; well field equipment, including piping, would be installed; transmission lines would be built; and well work-overs, repairs, and maintenance would occur.

Three types of geothermal power plant systems are commonly used to generate electricity indirectly; the technology selected is dependent on the temperature, depth, and quality of the water and steam in the area:

- **Flash steam**—this type of plant uses hot water that is above 360 degrees Fahrenheit (182 degrees Celsius). The high pressure underground keeps the water in a liquid state. As the water is pumped from the reservoir to the power plant, the drop in pressure causes the water to convert to steam to power turbines.

- **Binary-cycle—**this type of plant uses water with a range of temperature from 165 to 360 degrees Fahrenheit (74 to 182 degrees Celsius). The water passes through a heat exchanger, which transfers heat to a separate pipe containing other fluids with lower boiling points. These fluids then are vaporized to power a turbine. Most U.S. power plants would be composed of this type of system.
- **Dry steam power plants—**this type of plant uses very hot water, with a temperature exceeding 455 degrees Fahrenheit (235 degrees Celsius). The water within a reservoir primarily is in the form of steam. The steam is routed to the surface via a well and then is used to turn a turbine.

These plants also can be hybridized by including elements of the three different technologies at a single location. All three methods re-inject the remaining geothermal fluid back into the ground to replenish the reservoir and to recycle the hot water.

Some geothermal facilities will at times produce visible plumes from cooling towers. Binary and flash/binary power plants normally do not emit visible steam or water vapor plumes, whereas flash and steam plants do (Lund 2007). Two other types of plumes may be visible. These consist of bore head plumes and natural vents. Bore head plumes are pressurized steam, and are quite dense in comparison to those emitted from cooling towers. The bore head plume has greater vertical scale and generally is visible during all weather conditions. Steam plumes from natural vents can vary in size and density.

Steam plumes rise from cooling towers at a dry steam plant. (Geysers facility near Calistoga, California. Credit: U.S. Geological Survey.)

Drilling and flow-testing activities associated with geothermal energy production often are conducted 24 hours per day, and would require night lighting during operations. Nighttime light sources during drilling and flow testing would be confined to the drill rigs and other operational areas as necessary for safety. Additional lighting may be needed in areas used for the movement of personnel.

As noted above, as part of the development of geothermal facilities, drilling is an important activity during exploration and production. During production, the size of the drill rigs increases. For instance, the top of a drill rig derrick could be as much as 180 ft above the ground surface, and the rig floor could be 20 to 30 ft above the ground surface. These rigs typically are equipped with diesel engines, fuel and drilling mud storage tanks, mud pumps, and other ancillary equipment. Full-size tractors may be used to get this equipment to a drilling site.

In addition, a pipeline system would be needed to connect each of the production wells and injection wells to the power plant. Pipelines are usually 24 to 36 in. in diameter and typically are constructed on supports above the ground surface. The pipelines may have a few feet of clearance underneath them. Every 100 to 200 ft or so, the pipeline may have an expansion loop, or U-shaped bends, to allow for expansion due to heating and cooling. Pipelines transporting hot fluids to the plant are wrapped in insulation, but injection pipelines generally are not.

Geothermal facilities generally have one or more cooling towers used for cooling systems. Cooling towers prevent turbines from overheating and help to prolong facility life. The height of these towers can vary, although typically they are around 50 ft tall or less. Plumes from cooling towers at facilities using wet cooling systems also may increase the overall visibility of the individual structures, as previously discussed.

Decommissioning and Reclamation Phase

After well production ceases, wells would be plugged and capped, and the well site would be reclaimed. Aboveground components and gravel from well pads and access roads (if not maintained for other uses), and from other ancillary facility sites, would be removed. Other activities would include recontouring the site and access roads, and revegetation. Following decommissioning, the site would be restored to approximate its original condition, or to some standard that results in stable environmental conditions.

Impacts would be similar to those addressed for the construction phase. Decommissioning activities would have only temporary and minor visual effects, resulting from the presence of workers, vehicles, and construction equipment (including lighting for safety); and from vegetation damage, dust generation, scarring of the terrain, and altering of landforms as structures are dismantled and removed.

References

Lund, J., 2007, *Characteristics, Development, and Utilization of Geothermal Resources*, GHC Bulletin, June 2007. Available at http://geoheat.oit.edu/pdf/tp126.pdf. Accessed Sept. 24, 2012.

Geothermal Energy Facility BMPs and Applicable Project Phases

	Siting and Design	Construction	Operations	Decommissioning and Reclamation
5.1 Use Dry-Cooling Technology (p 100)	●			
5.2 Screen Pipelines from Roads and Other Sensitive Viewpoints (p 102)	●			
5.3 Paint or Coat Aboveground Pipelines (p 104)	●			
5.4 Minimize Drill Rig and Well Test Facility Lighting (p 106)		●	●	

5.1 Use Dry-Cooling Technology

Project Phase: Siting and Design

Dry-cooling technology should be used instead of wet-cooling technology so that visual impacts from water vapor plumes can be avoided.

Steam plumes rise from cooling towers at a dry steam plant. (Geysers facility near Calistoga, California. Credit: NREL.)

Air-cooled geothermal plant. The use of dry cooling technology avoids visual impacts from plumes. Note the use of vegetation for partial screening of ground-level views of the plant. (Mammoth facility, eastern Sierra Nevada in California. Credit: NREL.)

Notes

The operation of many geothermal power plants requires cooling towers to cool the geothermal working fluid to its liquid state so that it can be re-injected into the steam field. Air-cooled (dry-cooling) systems are preferred in areas where the viewshed is particularly sensitive to the effects of vapor plumes. These types of plumes occur in water-cooled (wet-cooling) systems. A hybrid cooling system would still generate plumes, but less frequently than a wet-cooled system.

Limitations

Dry-cooling systems are less thermally efficient than wet-cooling systems. Compared to wet evaporative cooling systems, they require greater amounts of station power to produce the same amount of cooling capacity, therefore reducing the net power generating capacity of the power plant. Dry cooling is least efficient in hot summer months, when demand is greatest. However, in addition to reducing visible water vapor plumes, dry-cooling systems use far less water than wet-cooling systems, which is an especially important benefit in the generally arid western states. While visual impact considerations would not normally drive a decision regarding the use of wet- or dry-cooling technology, they provide an additional reason to choose dry-cooling technology where it is feasible to do so.

5.2 Screen Pipelines from Roads and Other Sensitive Viewpoints

Project Phase: Siting and Design

Pipelines should be set back from roadways and other sensitive viewpoints, and should be sited to take advantage of available topographic or vegetative screening to conceal them from view.

Geothermal pipelines at dual-flash geothermal power plant. Because of the low vertical profile, even moderate-height vegetation can effectively screen views of the pipelines (see more distant pipelines at right). This road is interior to the facility, and therefore no setback is needed for visual impact reduction; however, if it was a public road, a modest setback from the road and darker coloration could have greatly reduced the visual contrast from the pipelines, even at a very short viewing distance. (GEM 2/GEM 3 facility near Holtville, California. Credit: Robert Sullivan, Argonne National Laboratory.)

Notes

Geothermal plants require extensive pipeline systems for geothermal fluid, water, and/or steam transport that may create strong line, color, and texture contrasts with the surrounding landscape. The nature, extent, and visual complexity of the pipeline system are dependent on the type of geothermal technology employed, as well as the size and configuration of the individual facility. The pipelines generally run parallel to, and very close to, the ground, so moderate-height vegetation or topographic relief may provide effective screening. Site planning should use topography and vegetation to screen pipelines from view.

For vegetative screening, the setback distance will depend on the density of the vegetation and its screening effectiveness. The color of the pipeline may also affect the setback distance; painting or coating the pipelines to match darker colors in the natural surroundings (see BMP 5.3) may reduce the distance required for effective screening.

Limitations

Although geothermal pipeline systems generally have relatively low profiles, fencing and other screening may not be tall enough to block views of the pipelines from high-elevation viewpoints, such as nearby mountains. In addition, if artificial screening elements are constructed (e.g., fences or berms) the introduction of these screening elements may create negative visual impacts that must be weighed against the benefits of reduced contrast from the screening of pipelines. In addition, if additional bends in the re-injection lines are needed, this could add to pumping costs; any increase in the length of the pipeline will add to the cost as well.

5.3 Paint or Coat Aboveground Pipelines

Project Phase: Siting and Design

Aboveground pipelines should be painted or coated to match colors in the natural surroundings. Select colors from the BLM Standard Environmental Colors Chart CC-001 (see BMP 6.4.6).

Uncoated geothermal pipelines contrast strongly with their surroundings. (Geysers facility near Calistoga, California. Credit: David Parsons, NREL.)

Notes

Geothermal plants generally require extensive pipeline systems for geothermal fluid, water, and/or steam that may create strong color contrasts with the surrounding landscape if untreated. Aboveground pipelines should generally be painted or coated to match darker colors in the natural surroundings; however, appropriate color selection is dependent on a careful analysis of site- and project-specific factors.

Limitations

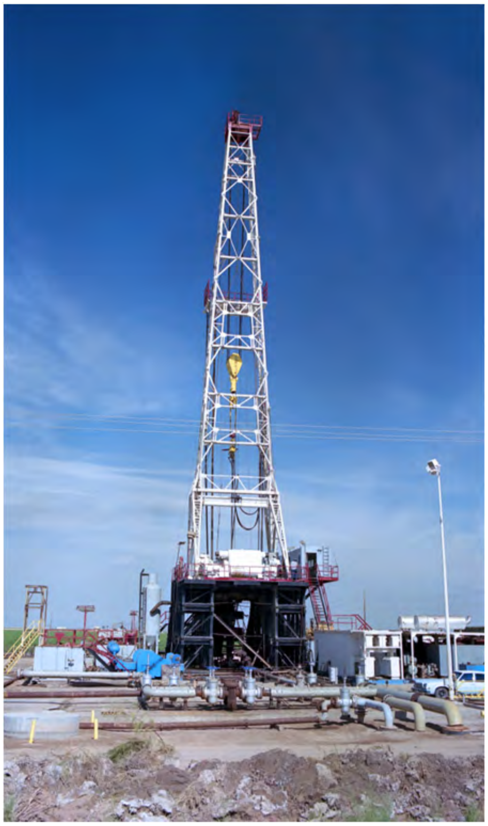
Paint/coatings will require periodic retreatments to maintain effectiveness in reducing color contrast. In some facilities, pipes may be color-coded to identify pipeline contents or relative temperature (hot or cold), for both safety and environmental protection reasons. Dark coatings on pipes could exacerbate thermal expansion problems for pipes exposed to desert sun. However, if selective emissivity coatings are used, they can reduce insolation (thus reducing thermal expansion and contraction problems) and black body radiation (thus keeping more heat in pipelines).

Geothermal pipelines coated to match surroundings at dual-flash geothermal power plant. Note that better results would have been obtained by using a darker color shade on the pipe coating. (GEM 2/GEM 3 facility near Holtville, California. Credit: Robert Sullivan, Argonne National Laboratory.)

5.4 Minimize Drill Rig and Well Test Facility Lighting

Project Phase: **Construction, Operations**

All drill rig and well test facility lighting should be limited to that required to safely conduct operations. Lighting should be shielded, and should direct light to focus on the immediate work area, except as may be required to comply with safety requirements.



Geothermal production well drilling. (Imperial Valley, California. Credit: Warren Gretz, NREL.)

Notes

Drill rig and well test facility lighting can be visible for long distances, and to reduce night-sky impacts its use should be limited to the lowest safe level. Drill rigs would not be limited to the initial facility construction phase, because new wells are typically drilled periodically during facility operation.

Limitations

Some lighting is required for nighttime construction activities; for safety reasons, the lighting usually must be bright.

6 Common Elements

Introduction

Despite using very different approaches and technologies for generating electricity, wind, solar, geothermal, and other types of energy generation facilities have numerous facility elements in common, including electric transmission infrastructure, roads, buildings, tanks, and other structures. Development of the facilities involves common processes as well, including both planning activities, such as facility siting and design, and "on the ground" activities, such as vegetation clearance and recontouring.

To avoid repetition, the BMP publication presents BMPs that relate to these common facility elements and processes separately, as "Common Element" BMPs. Within this grouping, the BMPs have been divided into ten topic areas, based on common themes, such as BMPs for facility siting and design, vegetation management, and lighting. Although they may deal with different physical or planning elements, the BMPs within each topic area share a common principle or purpose. The ten topic areas are introduced briefly below.

6.1 Mitigation Planning

These 11 BMPs address planning issues concerning visual impact analysis and mitigation, including making sure the right qualified parties conduct the work using appropriate methods, and that necessary planning documents are in place. They include the following:

6.1.1 Ensure that Qualified Individuals Conduct and Review Impact Analyses and Mitigation Plans;

6.1.2 Use Appropriate Methods and Data for Visual Impact Assessment and Mitigation Planning and Design;

6.1.3 Incorporate Stakeholder Input into the Siting and Design and Mitigation Planning Processes;

6.1.4 Conduct a Thorough Assessment of Existing and Potentially Affected Visual Resources;

6.1.5 Consult the Applicable VRI and VRM Class Designations;

6.1.6 Develop Spatially Accurate and Realistic Photo Simulations of Project Facilities;

6.1.7 Develop a Decommissioning and Site Reclamation Plan;

6.1.8 Develop a Visual Resource Impact Monitoring and Mitigation Compliance Plan;

6.1.9 Hold a Preconstruction Meeting to Coordinate the Mitigation Strategy;

6.1.10 Discuss Visual Mitigation Objectives with Equipment Operators; and

6.1.11 Use Offsite Mitigation.

6.2 Siting and Design

These 17 BMPs help ensure that facilities and their components are sited to avoid or reduce impacts on visually sensitive areas. They include the following:

6.2.1 Site Facilities and ROWs outside Sensitive Viewsheds, or as Far as Possible from Sensitive Viewing Locations;

6.2.2 Site ROW Crossings to Minimize Impacts on Linear KOPs;

6.2.3 Site Projects Away from Visually Prominent Landscape Features;

6.2.4 Site Facilities to Avoid Night-Sky Impacts on Sensitive Locations;

6.2.5 Site Facilities in Previously Developed or Disturbed Landscapes;

6.2.6 Site and Design Facilities to Repeat the Form, Line, Color, and Texture of the Existing Landscape;

6.2.7 Site Facilities in Areas Suitable for Reclamation;

6.2.8 Minimize the Number of Facility Structures;

6.2.9 Collocate Linear Features in Existing ROWs or Corridors;

6.2.10 Avoid Siting Linear Features in the Centers of Valley Bottoms and on Ridgetops;

6.2.11 Avoid Skylining;

6.2.12 Site Linear Facilities along Natural Lines within the Landscape;

6.2.13 Avoid Siting Roads on Side Slopes;

6.2.14 Site Facility Components to Minimize Cut and Fill;

6.2.15 Avoid Siting Staging and Laydown Areas in Visually Sensitive Areas;

6.2.16 Site Facilities and Components in Existing Clearings; and

6.2.17 Bury Underground Utilities along Roads.

6.3 Structure Design and Materials Selection

These eight BMPs address the selection and design of structures, landforms, and other materials to blend with the existing landscape setting. They include the following:

6.3.1 Use Low-Profile Structures and Tanks;

6.3.2 Custom Design Structures in Key Areas;

6.3.3 Consider Use of Alternative Components;

6.3.4 Use Natural-Looking Constructed Landform, Vegetative, or Architectural Screening;

6.3.5 Minimize Use of Signs and Make Signs Visually Unobtrusive;

6.3.6 Avoid Unnecessary Use of Gravel/Paved Surfaces;

6.3.7 Use Rounded Road Cut Slopes; and

6.3.8 Use Monopole and Lattice Electric Transmission Towers Appropriately.

6.4 Materials Surface Treatment

These 12 BMPs address the selection of appropriate colors and surface treatments for structures to reduce color contrast with the surrounding natural environment. They include the following:

6.4.1 Require a Site Study for Color and Texture Selection;

6.4.2 Select Materials and Surface Treatments to Repeat the Form, Line, Color, and Texture of Surrounding Landscape;

6.4.3 Consider Seasonal Changes and Seasons of Heaviest use in Choosing Materials Colors and Textures;

6.4.4 Color Treat Structures to Reduce Contrasts with Existing Landscape;

6.4.5 Use Non-reflective Materials, Coatings, and/or Paint;

6.4.6 Select Surface Treatment Colors from the BLM Standard Environmental Colors Chart;

6.4.7 Test Color Selections;

6.4.8 Color Treat Grouped Structures Using the Same Color;

6.4.9 Color Treat Exposed Rock Faces;

6.4.10 Color Treat Transmission Towers to Reduce Contrasts with Existing Landscape;

6.4.11 Use Camouflage and/or Disguise Strategies for Close KOPs in Highly Sensitive Viewsheds; and

6.4.12 Maintain Painted, Stained, or Coated Surfaces Properly.

6.5 Lighting

These seven BMPs help ensure that projects minimize night-sky impacts through proper lighting design and usage. They include the following:

6.5.1 Prepare a Lighting Plan;

6.5.2 Use Audio Visual Warning System Technology for Hazard Lighting on Structures Taller than 200 ft;

6.5.3 Use Full Cutoff Luminaires;

6.5.4 Direct Lights Properly to Eliminate Light Spill and Trespass;

6.5.5 Use Amber Instead of Bluish-White Lighting;

6.5.6 Minimize Lighting Usage during Construction and Operations; and

6.5.7 Use Vehicle-Mounted Lights or Portable Light Towers for Nighttime Maintenance Activities.

6.6 Avoiding Disturbance

These eight BMPs help to avoid or minimize land and other types of disturbance. They include the following:

6.6.1 Minimize Project Footprint and Associated Disturbance;

6.6.2 Avoid Unnecessary Road Improvements;

6.6.3 Use Penalty Clauses to Protect High-Value Landscape Features;

6.6.4 Confine Construction Activities and Facilities to Pre-Defined Areas;

6.6.5 Provide Construction Personnel with Avoidance Area Maps;

6.6.6 Do Not Apply Paints or Permanent Discoloring Agents to Rocks or Vegetation to Mark Survey Limits

6.6.7 Require Overland Driving Where Recontouring Is Not Required; and

6.6.8 Use Air Transport to Erect Transmission Towers.

6.7 Soils and Erosion Management

These five BMPs help to avoid or reduce visual impacts from wind and water erosion through dust control, erosion and sediment control, and topsoil management. They include the following:

6.7.1 Implement Dust and Wind Erosion Control Measures;

6.7.2 Implement Erosion and Sediment Control Measures;

6.7.3 Implement Temporary and/or Permanent Soil Stabilization Measures;

6.7.4 Strip, Stockpile, and Stabilize Topsoil for Re-spreading; and

6.7.5 Segregate Topsoil and Reapply to Disturbed Areas.

6.8 Vegetation Management

These eleven BMPs concern vegetation protection, vegetation clearing techniques, and measures to promote successful revegetation. They include the following:

6.8.1 Prepare a Reclamation Plan;

6.8.2 Preserve Existing Vegetation;

6.8.3 Use Retaining Walls, Berms, Fences, and Markings to Protect Trees and Other Scenic Features;

6.8.4 Design Vegetative Openings to Mimic Natural Openings;

6.8.5 Use Partial ROW Clearing and Feather Edges of Transmission ROWs;

6.8.6 Avoid Slash Piles in Sensitive Viewing Areas; Chip Slash for Mulch to Hide Fresh Soil;

6.8.7 Mulch Cleared Areas, Furrow Slopes, and Use Planting Holes;

6.8.8 Use Pitting and Vertical Mulching to Facilitate Revegetation and Discourage Vehicle Traffic;

6.8.9 Revegetate Using Salvaged Native Plants and Approved, Weed-free Seed Mixes;

6.8.10 Transplant Vegetation from Cleared Areas; and

6.8.11 Monitor and Maintain Revegetated Areas until Vegetation Is Self-Sustaining.

6.9 Reclamation

These nine BMPs promote successful interim and long-term reclamation through good recontouring practices, site preparation to promote revegetation, and removal of structures and surface treatments. They include the following:

6.9.1 Review Predevelopment Visual Conditions after Construction;

6.9.2 Begin Site Reclamation during Construction and Operations, Immediately after Disturbances;

6.9.3 Recontour Disturbed Areas to Approximate Natural Slopes;

6.9.4 Scarify/Roughen Cut Slopes and Recontoured Areas;

6.9.5 Salvage and Replace Rocks, Brush, and Woody Debris;

6.9.6 Sculpt and Shape Bedrock Landforms;

6.9.7 Close and Remediate Unused Access Roads;

6.9.8 Remove Aboveground and Near-Ground Structures; and

6.9.9 Remove or Bury Gravel and Other Surface Treatments.

6.10 "Good Housekeeping"

These nine BMPs address measures to keep the site clean and orderly during construction, operations, and decommissioning. They include the following:

6.10.1 Develop "Housekeeping" Procedures;

6.10.2 Maintain a Clean Worksite;

6.10.3 Prohibit Onsite Burning;

6.10.4 Use Exit Tire Washes and Vehicle Tracking Pads to Reduce the Tracking of Sediment onto Roads;

6.10.5 Remove or Avoid Slash Piles;

6.10.6 Clean Off-Road Equipment;

6.10.7 Remove Stakes and Flagging;

6.10.8 Use Fabric-Covered Fences to Conceal Material Storage Yards and Laydown Yards; and

6.10.9 Actively Maintain Operating Facilities.

6.1 Mitigation Planning

These BMPs address planning issues concerning visual impact analysis and mitigation, including making sure that qualified parties conduct the work using appropriate methods, and that necessary planning documents are in place.

6.1 Mitigation Planning	Siting and Design	Construction	Operations	Decommissioning and Reclamation
6.1.1 Ensure that Qualified Individuals Conduct and Review Impact Analyses and Mitigation Plans (p 114)	●			
6.1.2 Use Appropriate Methods and Data for Visual Impact Assessment and Mitigation Planning and Design (p 116)	●			
6.1.3 Incorporate Stakeholder Input into the Siting and Design and Mitigation Planning Processes (p 118)	●			
6.1.4 Consult the Applicable Visual Resource Inventory (VRI) and Visual Resource Management (VRM) Class Designations (p 120)	●			
6.1.5 Conduct a Thorough Assessment of Existing and Potentially Affected Visual Resources (p 123)	●			
6.1.6 Develop Spatially Accurate and Realistic Photo Simulations of Project Facilities (p 127)	●			
6.1.7 Develop a Visual Resource Impact Monitoring and Mitigation Compliance Plan (p 131)	●			
6.1.8 Develop a Decommissioning and Site Reclamation Plan (p 133)	●			
6.1.9 Hold a Preconstruction Meeting to Coordinate the Mitigation Strategy (p 134)	●			
6.1.10 Discuss Visual Mitigation Objectives with Equipment Operators (p 136)		●		
6.1.11 Use Offsite Mitigation (p 138)	●			

6.1.1 Ensure that Qualified Individuals Conduct and Review Impact Analyses and Mitigation

Project Phase: Siting and Design

A qualified visual resource specialist (usually a professional landscape architect) with demonstrated experience with the BLM's VRM policies and procedures should be a part of the developer's and the BLM's respective planning teams, and should be engaged as early as possible in the project planning process.

BLM staff, contractors, and other federal and state agency staff receive visual resource management training from BLM. (Credit: John McCarty, BLM.)

Notes

Decisions regarding design aesthetics and the associated visual impact on the surrounding environment should be made by qualified persons. VRM is a design-based program necessitating early involvement of qualified environmental design arts professionals to assure proper integration of VRM principles into project site selection, site planning, and design development as a means to avoid expensive mitigation identified during NEPA analyses. Such qualifications normally include academic or other accepted credentials in landscape architecture. Familiarity with BLM's VRM system, and especially with the use of the VCR process to determine conformance to VRM Class objectives, is essential. Practical field experience with utility-scale energy projects is highly desirable.

The visual resource specialist's responsibilities include identifying and addressing visual resource issues as a part of the early planning and design phase of the projects; working directly with the proponent's engineer to explore potential design options; evaluating and preparing additional mitigation measures when preparing NEPA documents; and monitoring compliance with VRM conditions of approval when under construction, during operation, and at decommissioning.

The large size and generally strong visual contrasts generated by renewable energy facilities and associated transmission makes visual impact mitigation for these projects challenging. Proper siting of facilities and facility components is the most effective way to mitigate potential visual impacts; engaging a visual resource specialist early in the project planning process helps to avoid costly corrective mitigation that could have been avoided though better siting and design decisions.

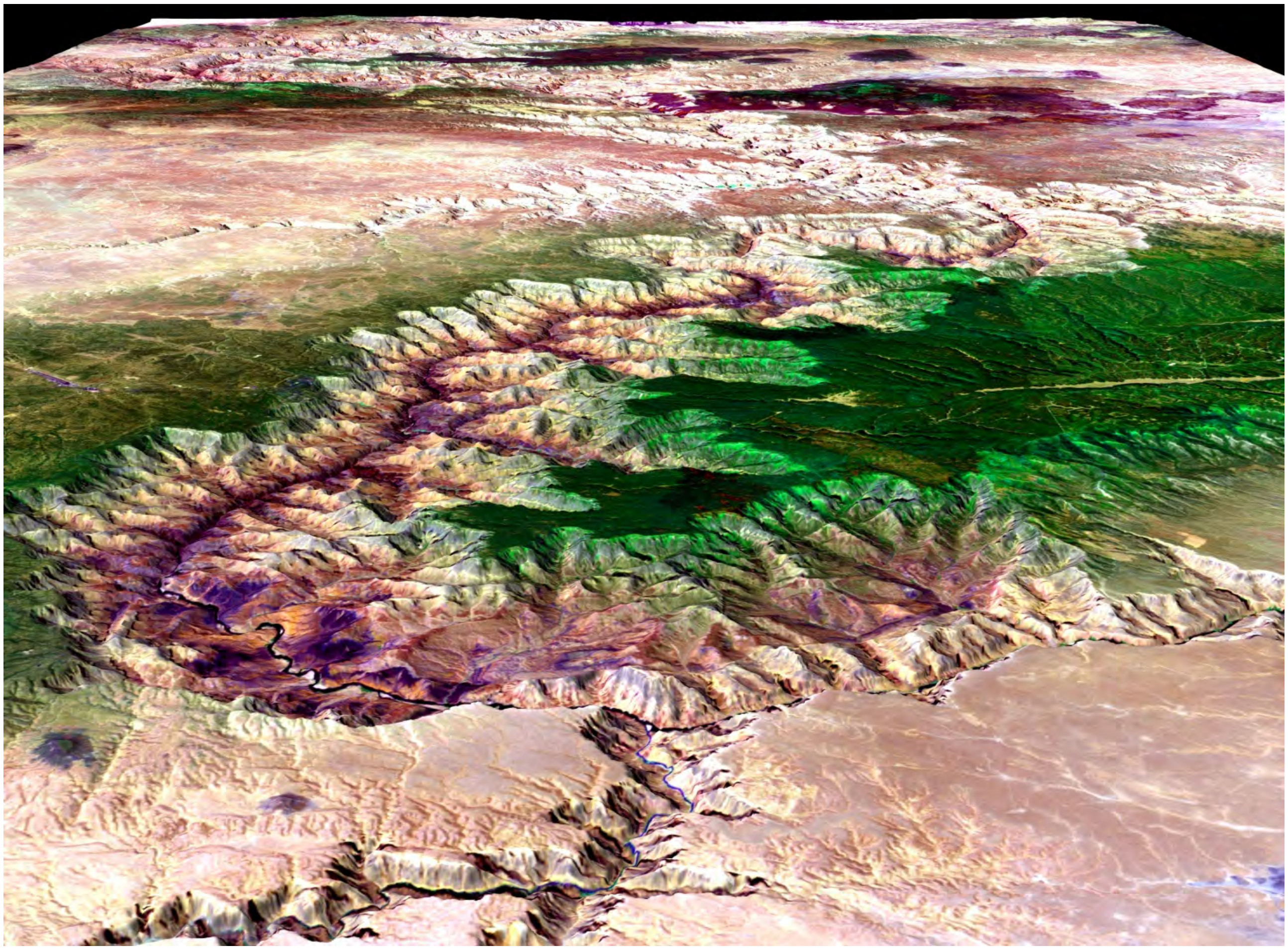
Limitations

Project proponents typically will not have visual resource expertise on staff, and the same may be true for contractors hired to conduct visual impact analyses. BLM project staff may need to consult with state VRM leads and other VRM specialists within BLM.

6.1.2 Use Appropriate Methods and Data for Visual Impact Assessment and Mitigation Planning and Design

Project Phase: Siting and Design

Topographical data of appropriate engineering-design quality should be used for digital terrain mapping and project visualization, including exploration of visual aspects of project location selection, site planning and design, visual impact analysis and simulation, and visual impact mitigation planning and design.



LANDSAT satellite imagery overlaid onto National Elevation Dataset elevation data depicting Grand Canyon and the Colorado Plateau. (Credit: National Aeronautics and Space Agency.)

Notes

Visual impact analysis and mitigation planning and design should be performed through field assessments, and through the use of global positioning system (GPS) technology, photo documentation, computer-aided design and development software, GIS software, and three-dimensional modeling and rendering software. These tools should be used to analyze visibility, select KOPs, depict site conditions, and create visual simulations that reflect potential visual impacts and mitigation measures, including iterative visualization of both project design evolution and mitigation outcomes. The digital terrain data should be at a horizontal and vertical resolution suitable for site design and accurate placement of proposed developments at a landscape and project viewshed scale. Visualization tools should be used early in project planning to inform project siting, design, and mitigation planning and to support the visual impact assessment.

Limitations

In some remote areas, terrain data of sufficiently high resolution may be difficult or very expensive to obtain. Some visualization techniques require advanced computing skills and software/hardware.

6.1.3 Incorporate Stakeholder Input into the Siting and Design and Mitigation Planning Processes

Project Phase: Siting and Design

Project stakeholders including the appropriate BLM field office, appropriate land management agencies, Native American governments, and the public should be consulted to provide input on identifying important visual resources within the project area and on the siting and design process.

BLM public involvement activity for identifying visual resource concerns in Wyoming. (Credit: BLM).

Notes

The appropriate land management agencies, planning entities, Native American governments, and the public should be consulted to provide input on identifying important visual resources within the project area and on the siting and design process.

Project developers should consult with the respective land management agencies that have been assigned administrative responsibilities for landscapes having special designations within the project's viewshed on each agency's viewshed protection objectives and practices. Developers should demonstrate a concerted effort to reconcile conflicts.

The lead federal agency (usually the BLM) should consult with Native American governments early in the planning process to identify issues and areas of concern regarding the proposed development. Aside from requirements under the National Historic Preservation Act (NHPA), consultation is necessary to establish whether the project is likely to disturb traditional cultural properties, affect access rights to particular locations, disrupt traditional cultural practices, and/or visually impact areas important to the tribe(s).

In addition to traditional meetings, possible approaches for stakeholder involvement include conducting public forums for disseminating information, offering organized tours of operating renewable energy development projects, using computer simulation and visualization techniques in public presentations, and conducting surveys regarding public perceptions and attitudes about specific types of renewable energy developments. Beyond traditional meetings, these efforts often help stakeholders better understand the potential visual impacts of the project, and in some cases this may result in decreased stakeholder opposition.

Limitations

Potentially affected stakeholders may be difficult to identify or to engage in the earliest stages of project planning. The input of participating stakeholders may not be complete and may not be representative of all viewpoints. Some stakeholders may be entirely opposed to the project on the basis of visual impacts that are not mitigated effectively; if the project is built, they may feel that their input was not appropriately considered in the planning and siting process. It may also be challenging to reconcile opposing views among project stakeholders.

6.1.4 Consult the Applicable Visual Resource Inventory (VRI) and Visual Resource Management (VRM) Class Designations

Project Phase: Siting and Design

Project developers should consult the relevant VRI class values and VRM class designations of proposed and alternative project locations and surrounding viewsheds for information regarding visual quality, public sensitivities, visibility, visual management objectives, and potential VRM conformance issues.

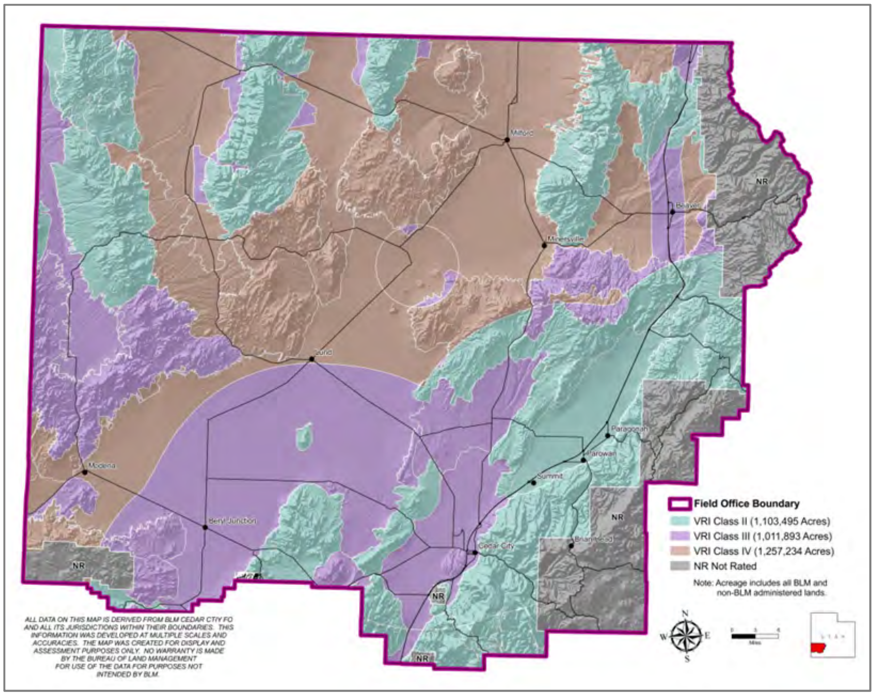
Notes

The applicable VRI provides important baseline information about the project area's visual resource values and should be used to identify visual resource attributes that may be affected by project development. Visual quality, public sensitivity, and visibility (distance zones) data from the VRI should be used in siting, design, and mitigation planning. The VRI narrative provides useful information about the locations, numbers, types, and sensitivities of viewers in the project area and can be used to inform the selection of KOPs. In order to meet the requirements of NEPA to disclose potential impacts on the resource, anticipated changes in VRI values must be analyzed.

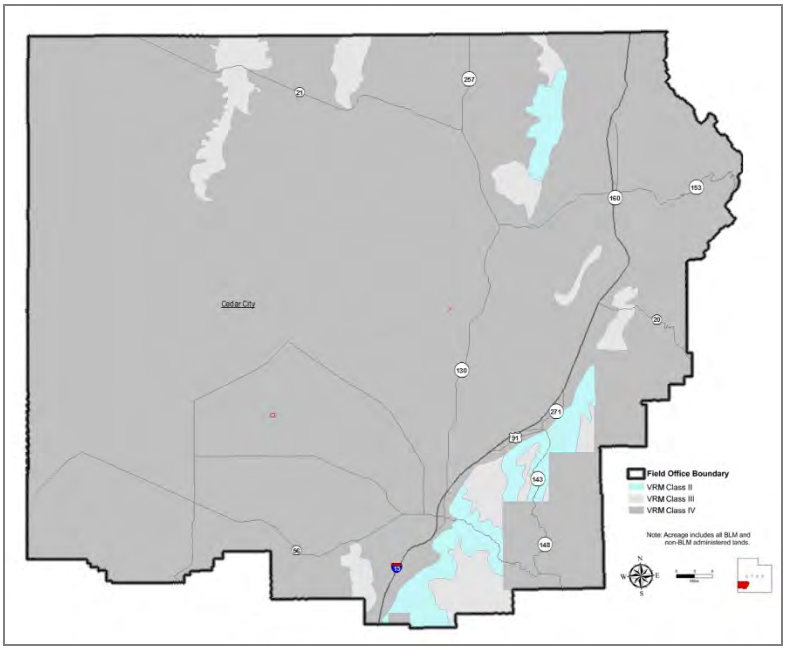
The VRM class designations for the proposed project location and surrounding viewshed include VRM objectives that reflect land management decisions (presented in the RMP) made in consideration of multiple land use objectives. VRM class designations are not measures of scenic quality or other visual resource values, and thus are fundamentally different than VRI classes. The impact analysis must discuss the project's conformance to the applicable VRM class designation. It is the developer's responsibility to conduct an early investigation of the respective project's compatibility with the VRM class objectives and the potential that these objectives can be met by applying effective siting, design, and mitigation strategies. Project developers should document and demonstrate how the visual management objectives were factored into the various phases of project planning and decision rationale.

Limitations

Inexperienced analysts sometimes confuse VRM and VRI data, and BLM staff may need to provide oversight to ensure that the VRI information is considered and presented correctly. In some field offices, VRI data may be outdated or difficult to obtain in an easily usable format (e.g., GIS data), although the BLM has updated the VRIs for many field offices in the years prior to issuing this visual BMP publication. Due in part to its historic lack of availability, VRI information is sometimes not included in visual impact assessments, so BLM staff may have to work with developers to make sure that current VRIs are consulted and that VRI values are discussed in the impact analysis at the appropriate scale. Although the inventory provides baseline data that can be used for disclosing impacts in the NEPA process, the data is intended only for discussion of broad-scale changes since the VRI process is a broad-scale planning effort. Site-specific impacts need to be disclosed separately from these broad-scale impacts.



BLM VRI map for Cedar City Field Office in Utah. The VRI contains information about the project area's visual quality, public sensitivities, and visibility, and is useful for multiple purposes, including visual impact assessment. (Credit: BLM.)



BLM VRM map for Cedar City Field Office in Utah. The VRM class designations identify visual resource management objectives, and reflect land management decisions made in consideration of multiple land use objectives. (Credit: BLM.)

6.1.5 Conduct a Thorough Assessment of Existing and Potentially Affected Visual Resources

Project Phase: Siting and Design

The visual impact analysis should identify and map landscape characteristics, key observation points (KOPs) and key viewsheds, prominent scenic and cultural landmarks, and other visually sensitive areas near the project location. The analysis should include a review of the land-use planning-level VRI to assess and analyze potential impacts on the relative visual resource values and the applicable RMP, and to identify the VRM objectives for potential conformance conflicts (see BMP 6.1.4).

Notes

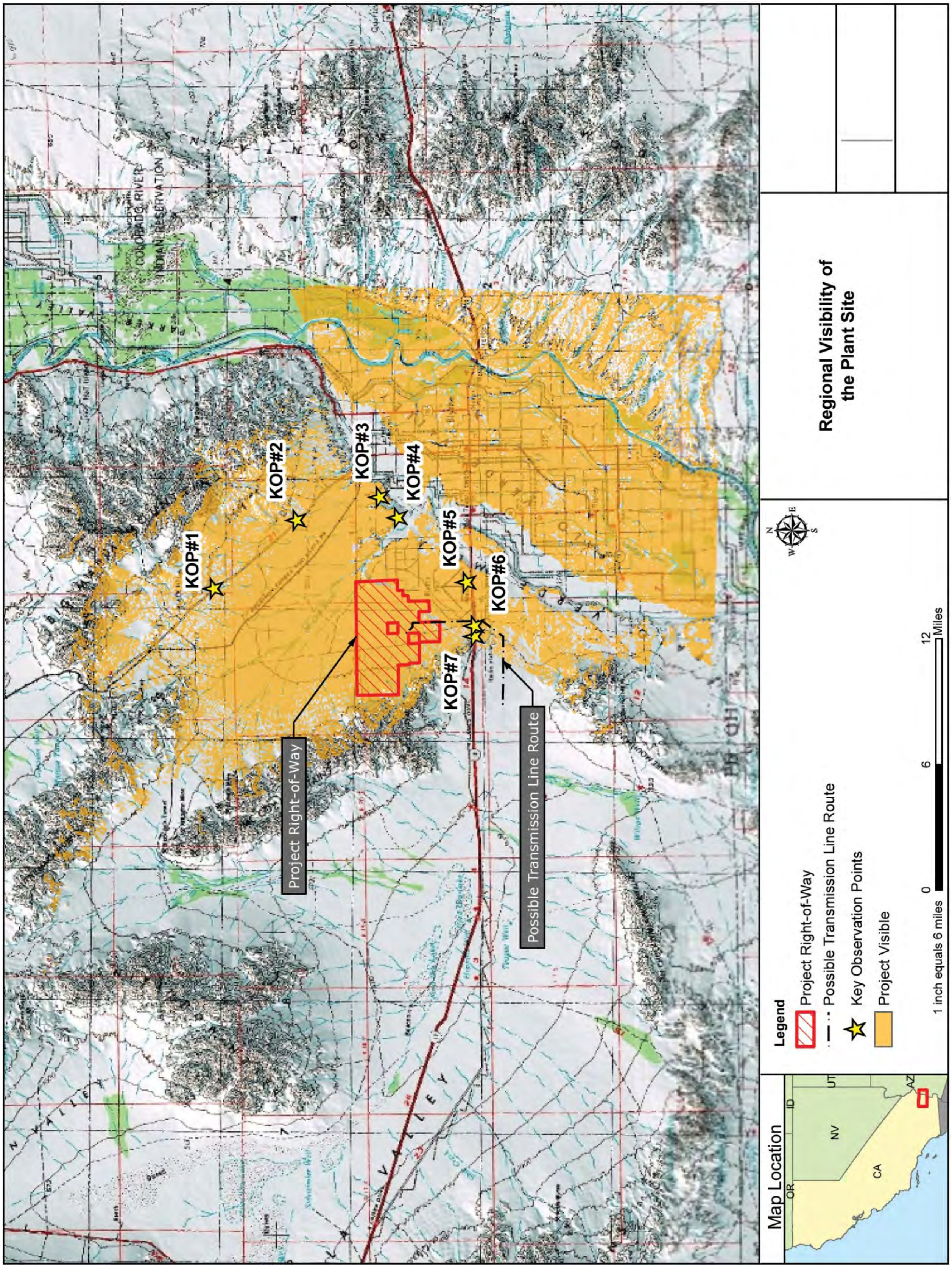
KOPs should be selected by first determining the extent of the viewshed using GIS-based viewshed modeling tools. The viewshed modeling should illustrate the areas from which the proposed facilities may theoretically be seen. The distance from the project selected for the viewshed analysis should be sufficient to include all areas likely to be subject to non-negligible visual contrasts from the proposed project. The viewshed analysis should incorporate offsets for both viewer and target (project) heights. Viewer height offset should be 5.5 ft. The target height offset should be equivalent to the tallest facilities to be incorporated in the impact analysis. Because of the long visibility distances for utility-scale renewable energy facilities, the viewshed analysis should incorporate earth curvature.

From within the visible areas, KOPs should then be selected at places where people would be expected: for example, at scenic overlooks, roads, trails, campgrounds, recreationally active river corridors, historical sites and trails, and residential areas. For the purpose of conducting a visual contrast rating evaluation, the number of KOPs should be reduced to those that serve as the best representations for determining conformance to the respective VRM class objectives. The BLM should approve KOP selections, and the BLM should reserve the right to require additional KOPs to further determine the extent of visual impacts and conformance to VRM class objectives.

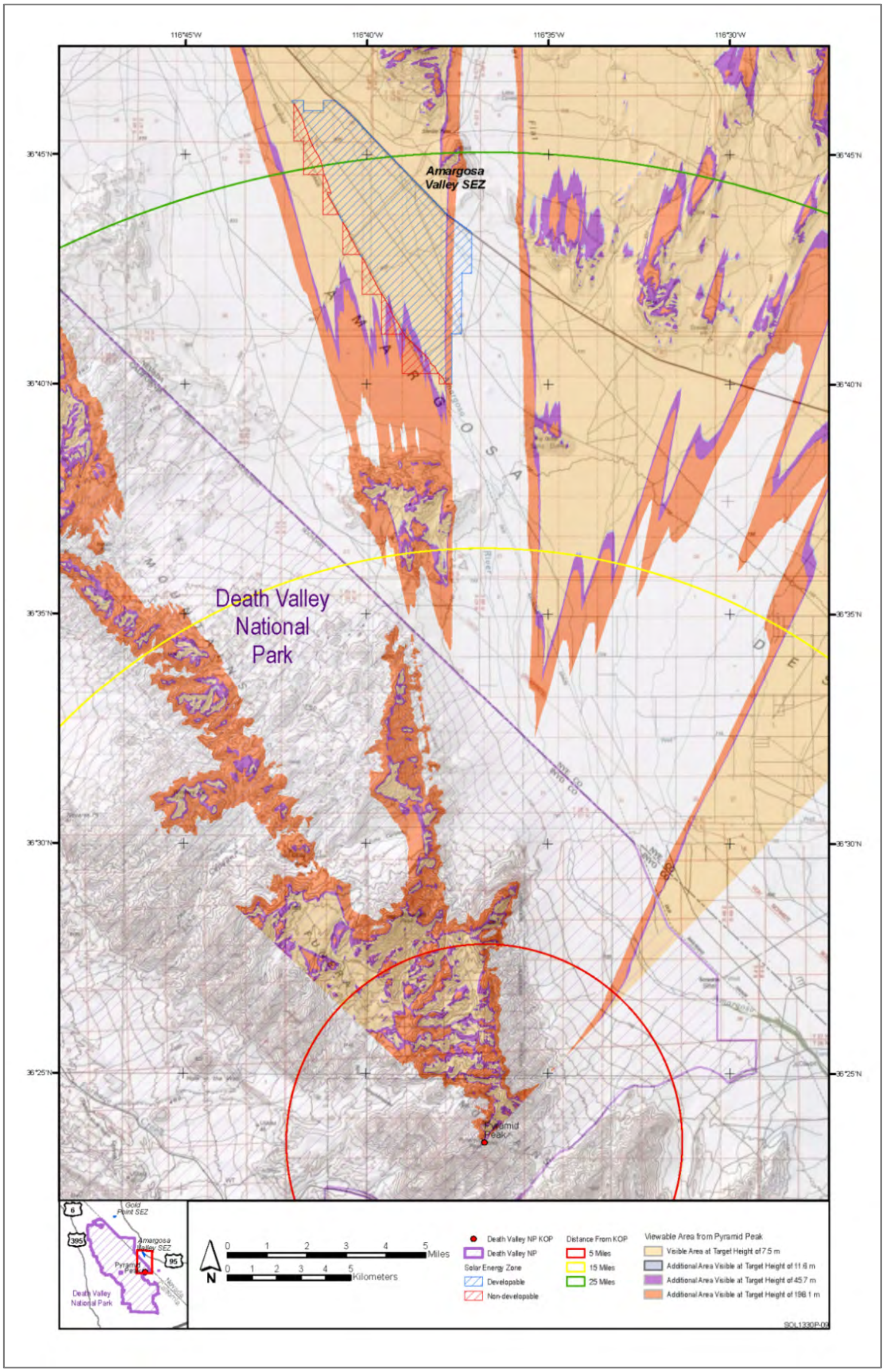
The assessment of visual resources should be part of the project's early pre-planning phases, and may need to be re-assessed during the life of the project as the project design progresses, or if KOPs change, for example, in response to residential area or road construction, development of scenic attractions, or changing recreation patterns.

Limitations

There is no required or accepted radius of visual impact analysis for utility-scale renewable energy facilities. An appropriate value may need to be determined on a site- and project-specific basis; however, because of the large size and generally high visibility of renewable energy facilities (particularly wind and solar facilities), distances of 25 mi or more may be appropriate in the open landscapes typical of BLM-managed lands.



Project viewshed map depicting the potential visibility of a solar facility from surrounding lands. The facility could potentially be seen from any location within the orange-tinted areas. (Credit: California Energy Commission.)



KOP viewshed map depicting the potential visibility of solar facilities in Amargosa Valley Solar Energy Zone from Pyramid Peak in Death Valley National Park (solar energy zone in blue and red cross-hatching). Color-shaded areas are visible from the Pyramid Peak KOP. (Credit: Argonne National Laboratory.)

6.1.6 Develop Spatially Accurate and Realistic Photo Simulations of Project Facilities

Project Phase: Siting and Design

Spatially accurate and realistic photo simulations of project facilities in the proposed location must be prepared and evaluated in accordance with BLM Handbook H-8431-1 and other agency directives, as part of the siting process. They should show views from KOPs including sensitive visual resource areas and highly sensitive viewing locations such as specially designated areas, scenic highways, and residences. The BLM and other stakeholders should be involved in selecting KOPs for simulations. The BLM should approve KOP selections for use in preparing simulations, and should reserve the right to require additional simulations to further determine the extent of visual impacts and conformance to VRM class objectives.

Notes

Visual impact simulations are a critical component of the visual impact analysis and mitigation planning and design process. BLM VRM policy strongly recommends that visual impact simulations be prepared for potentially high-impact projects, which would normally include utility-scale wind, solar, and geothermal facilities, as well as transmission projects. Simulations should be prepared as described in BLM Handbook H-8431-1, *Visual Resource Contrast Rating*, in order to evaluate visual contrasts of the energy projects to determine if the proposed project is in conformance with the VRM Management Class objectives that apply to the project area.

Simulations should be based on accurate project design specifications and on accurate spatial information (particularly elevation data) and must account for screening vegetation and structures. Simulations should be spatially accurate; they should show all of the project elements that would be visible, at the correct size and location, and in the correct visual perspective. They should be realistic (i.e., they should look like the facility would actually look when built, as seen from the relevant KOP), and they should be colored and shaded realistically, with cast shadows that are depicted accurately and realistically. Any known errors in accuracy or realism should be clearly stated so that viewer expectations are appropriate.

Simulations should portray a range of viewing conditions and anticipated impacts associated with lighting conditions and sun angles. Simulations also should show enough of the surrounding landscape to show the project in the appropriate spatial context. They should be reproduced at a size large enough to be comfortably viewed from the appropriate specified distance to accurately depict the apparent size of the facility in a real setting. The appropriate viewing distance for the simulation as presented to stakeholders and decision-makers should be clearly stated.

Simulations should include a variety of specifications and supplementary information, preferably presented with the simulation itself, including the following:

- Geographic coordinates for the camera/KOP location;
- Date and time of the photograph;
- View direction;
- Weather conditions;
- Lighting condition (frontlit, backlit, sidelit);
- Camera and lens make and model;
- Focal length used for photograph (for film SLR cameras) or 35-mm equivalent focal length for digital SLR cameras;
- Horizontal and vertical width of field depicted in the simulation; and
- Distance to nearest visible portion of facility (e.g., the nearest visible wind turbine).

The proper viewing distance for the simulation at its intended reproduction size should be specified, as viewing the simulation from the incorrect viewing distance will result in the objects in the simulation being perceived to be either larger or smaller than they would be in a real view from the KOP. The simulation should include an inset or supplementary map (with a legend) that shows the location of the KOP, the facility boundary and major components, and nearby features such as roads and populated places; and depicts graphically the horizontal field of view shown in the simulation. The simulation should be clearly labeled to indicate the project, KOP location, and alternative depicted in the simulation.

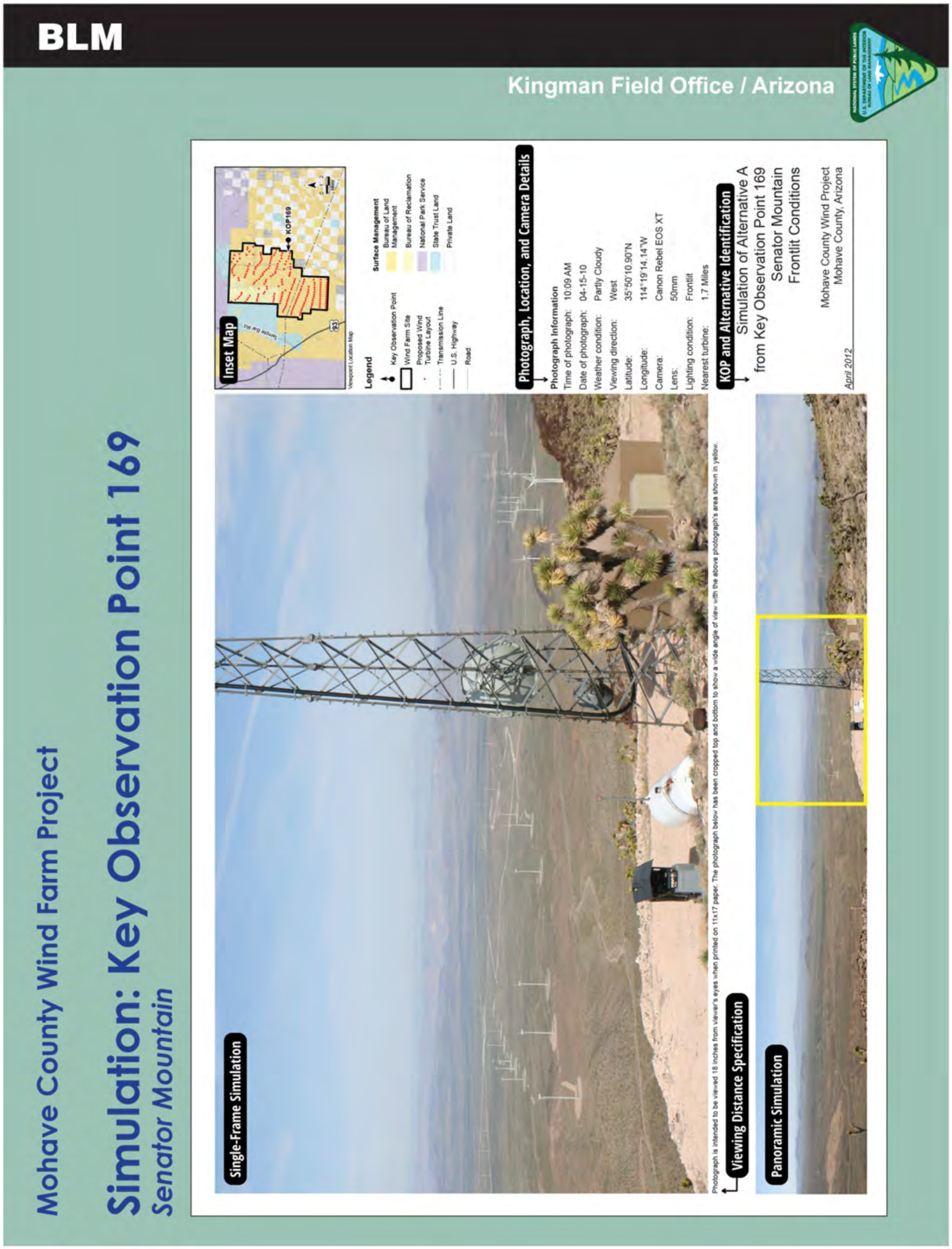
Simulations may be single-frame, panoramic, or both; the choice should be determined on a case-by-case basis. In most cases, the presentation of both a single-frame and a panoramic image for each simulated view is greatly preferable to showing either one alone. Single-frame images may be needed to show adequate details of the objects in the simulation to depict it realistically, but may not show as much of the facility as would be seen in "real world" views, and may not show enough of the surrounding landscape to portray the visual context properly, or to show the scale of the project in relation to its surroundings. Panoramic images show more of the project and its surroundings; this is particularly important for the depiction of renewable energy facilities in typical BLM landscapes, as the facilities tend to be very large, and the landscapes very open, with expansive views. However, in some cases, panoramic images may lack details that would be visible in reality, especially when they are reproduced at relatively small sizes, which is common in practice. Showing both types of images for each simulated view allows proper depiction of facility details while showing the facility in the proper visual context and better depicting its scale in relationship to its surroundings.

In some cases, the use of animations may be appropriate. The visual chracteristics of renewable energy facilities are such that the viewing experience is dynamic; the appearance of wind and solar facilities in particular may change dramatically in the course of a day. Animations are particularly effective at showing wind turbine blade motion, changes in position and reflectivity of solar collectors/reflectors over the course of a day, and changes in lighting conditions as the sun rises and sets or clouds pass in front of the sun. Animations can also depict changes in the viewed landscape and visual contrasts as the viewer moves, for example, while hiking a trail, floating a river, or driving a scenic byway.

Limitations

The development of spatially accurate and realistic simulations is a complex technical process that requires a high degree of skill, appropriate technology, accurate data, and rigorous methods. If improperly prepared, simulations may be misleading, but the errors may not be apparent to casual observers. For a variety of technical reasons, even when properly prepared, simulations are limited in their ability to realistically portray the full range of the visual experience of utility-scale renewable energy facilities, particularly wind and solar facilities. In addition, if the project design changes after the preparation of the simulations (a relatively common occurrence), the simulations may not depict the actual project that is eventually built.

Because animations are more expensive to produce than still-image simulations, their use is generally restricted to situations of high visual sensitivity.



Photomontage simulation of wind energy facility on BLM-administered land in Arizona. Note the extensive supplementary information provided with the simulation, including panoramic photograph to show landscape context, inset map of wind facility and simulation KOP, description of lighting conditions, photography details, and correct simulation viewing distance. (Credit: BLM.)

6.1.7 Develop a Visual Resource Impact Monitoring and Mitigation Compliance Plan

Project Phase: Siting and Design

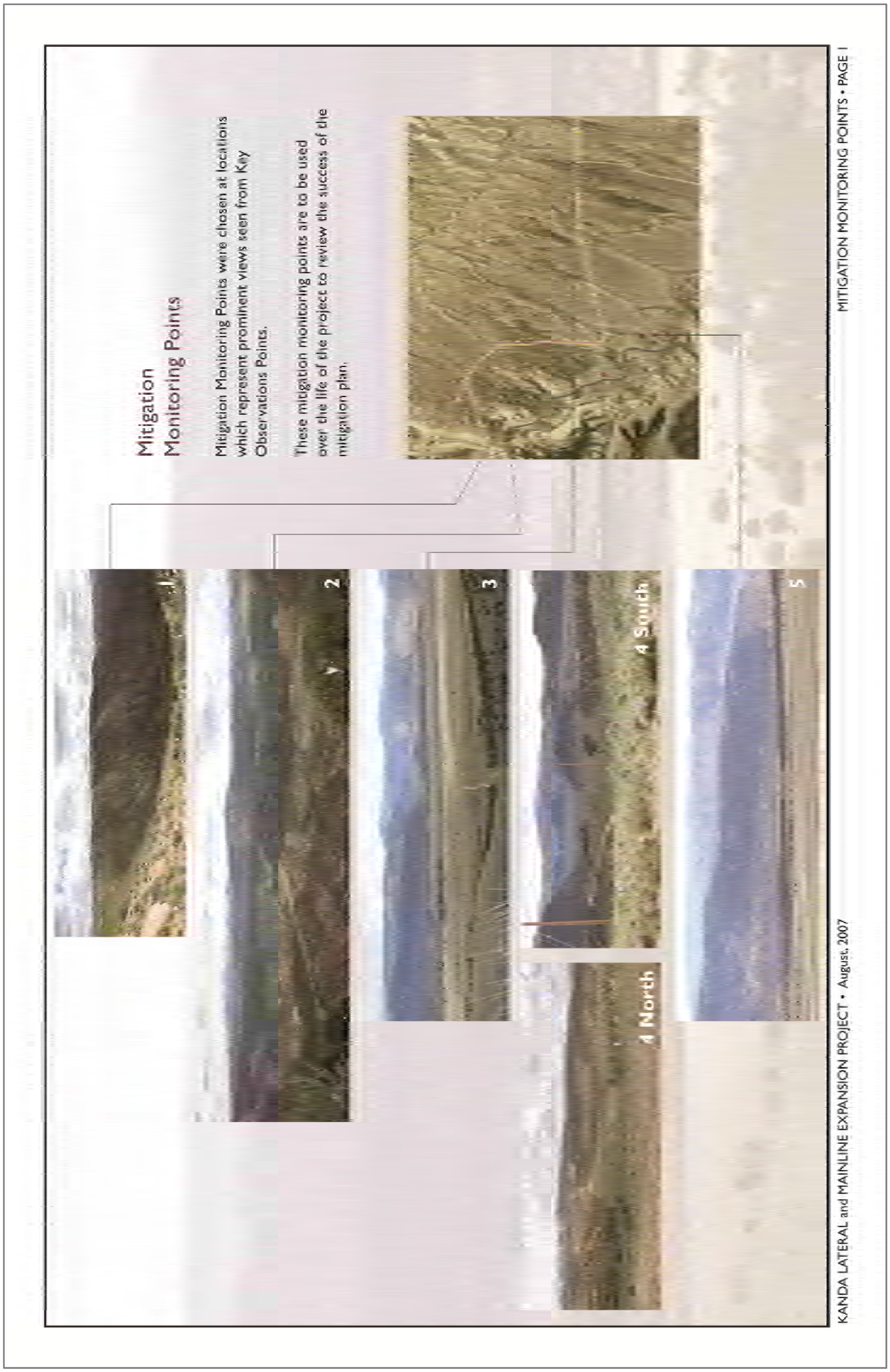
A visual resource impact monitoring and mitigation compliance plan should be developed and implemented. The plan should include provisions for monitoring the effectiveness of the visual impact mitigation strategy and determining compliance with the project's visual impact mitigation requirements.

Notes

The visual resource impact monitoring and mitigation compliance plan should ensure that required visual impact mitigations are implemented and are effective. Visual design objectives within the plans should be measurable and monitored during construction, operations, and decommissioning. The plan should include monitoring and compliance elements that establish the monitoring requirements and thresholds for acceptable performance, and measures for corrective actions. The visual contrast rating procedures should also be included for field-based compliance assessment during operations and after decommissioning.

Limitations

Currently, the BLM lacks protocols or guidelines for visual impact and mitigation conformance monitoring, and it is not required of developers.



This visual impact mitigation plan specifies mitigation monitoring locations. (Credit: BLM.)

6.1.8 Develop a Decommissioning and Site Reclamation Plan

Project Phase: Siting and Design

A decommissioning and site reclamation plan should be developed and implemented in order to ensure that the area's pre-development scenic quality and integrity are restored and that the project area is visually integrated into the surrounding landscape setting. Important plan elements should include requirements that most aboveground and near-ground structures be removed, that the project site be re-graded, and that native vegetation be re-established to be consistent with the surrounding landscape.

Notes

The plan should be in place prior to construction because decommissioning decisions can influence all phases of the facility's life cycle. Reclamation of the construction areas, including roads and rights-of-way (ROWs), should begin immediately after construction to reduce the likelihood of visual contrasts associated with erosion and invasive plant infestation and to reduce the visibility of temporarily disturbed areas as quickly as possible. Topsoil from all decommissioning activities should be salvaged and reapplied during final reclamation. See BMPs 6.9.1–6.9.9 for specific recommended best practices for site reclamation. The decommissioning and site reclamation plan should be developed in coordination with the visual impact monitoring and mitigation compliance plan (see BMP 6.1.7).

Limitations

The ultimate success of the decommissioning and site reclamation plan depends in part on diligence on the part of the project proponent and effective monitoring by the BLM.

6.1.9 Hold a Preconstruction Meeting to Coordinate the Mitigation Strategy

Project Phase: Siting and Design

BLM landscape architects or other designated visual resource specialists should participate in the project pre-construction meeting to coordinate the VRM mitigation strategy and confirm the compliance-checking schedule and procedures. Final design and construction documents should be reviewed for completeness with regard to the visual mitigation elements, assuring that requirements and commitments are adequately addressed. The construction documents should include, but not be limited to, grading, drainage, revegetation, vegetation clearing, and feathering plans, and they should demonstrate how VRM objectives will be met, monitored, and measured for conformance.

BLM landscape architects or other designated visual resource specialists should participate in the project pre-construction meeting. (Credit: BLM.)

Notes

VRM consultations should take place early in the project planning phase, in accordance with BLM VRM manuals and handbooks, to help determine the proposed project's potential conformance to the applicable RMP's VRM class designation and other potential constraints. Early consultation between the project proponent and BLM VRM specialists results in better mitigation and fewer potentially costly "surprises" for both the developer and the BLM.

Limitations

Design details for all project elements may not yet exist at a given point in time, and are subject to change. Additional meetings may be necessary, especially if the project plans change significantly after the initial preconstruction meeting.

6.1.10 Discuss Visual Mitigation Objectives with Equipment Operators

Project Phase: Construction

Visual impact mitigation objectives and activities should be discussed with equipment operators before construction activities begin.

Making sure that equipment operators understand good practices to avoid unnecessary damage to visual resources can have significant benefits in improved mitigation results. (Credit: BLM.)

Notes

Because equipment operators are the persons actually making the alterations to the landscape associated with project development, making sure that they understand good practices to avoid unnecessary damage to visual resources can have significant benefits in improved mitigation results. Furthermore, experienced equipment operators may have good suggestions for improving techniques for specific mitigation procedures that must be tailored to the environment of a specific site. At the most basic level, making equipment operators aware of the importance of visual resource values may make them less likely to litter or to engage in other actions that cause unnecessary visual impacts.

Providing equipment operators with example photographs or with diagrams of desired results (e.g., a properly feathered ROW edge) can be very helpful in achieving better outcomes.

Limitations

A large renewable energy project, particularly a large solar facility, may involve hundreds or thousands of workers over a period of several years, with workers involved with a particular project for very specific tasks over a relatively short period of time. Under these circumstances, effective communication with equipment operators may be difficult.

6.1.11 Use Offsite Mitigation

Project Phase: Siting and Design

In addition to mitigation measures that directly reduce the impacts of the renewable energy facility under consideration and its associated facilities, offsite mitigation of visual impacts may be an option in some situations. Offsite mitigation should be considered in situations where nonconforming proposed actions that will result in unavoidable visual impacts may lead to changing the VRM class objectives through an RMP amendment. Unavoidable visual impacts may then be mitigated by correction or remediation of impacts of approximately equal magnitude for a nonconforming existing condition resulting from a different proposed action located within the same viewshed, and within the same or a more protective VRM class.

In situations where offsite mitigation opportunities are absent within the same viewshed, different viewsheds that need mitigation of visual impacts that could affect highly sensitive visual resources (for example, along National Scenic and Historic Trails, Wild and Scenic River corridors, Scenic or Backcountry Byways) may be considered.

Notes

Offsite mitigation serves as a means to offset a loss of visual landscape integrity. For example, offsite mitigation could include reclaiming unnecessary roads, removing abandoned buildings, reclaiming abandoned mine sites, putting utility lines underground, rehabilitating and revegetating existing erosion or disturbed areas, or establishing scenic conservation easements.

Limitations

Appropriate offsite mitigation will be determined on a project-specific basis in consultation with the BLM. The BLM's policy is to mitigate impacts to an acceptable level onsite whenever possible through avoidance, minimization, remediation, or reduction of impacts over time. Offsite mitigation may be used only when the BLM can demonstrate that the proposed mitigation is reasonably necessary to accomplish an authorized BLM purpose. When proposed offsite mitigation is geographically distant from the project area, particularly when it occurs on non-Federal land, the connection to resources for which the BLM is responsible should be clear. BLM policy guidance on offsite mitigation procedures is contained in BLM IM 2008-204, Offsite Mitigation.

6.2 Siting and Design

These BMPs help ensure that facilities and their components are sited and designed to avoid or reduce impacts on visually sensitive areas.

6.2 Siting and Design	Siting and Design	Construction	Operations	Decommissioning and Reclamation
6.2.1 Site Facilities and ROWs outside Sensitive Viewsheds, or as Far as Possible from Sensitive Viewing Locations (p 141)	●			
6.2.2 Site ROW Crossings to Minimize Impacts on Linear KOPs (p 145)	●			
6.2.3 Site Projects Away from Visually Prominent Landscape Features (p 147)	●			
6.2.4 Site Facilities to Avoid Night-Sky Impacts on Sensitive Locations (p 149)	●			
6.2.5 Site Facilities in Previously Developed or Disturbed Landscapes (p 150)	●			
6.2.6 Site Facilities and Components in Existing Clearings (p 151)	●			
6.2.7 Site and Design Facilities to Repeat the Form, Line, Color, and Texture of the Existing Landscape (p 152)	●			
6.2.8 Site Facilities in Areas Suitable for Reclamation (p 155)	●			
6.2.9 Minimize the Number of Facility Structures (p 156)	●			
6.2.10 Collocate Linear Features in Existing ROWs or Corridors (p 157)	●			
6.2.11 Avoid Siting Linear Features in the Centers of Valley Bottoms and on Ridgetops (p 158)	●			
6.2.12 Avoid Skylining (p 160)	●			

6.2 Siting and Design	Siting and Design	Construction	Operations	Decommissioning and Reclamation
6.2.13 Site Linear Facilities along Natural Lines within the Landscape (p 161)	●			
6.2.14 Avoid Siting Roads on Side Slopes and Ridge Faces (p 163)	●			
6.2.15 Site Facility Components to Minimize Cut and Fill (p 164)	●			
6.2.16 Avoid Siting Staging and Laydown Areas in Visually Sensitive Areas (p 166)		●		
6.2.17 Bury Underground Utilities along Roads (p 167)	●			

6.2.1 Site Facilities and ROWs outside Sensitive Viewsheds, or as Far as Possible from Sensitive Viewing Locations

Project Phase: Siting and Design

Facilities and ROWs should be sited outside the viewsheds of highly sensitive viewing locations, and/or areas with limited visual absorption capability and/or high scenic integrity. When facilities must be sited within view of visually sensitive areas, they should be sited as far away as possible. Where full screening of facility views is not possible, siting should take advantage of partial screening opportunities.

The Wedge Overlook—a KOP in the San Rafael Swell in BLM's Price Utah Field Office. (Credit: BLM.)

Notes

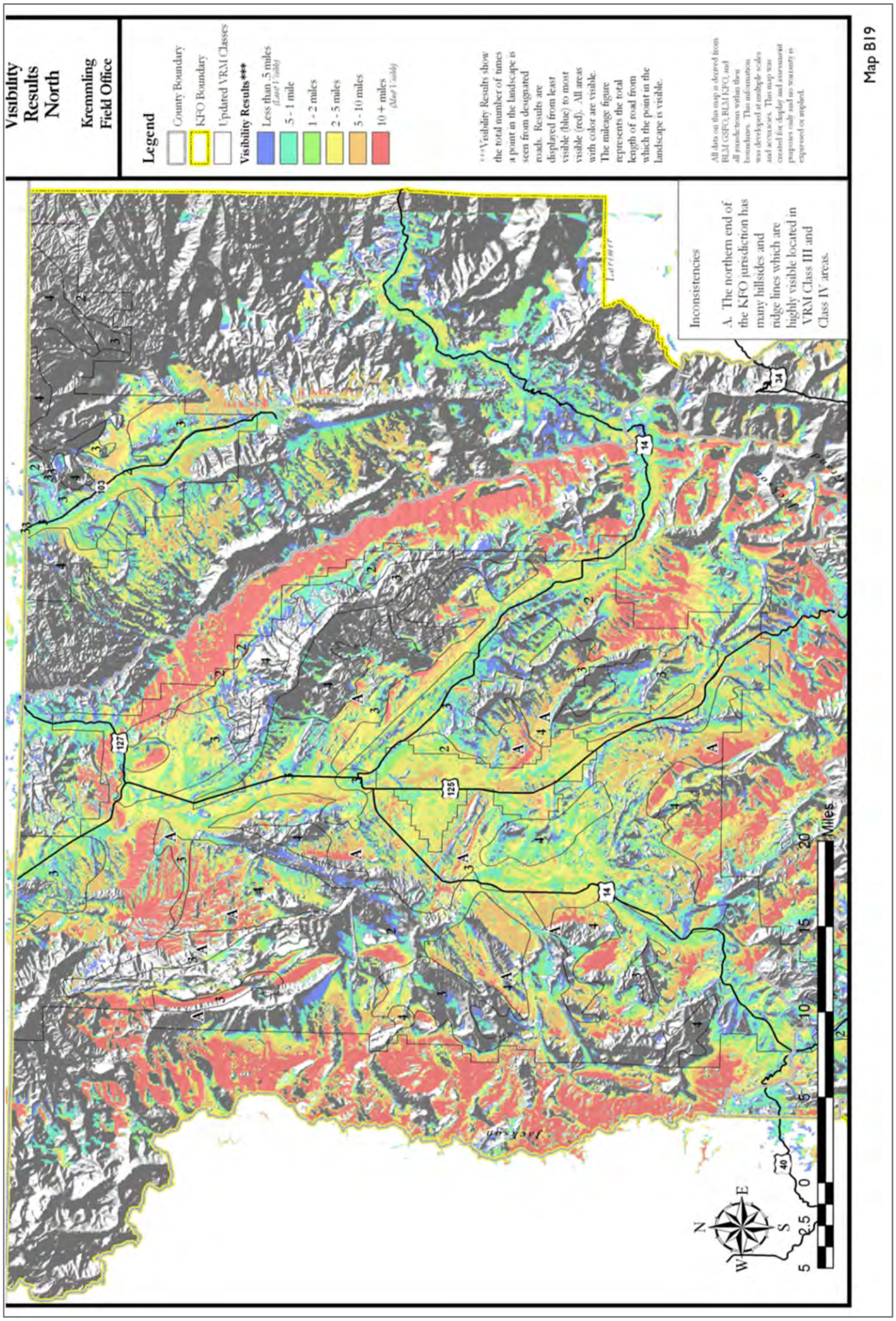
Siting should take advantage of both topography and vegetation to screen the views of projects or project elements from visually sensitive areas. For example, facility elements, including structures, roads, and ROWs, can be sited around bends, or behind ridges and vegetative screens. For projects with low vertical profiles, even slight undulations in topography can provide at least partial concealment. Visually complex landscape backdrops often provide opportunity for visual concealment. ROW location, size, and boundary determinations should consider terrain characteristics and opportunities for full or partial project concealment by recessing the project into the landscape terrain. Where the entire facility cannot be screened, partial screening is generally preferred, in order to reduce the apparent size and visual dominance of the visible elements.

Special consideration should be given when siting facilities within view of National Historic Trails and Sites (including sites eligible for Listing on the National Register of Historic Places), and tribal cultural resources, especially if the visual setting is important to the historic or cultural context and integrity of the area. A detailed visual analysis should be conducted, and stipulations, such as restrictions on surface disturbance, may be warranted. Population centers and highly sensitive scenic resources, including, but not limited to, units of the National Park Service, National Monuments, National Scenic Highways, and Wild and Scenic Rivers, should also be given special consideration, and every attempt should be made to avoid visual impacts on these areas, including consideration of alternative siting locations.

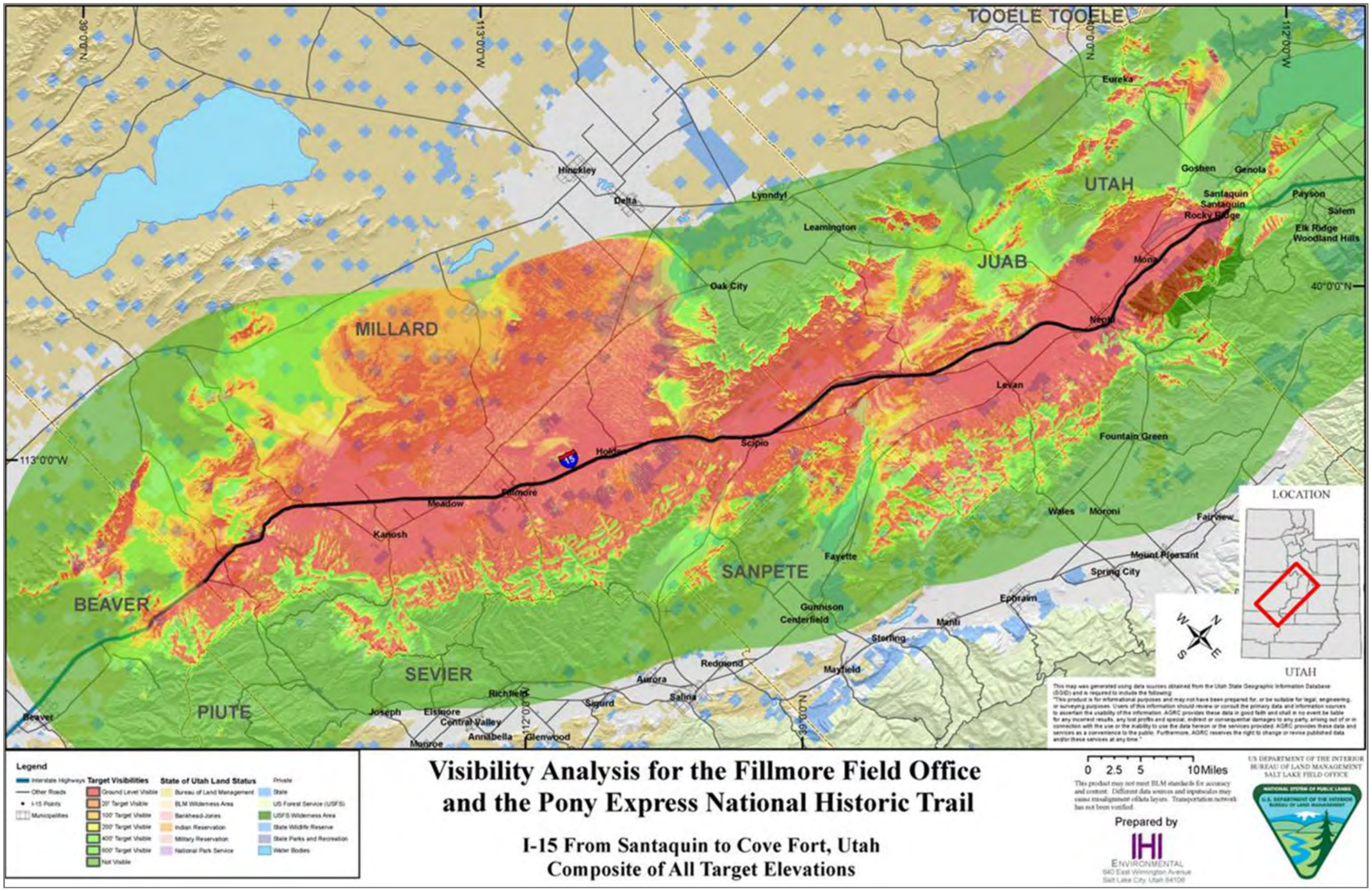
When facilities must be sited within view of visually sensitive areas, they should be sited as far away as possible, as visual impacts generally diminish as viewing distance increases. Where they occur, landscapes with low scenic integrity and/or high visual absorption capability are generally preferred as siting locations.

Limitations

Some BLM landscapes have low relief and lack vegetation tall enough to screen the taller elements of renewable energy facilities, particularly wind turbines, solar power tower receivers, plumes from boilers or cooling towers, and transmission lines and towers. The very large size of most renewable energy facilities may make complete screening of facility views difficult or impossible, especially for views from relatively close viewpoints.



Advanced viewshed analysis map for the road network in the BLM's Kremmling Field Office in Colorado. Roads are linear KOPs; the colored areas on the map indicate the length of road from which a given point in the landscape is visible, with red-tinted areas being the most visible, and blue areas the least visible (gray areas are not visible from the roads). From a visual impact standpoint, the red-tinted areas would generally be less optimal facility siting locations. (Credit: BLM.)

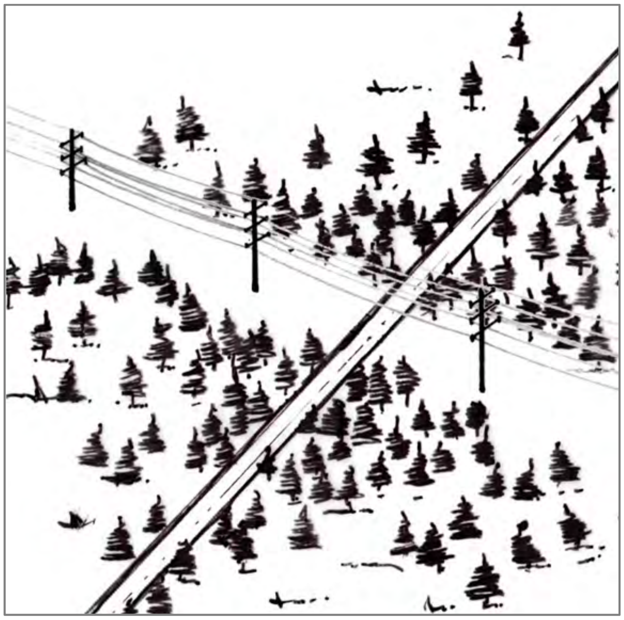


Advanced viewshed analysis map for a portion of the Pony Express Trail in the BLM's Filmore Field Office in Utah. The trail is a linear KOP; the colored areas on the map indicate how tall a structure could be at a given location and still be concealed from view at any point on the trail. In the red-tinted areas, any structure could be visible from the trail, while in the green areas, objects as tall as wind turbines would be concealed from the view on the trail by intervening topography. From a visual impact standpoint, the green-tinted areas would generally be more optimal facility siting locations. (Credit: BLM.)

6.2.2 Site ROW Crossings to Minimize Impacts on Linear KOPs

Project Phase: Siting and Design

Locations for right-of- way (ROW) crossings of roads, waterways, and other linear KOPs should be chosen to avoid the most visually sensitive points or segments along the linear KOP. Site crossings should be chosen to minimize duration of view for observers traveling on the linear KOP. ROWs should cross linear features at right angles whenever possible.



Crossing sensitive linear features at a right angle minimizes the visibility of facilities on the ROW for viewers traveling along the linear feature. (Credit: Lindsey Utter, Argonne National Laboratory.)

Notes

Crossings of ROWs (and associated facilities) with waterways, roads, trails and other features may attract visual attention because of strong visual contrasts in form, line, color, and texture, especially where they involve extensive vegetation clearing. They may become undesirable visual focal points in the landscape. ROW crossings of roads, waterways, and other linear features should be concealed or located as far as possible from the most visually sensitive points or segments on a linear KOP.

Where ROWs cross linear features (e.g., trails, roads, and rivers) at oblique angles, viewers traveling along the linear features may be subject to relatively long-duration views of facilities in the ROW, at relatively short distances. ROWs should cross linear features at right angles whenever possible to minimize the viewing area and duration. Avoid crossings in the middle of long, straight segments and at road intersections.

Road, trail, and waterway crossings often offer extended views down ROWs. Structures, roads, and other project elements should be set as far back as possible from road, trail, and waterway crossings, and vegetation should be used to screen views from crossings. Vegetative screening should mimic natural vegetative patterns (using native plants) and be made to blend with the natural form, line, color, and texture.

Limitations

Many technical, environmental, and economic factors must be considered in locating ROW crossings; these other considerations may outweigh potential visual impacts in the siting decision. Technical requirements may determine where structures are located along ROWs, and may dictate that structures or other project elements are sited near crossings. In these instances, vegetative screening may help to reduce negative visual contrasts, although adding new vegetation may itself cause undesirable visual contrasts.

6.2.3 Site Projects Away from Visually Prominent Landscape Features

Project Phase: Siting and Design

Avoid siting facilities near visually prominent landscape features that naturally draw an observer's attention. Do not site facilities so that they are visually aligned with prominent landscape features, as seen from KOPs.

Siting this windfarm directly in front of a prominent mountain ridge (as seen from this KOP) draws visual attention to the wind turbines. (Dunlap Ranch Wind Energy Project, Carbon County, Wyoming. Credit: Robert Sullivan, Argonne National Laboratory.)

Notes

Because the eye is naturally drawn to prominent landscape features (e.g., knobs and waterfalls), facilities and their components should be sited away from these features. Similarly, facilities should be sited so that they are away from the direct line of sight from a KOP to a prominent landscape feature. In some instances, landscape features to avoid could be manmade (e.g., bridges or dams).

Limitations

Siting facilities near or in line with prominent landscape features may be unavoidable in some circumstances, such as when there are multiple KOPs or multiple prominent landscape features, or when the only feasible location for a facility is near a landmark.

This prominent landmark would draw visual attention to any renewable energy facilities in its vicinity or along the line of sight between the viewer and the landmark. (Credit: BLM.)

6.2.4 Site Facilities to Avoid Night-Sky Impacts on Sensitive Locations

Project Phase: Siting and Design

Renewable energy facility siting should take into account the impacts of facility lighting on the night sky, and should avoid siting in areas where potential viewers are most sensitive to night-sky impacts.

Notes

Facility siting should consider the potential for night-sky impacts, because starry night skies free from glare and skyglow are a highly valued resource in many parts of the western United States, and night-sky tourism is an important economic activity in some areas. In addition, nocturnal wildlife can be adversely affected by outdoor lights. Research has shown that wind turbine lights may be visible for very long distances (more than 35 mi), and indirect lighting impacts such as skyglow (the scattering of light in the sky) may reduce night-sky quality at locations very distant from the light sources. Review of local Comprehensive Plans and stakeholder consultation are excellent ways to determine the importance of night skies to local residents, tourists, and other parties. See BMPs 6.5.1 through 6.5.7 for practices to reduce lighting impacts from renewable energy facilities.

Limitations

Economic considerations may sometimes preclude avoiding areas sensitive to night-sky impacts; however, there are many cost-effective ways to reduce the use of lighting at facilities and to use lighting equipment and practices that minimize night-sky impacts.

6.2.5 Site Facilities in Previously Developed or Disturbed Landscapes

Project Phase: Siting and Design

Facilities and facility components should be sited in already industrialized and developed landscapes.

Siting this windfarm in an already cluttered viewscape helps to reduce the effects of the additional contrasts from the wind turbines. In this view, the vertical lines of the turbines repeat the vertical lines of the utility poles in the foreground. (Seven Mile Hill Wind Farms, Carbon County, Wyoming. Credit: Robert Sullivan, Argonne National Laboratory.)

Notes

Where possible, developments should be sited in landscapes that have already been industrialized or disturbed, with due consideration for visual absorption capacity and possible cumulative effects.

Limitations

In some instances, siting a new facility in a previously developed landscape may exceed the landscape's visual absorption capability, and thereby create more negative impacts than siting the facility in an undeveloped area. In some instances, it could be more desirable to site a facility in an undeveloped area with few potential viewers than to increase cumulative visual impacts by adding a new facility near existing facilities in an area with many potential viewers or with high visual sensitivity.

6.2.6 Site Facilities and Components in Existing Clearings

Project Phase: Siting and Design

In forested areas or shrublands, site facilities and their components in existing clearings.

Clearings for two facilities are shown in this photograph. The one on the lower left is at the edge of an existing clearing. The clearing to the upper right is located in densely vegetated area. Both clearings create strong color contrasts, but the upper clearing creates stronger line and texture contrasts. (Credit: BLM.)

Notes

Because visual impacts are usually lessened when vegetation and ground disturbances are minimized, where possible in forested areas or shrublands, siting should take advantage of existing clearings to reduce vegetation clearing and ground disturbance.

Limitations

There may be other environmental or technical reasons to avoid siting facilities in a particular clearing.

6.2.7 Site and Design Facilities to Repeat the Form, Line, Color, and Texture of the Existing Landscape

Project Phase: Siting and Design

A careful study of the project site should be performed to identify appropriate colors and textures for materials; the siting and design of facilities, structures, roads, and other project elements should match and repeat the form, line, color, and texture of the existing landscape in accordance and compliance with the visual resource management (VRM) class objectives.

Despite the elevated viewpoint, at a viewing distance of almost 7 mi the low, flat, and visually simple forms, lines, color, and texture of the Solar Energy Generating Systems III-VII parabolic trough facilities blend in well with the broad flat expanse of the valley in which they are located. Note, however, how lines from ROW clearing focus views on the facilities. (Credit: Robert Sullivan, Argonne National Laboratory.)

Notes

Careful siting of facilities and facility components, along with good choices of materials and paints/coatings can, in some instances, substantially reduce the apparent visual contrast associated with renewable energy facilities through repetition of the form, line, color, and texture that occur in the natural landscape. Reflective surfaces should be coated with flat or low-reflectivity finishes where functional requirements permit.

In many BLM-administered lands, the landscape is strongly horizontal; it is dominated by the horizon line, which may be unbroken by the short vegetation that in many cases has only a few dominant, typically muted colors. These situations favor low, flat structures, with simple geometry and consistent, subdued coloring. Low-height solar collector arrays may blend well in these settings, particularly when KOPs are not significantly elevated with respect to the arrays. A line of distant wind turbines sited on level ground such that the hubs appear to be at a uniform height may also echo the strong horizon line and thereby be less conspicuous, particularly if the intervening landscape has some vertical elements such as fence posts or telephone poles.

At night, the elements of form and texture are generally absent; lights typically create strong color contrast, and sometimes line contrast if they are arranged in a row. Existing lights in the landscape can reduce the apparent contrast to a degree, and if the lights appear to be of uniform height they repeat the horizon line, if it is visible. This repetition may reduce the apparent contrast from the wind turbines.

Limitations

In landscapes with vegetation that varies by season, repetition of the existing vegetation color may reduce color contrast in one season but be very conspicuous in other seasons. Generally, the best approach is to match colors that routinely occur in the season of greatest use.

In some situations, glare from reflective surfaces may make them highly conspicuous, even if the actual surface color blends with colors in the existing landscape.

Because of their vertical towers and blade motion, and because the FAA effectively requires that wind turbines be white, current wind turbine designs do not generally repeat the form, line, color, and texture of typical BLM landscapes, although the presence of vertical elements in the existing landscape is helpful. At night, the synchronized red flashing lights of wind facilities are very unlikely to blend with the existing landscape.

Power tower receiver towers are generally single, strong vertical elements that will contrast strongly with the predominant horizon line. The brilliant white light of the receiver, visible during sunny daylight hours, presents a unique and strong color contrast that is generally very conspicuous, even at long distances.

The facility clearing in this view (at far right) mimics the organic shape of natural clearings, reducing form and line contrasts, and blends in well with the surrounding landscape. (Credit: BLM.)

Burying a pipeline. Slopes are contoured to approximate naturally occurring slopes. (Credit: Rob Sweeten, BLM.)

Pipeline ROW after revegetation. (Credit: Rob Sweeten, BLM.)

6.2.8 Site Facilities in Areas Suitable for Reclamation

Project Phase: Siting and Design

Facilities, structures, and roads should be sited in locations with stable soils and that are favorable for revegetation and reclamation/restoration.

Notes

Facilities, structures, and roads should be sited in stable soils and in areas favorable for revegetation and reclamation/restoration, in order to aid interim reclamation and to avoid visual contrasts associated with unreclaimed/restored sites after decommissioning. Hydrology should be carefully considered in siting operations to avoid erosion and to help assure successful revegetation.

Limitations

Many project sites may lack stable soils in areas where facility components must be located.

6.2.9 Minimize the Number of Facility Structures

Project Phase: Siting and Design

Design facilities to use the minimum number of structures.

Notes

Through site design, the number of permanent structures required should be minimized. Activities should be combined and carried out in one structure, or structures should be collocated to share pads, fences, access roads, and lighting. When the facility is not far from developed areas, some activities (e.g., storage of spare parts) could also take place at offsite locations. Where multiple structures are required, they should be clustered to the extent possible in order to decrease "sprawl;" reduce the visual footprint of associated infrastructure (e.g., roads and potentially fences and lighting); and to take advantage of the screening opportunities that closely spaced structures may provide.

The number of temporary structures (e.g., water tanks) should also be minimized; in some cases, these structures may be onsite for long periods of time.

Limitations

Safety and technical considerations will require separation of some project components.

6.2.10 Collocate Linear Features in Existing ROWs or Corridors

Project Phase: Siting and Design

Collocate linear features adjacent to existing ROWs or in designated utility corridors, rather than utilizing new ROWs.

Collocation of transmission lines generally reduces overall visual impacts. (Credit: BLM.)

Notes

To the extent possible, transmission lines, roads, and other extensive structures associated with renewable energy should be collocated within a corridor to utilize existing/shared ROWs, access and maintenance roads, and other infrastructure in order to reduce visual impacts associated with new construction. Collocation of linear features, such as transmission lines and pipelines, usually results in reduced visual contrast because of reduced vegetation clearing and road development. Where there are multiple ROWs, they should be located on the same side of the road, preserving open views of landscapes on the opposing side.

Limitations

Regulatory authorities may prohibit or restrict collocation of facilities within existing ROWs for safety or other reasons. Existing corridors may lack sufficient space for new facilities, or routing requirements may preclude using existing ROWs. There are potential technical interferences between certain utilities. Issues of liability and ROW access would also need to be addressed.

6.2.11 Avoid Siting Linear Features in the Centers of Valley Bottoms and on Ridgetops

Project Phase: Siting and Design

Site transmission lines and other linear features to avoid valley bottoms and ridgetops.

This ROW bisects several ridges, creating prominent strong lines for the eye to follow. (Credit: BLM.)

Notes

The eye follows strong natural lines in the landscape, and these lines and associated landforms can "focus" views on particular landscape features. For this reason, linear facilities associated with renewable energy projects, such as transmission line ROWs, should be sited to avoid running across the centers of valley bottoms, and to avoid ridgetop bisection (i.e., routing the ROWs perpendicular to and over ridgelines).

Limitations

Technical issues, land ownership patterns, cost, and various environmental factors generally dictate where ROWs are located. For example, in rugged canyons, valley bottoms may provide the only buildable land and be the only feasible, cost-effective route, especially if facilities are collocated in an existing ROW or corridor.

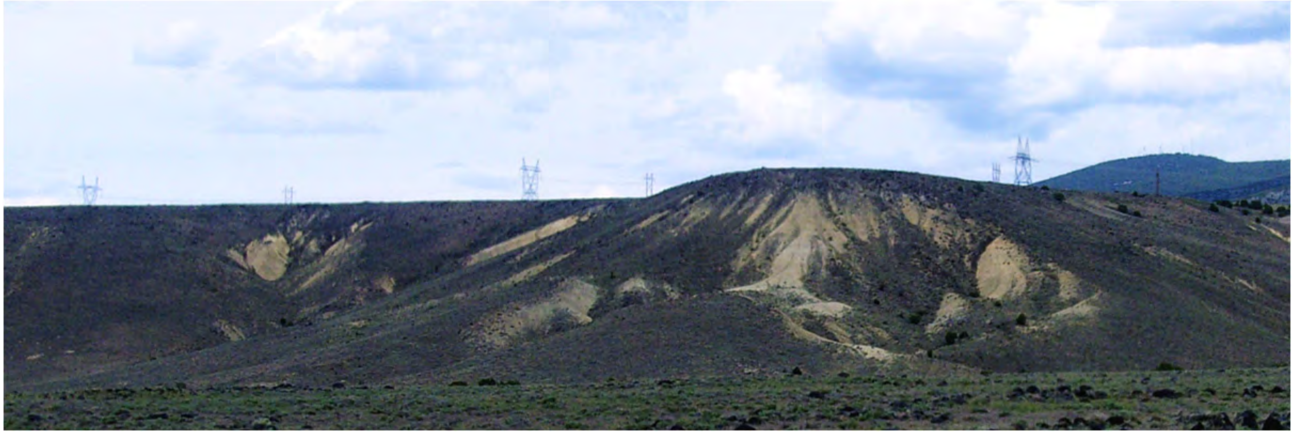
This ROW bisecting the ridgeline is conspicuously visible from any view aligned with the ROW. (Credit: BLM.)

This ROW crossing a valley floor is conspicuously visible from this elevated KOP. (Credit: BLM.)

6.2.12 Avoid Skylining

Project Phase: Siting and Design

"Skylining" of transmission/communication towers and other structures should be avoided.



Skylining of transmission lines makes them conspicuously visible against the sky backdrop. (Credit: BLM.)

Notes

Transmission/communication towers and other structures should not be placed on ridgelines, summits, or other locations where they would be silhouetted against the sky. Skylining draws visual attention to the project elements and can greatly increase visual contrast. Siting should take advantage of opportunities to use topography as a backdrop for views of facilities and structures to avoid skylining. Roads may be less visible if located along ridgetops, but if they are located on the ridge face they can be highly visible because of increased cut, fill, and side cast material.

Although wind turbines may sometimes be located near ridgelines, skylining of substations, transmission towers, communication towers, and other structures associated with wind developments should be avoided.

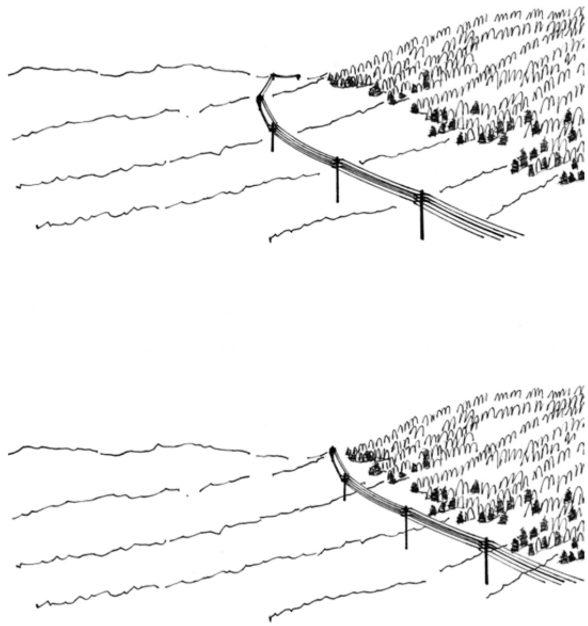
Limitations

Routing requirements generally dictate where ROWs are located, and this may result in skylining, especially if facilities are collocated in an existing ROW. Areas suitable for ROWs may be limited in rugged landscapes. There may be conflicts between avoiding skylining structures and siting facilities away from prominent landforms (e.g., conspicuous mountain ridges). If moving transmission tower sites results in greater span lengths, the use of more massive towers may be required to bear the increased weight loads.

6.2.13 Site Linear Facilities along Natural Lines within the Landscape

Project Phase: Siting and Design

Siting of facilities, especially linear facilities (e.g., transmission lines, pipelines, roads), should take advantage of natural lines within the landscape (e.g., natural breaks in the landscape topography, the edges of clearings, or transitions in vegetation). Siting of facilities on steep slopes should be avoided.



Siting transmission lines along natural vegetative breaks rather than through the middle of open areas can substantially reduce visual contrast. (Credit: Lindsey Utter, Argonne National Laboratory.)

Notes

Siting linear facilities along naturally occurring lines in the landscape can reduce apparent contrast through repetition of the line element or through combination of multiple line elements into a single line element. Facilities sited on steep slopes are often more visible (particularly if either the project or viewer is elevated); they may also be more susceptible to soil erosion, which could also contribute to negative visual impacts.

Limitations

Routing requirements may preclude following naturally occurring lines in the landscape. Ecological or cost considerations may make it infeasible to run a linear facility along the edge of a clearing or along an existing linear feature if it would add substantially to the length of the facility, or route it through difficult areas.

This road follows the undulating contours of the landform, making it less visually prominent. (Credit: John McCarty, BLM.)

6.2.14 Avoid Siting Roads on Side Slopes and Ridge Faces

Project Phase: Siting and Design

Avoid siting roads on steep side slopes and ridge faces. Site roads along ridgetops.

Siting this road on a side slope resulted in a large amount of fill that creates strong visual contrasts. (Credit: BLM.)

Notes

Siting of roads should avoid steep side slopes and ridge faces. Placing roads on steep side slopes and ridge faces can make them highly visible due to increased cut and fill, and especially side cast material. Where possible, site roads along ridgetops rather than side slopes and ridge faces. Siting roads along ridgetops helps to minimize cut and fill and avoids contrast created by side cast material. Truck excess fill offsite rather than side casting. If siting roads on steep slopes and ridge faces is unavoidable, use retaining walls to minimize excessive cut and fill, and create cuts and fills that match existing lines, forms, colors, and textures of the surrounding landscape as closely as possible. Minimize switchbacks by following the natural contours.

Limitations

Routing or other requirements may dictate that roads be sited on side slopes and ridge faces.

6.2.15 Site Facility Components to Minimize Cut and Fill

Project Phase: Siting and Design

Structures and roads should be designed and located to minimize cut and fill. Use retaining walls and bridges to reduce cut and fill.

Building this road on a steep side slope resulted in excessive and highly visible cut and fill. (Credit: BLM)

Notes

Minimizing cut and fill reduces vegetation and soil disturbance, which reduces associated visual contrasts; it also reduces the potential for erosion and dust that have negative visual impacts. Minimizing cut and fill also has substantial ecological benefits, and generally reduces cost. Retaining walls and bridges should be used to reduce cut and fill. Cuts and fills should match existing lines, forms, colors, and textures of the surrounding landscape as closely as possible.

Limitations

Site characteristics and project requirements may limit opportunities to minimize cut and fill. Retaining walls and bridges have their own potential visual impacts that must be considered.

This road follows natural contours, reducing the need for cut and fill. (Credit: BLM)

6.2.16 Avoid Siting Staging and Laydown Areas in Visually Sensitive Areas

Project Phase: Construction

Site staging areas and laydown areas outside the viewsheds of KOPs, and not in visually sensitive areas.

Staging area at Ivanpah Solar Energy Generating System power tower facility, Ivanpah Valley, California. (Credit: Robert Sullivan, Argonne National Laboratory.)

Notes

Staging areas and laydown areas should be sited outside the viewsheds of KOPs and not in visually sensitive areas; they should be sited in swales, around bends, and behind ridges and vegetative screens, where these screening opportunities exist. They should also be sited in already-disturbed areas, if possible.

Limitations

In open landscapes, siting staging areas and laydown areas outside the viewsheds of KOPs may be impossible because staging and laydown areas must be close to the project site. For example, wind turbine component staging areas are often in the immediate vicinity of the wind turbines.

6.2.17 Bury Underground Utilities along Roads

Project Phase: Siting and Design

Electrical collector lines, utility pipelines, and communication and other local utility cables should be buried where feasible, and should be sited along the edge of roads.

Burying a small pipeline. (Credit: BLM.)

Notes

Burying pipelines and utility cables will often substantially reduce line contrasts and reduce visual clutter. Underground utilities should be placed along the edge of roads in order to reduce surface disturbance.

Limitations

Technical and cost considerations may require siting utilities above ground and away from roads. In some wind facilities, pre-existing land uses may be allowed (e.g. agriculture, grazing), and any surface-disturbing uses must be considered if utilities are to be buried.

6.3 Structure Design and Material Selection

These BMPs address the selection and design of structures, landforms, and other materials to blend with the existing landscape setting.

6.3 Structure Design and Material Selection	Siting and Design	Construction	Operations	Decommissioning and Reclamation
6.3.1 Use Low-Profile Structures and Tanks (p 170)	●			
6.3.2 Custom Design Structures in Key Areas (p 172)	●			
6.3.3 Consider Use of Alternative Components (p 173)	●			
6.3.4 Use Natural-Looking Constructed Landform, Vegetative, or Architectural Screening (p 174)	●			
6.3.5 Minimize Use of Signs and Make Signs Visually Unobtrusive (p 176)	●			
6.3.6 Avoid Unnecessary Use of Gravel/Paved Surfaces (p 177)	●			
6.3.7 Use Rounded Road Cut Slopes (p 178)	●			
6.3.8 Use Monopole and Lattice Electric Transmission Towers Appropriately (p 179)	●			

6.3.1 Use Low-Profile Structures and Tanks

Project Phase: Siting and Design

Facility siting should incorporate measures to minimize the profile of all facility-related structures, particularly for facilities proposed within the foreground/middle-ground distance of sensitive viewing locations.

Low-profile tanks. (Credit: BLM.)

Horizontal tanks reduce tank height substantially. (Credit: John McCarty, BLM.)

Notes

The use of low-profile structures and tanks reduces their visibility and visual dominance within the viewshed. Partial burial of some ancillary structures may be possible, or underground tanks could be used preferentially for onsite fuel storage. Some buildings could occupy one story rather than two, resulting in substantial height reductions. Mechanical draft cooling towers could be employed rather than the much taller natural draft cooling towers.

Limitations

Functional requirements may dictate the height of some structures, such as wind turbines, power towers, and solar power block structures containing steam turbine generators. Burial of facility components will increase site development costs and may increase the difficulty and cost of inspection and maintenance. Using low-profile structures may increase the amount of disturbed land and vegetation, so a tradeoff decision must be made.

Partially buried tanks. (Credit: John McCarty, BLM.)

6.3.2 Custom Design Structures in Key Areas

Project Phase: Siting and Design

Custom-designed structures should be used in key areas when such designs would soften the visual impact and blend more effectively with the surroundings.

Notes

Massing and scale of structures should be considered, as should the architectural character appropriate to the region where a facility is to be located. Architectural considerations should include integration of vertical and horizontal relief variation to create shadow lines that diminish the overall visual scale and dominance of facilities.

Limitations

The ability of a structure to blend in with the surrounding landscape or to reflect architectural character appropriate to the region may be constrained by functional requirements of the structure.

6.3.3 Consider Use of Alternative Components]

Project Phase: Siting and Design

Alternate technologies that would serve the same function and simultaneously reduce visual impact should be explored by project designers.

Notes

Where visual impacts are an important concern, project designers should explore opportunities to substitute facility components that are similar in functionality, but less likely to cause negative visual impacts than the components that would normally be employed.

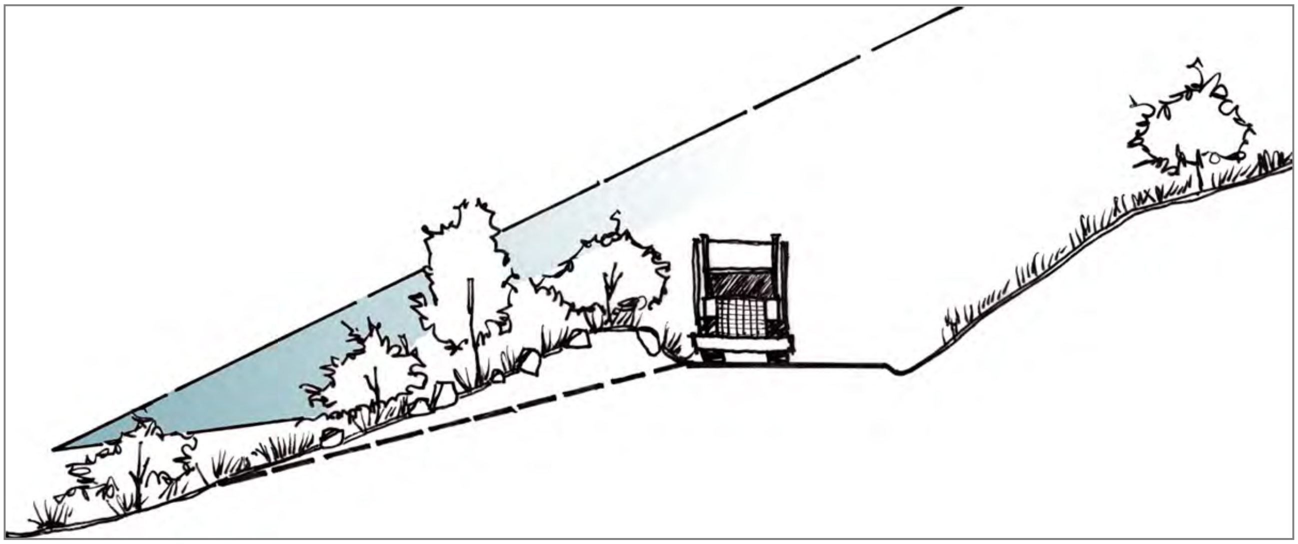
Limitations

Functional limitations or available technology may limit opportunities for using alternative components. Functional components of facilities are not typically selected based on visual impact considerations. Some alternative technologies might involve increased cost or decreased efficiency (e.g., mechanical draft versus natural draft cooling towers), and a tradeoff decision would be required.

6.3.4 Use Natural-Looking Constructed Landform, Vegetative, or Architectural Screening

Project Phase: **Siting and Design**

Where screening topography and vegetation are absent, natural-looking constructed landforms and vegetative or architectural screening should be used to minimize visual impacts.



Constructed landform and vegetation used to screen road cut. (Credit: Lindsey Utter, Argonne National Laboratory.)

Notes

Constructed landforms, or vegetative or architectural screening may conceal visual clutter, glare, and other visual impacts associated with a project. The shape and height of constructed landforms must be adapted to the surrounding landscape, and must consider the distance and viewing angle from KOPs in order to ensure that the earthworks are visually unobtrusive. Conventional berms do not conform to the natural contours of the landscape, and may introduce strong contrasts in form and line. Selection of the vegetative screening plant species should be addressed in the project's vegetation management plan, and should be consistent with restrictions in the relevant RMP.

Limitations

Depending on the landscape setting, constructing natural-appearing landforms may involve additional surface disturbance. Vegetative or architectural screening may not fit well with the surrounding landscape, potentially creating negative visual contrasts. Screening may be insufficient to screen taller project elements, or could potentially screen solar collectors or disrupt wind flow at wind facilities. Vegetative screening could increase fire risk by introducing an additional fuel source.

6.3.5 Minimize Use of Signs and Make Signs Visually Unobtrusive

Project Phase: Siting and Design

The use of permanent signs and project construction signs should be minimized. Beyond those required for basic facility and company identification for safety, navigation, and delivery purposes, commercial symbols or signs and associated lighting on buildings and other structures should be minimized.

All commercial symbols and signs and associated lighting should be designed to minimize offsite visibility. Necessary signs should be made of non-glare materials and utilize unobtrusive colors. The reverse sides of signs and mounts should be painted or coated using the most suitable color selected from the BLM Standard Environmental Color Chart CC-001 (see BMP 6.4.6) to reduce contrasts with the existing landscape.

Notes

Unnecessary signs, especially poorly designed commercial signs, may introduce strong color contrasts and seem out of place in more natural-appearing landscapes. Signs should be architecturally pleasing, and designed and placed to contribute to the visual quality of the facility entrance. The fronts and the backs of signs, as well as the mounts, are potential sources of glinting and glare when sunlit.

Limitations

Placement and design of any signs required by safety regulations must conform to regulatory requirements.

6.3.6 Avoid Unnecessary Use of Gravel/Paved Surfaces

Project Phase: Siting and Design

Installation of gravel and pavement should be avoided to reduce color and texture contrasts with the existing landscape.

Notes

Avoiding unnecessary use of gravel or paved surfaces reduces visual contrast, reduces decommissioning effort and cost, and may provide other ecological benefits, such as better drainage, and preservation of vegetation and animal habitat. It should be noted that in some settings, certain gravels may blend well with the colors and textures of the surrounding natural landscape.

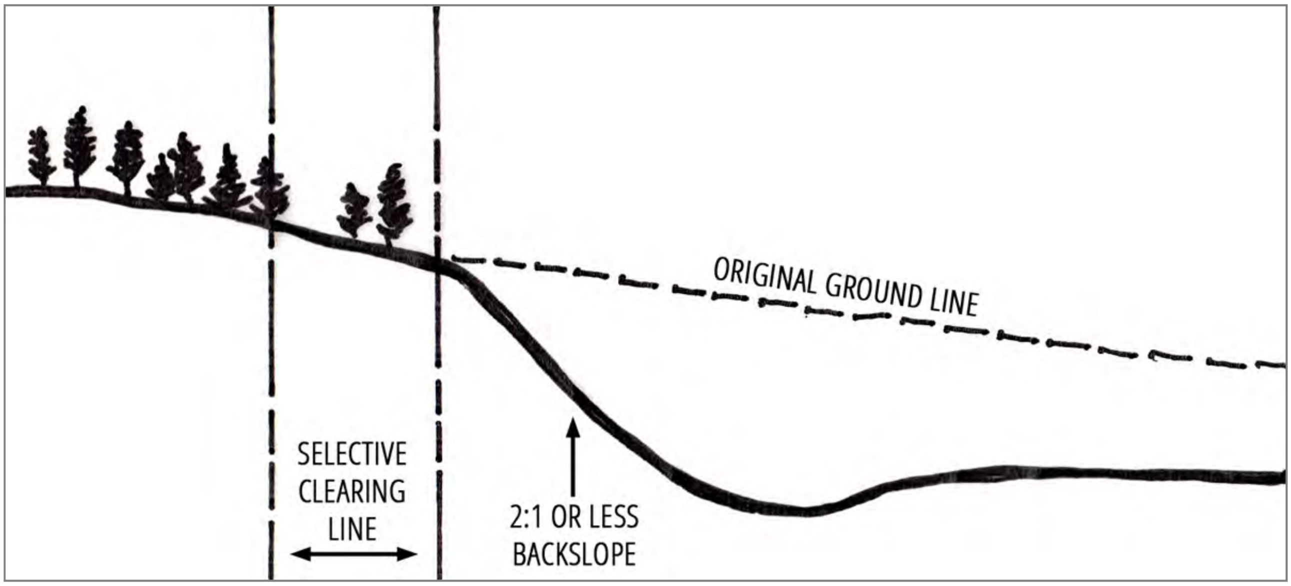
Limitations

Anticipated traffic and loads may require gravel or paved surfaces and roads, especially during construction and decommissioning.

6.3.7 Use Rounded Road Cut Slopes

Project Phase: Siting and Design

Road cut slopes should be rounded, and the cut-and-fill pitch should be varied to reduce contrasts in form and line; the slope should be varied as needed to preserve specimen trees and nonhazardous rock outcroppings where feasible.



Rounded road cut slopes with varied cut-and-fill pitch and that retain specimen trees and rock outcroppings have a more natural appearance than V-shaped or U-shaped cuts and ditches with uniform cut-and-fill pitch.

Notes

The geometry of road cut and ditch design should consider visual objectives; rounded slopes are preferred to V-shaped and U-shaped cuts and ditches. The preservation of specimen trees and nonhazardous rock outcroppings can reduce the strong visual contrasts from road cuts considerably.

Limitations

Site considerations may limit road cut designs in some locations. Safety requirements may preclude preservation of specimen trees and rock outcroppings that encroach on the ROW.

6.3.8 Use Monopole, Guyed, and Lattice Electric Transmission Towers Appropriately

Project Phase: Siting and Design

Consideration should be given to the appropriate choice of monopoles versus guyed or lattice towers for a given landscape setting.

Lattice and monopole towers near solar facility. Lattice towers are generally less visible than monopoles against landscape backdrops. (Credit: Robert Sullivan, Argonne National Laboratory.)

Notes

Lattice or guyed towers are less visually obtrusive on the rural landscape than monopoles, especially when placed half a mile or more from KOPs and against a landscape backdrop. When transmission towers are placed within a half mile or less from KOPs, then monopoles will occupy a smaller field of view than lattice towers. Monopoles are often more appropriate within built or partially built environments, while lattice or guyed towers tend to be more appropriate for less-developed rural landscapes, where the latticework would be more transparent against natural background textures and colors.

Where transmission facilities are to be collocated in ROWs or corridors, and the existing ROW or corridor has either lattice towers only, guyed towers only, or monopoles only, the same tower type should be selected for new transmission facilities within the ROW/corridor.

Limitations

A variety of important technical considerations affect the decision to use monopole or lattice transmission towers. These usually outweigh visual considerations.

6.4 Materials Surface Treatments

These BMPs address the selection of appropriate colors and surface treatments for structures to reduce color contrast with the surrounding natural environment.

6.4 Materials Surface Treatments	Siting and Design	Construction	Operations	Decommissioning and Reclamation
6.4.1 Require a Site Study for Color and Texture Selection (p 183)	●			
6.4.2 Select Materials and Surface Treatments to Repeat the Form, Line, Color, and Texture of Surrounding Landscape (p 185)	●			
6.4.3 Consider Seasonal Changes and Seasons of Heaviest Use in Choosing Material Colors and Textures (p 187)	●			
6.4.4 Color Treat Structures to Reduce Contrasts with Existing Landscape (p 189)	●			
6.4.5 Use Non-reflective Materials, Coatings, and/or Paint (p 191)	●			
6.4.6 Select Surface Treatment Colors from the BLM Standard Environmental Colors Chart (p 193)	●			
6.4.7 Test Color Selections (p 195)	●			
6.4.8 Color Treat Grouped Structures Using the Same Color (p 197)	●			
6.4.9 Color Treat Exposed Rock Faces (p 200)		●		
6.4.10 Color Treat Transmission Towers to Reduce Contrasts with Existing Landscape (p 201)	●			
6.4.11 Use Camouflage and/or Disguise Strategies for Close KOPs in Highly Sensitive Viewsheds (p 205)	●			

6.4 Materials Surface Treatments	Siting and Design	Construction	Operations	Decommissioning and Reclamation
6.4.12 Maintain Painted, Stained, or Coated Surfaces Properly (p 206)			●	

6.4.1 Require a Site Study for Color and Texture Selection

Project Phase: Siting and Design

A careful study of the site should be performed to identify appropriate colors and textures for facility structures. The choice of colors should be based on the appearance at typical viewing distances and consider the entire landscape around the proposed development.


A BLM landscape with a wide variety of colors and textures. (Credit: BLM.)

Notes

Visual contrast of project elements can be substantially reduced in many cases by choosing appropriate colors for any structures that can be painted, stained, or otherwise coated to reduce their visibility, and that have surface textures compatible with the surrounding landscape. Color choices should be made only after carefully considering the existing colors and textures in the broader landscape around the project, as seen from typical viewing distances, and preferably from project KOPs. Because even within a region the predominant landscape colors may vary widely from site to site, the choice of appropriate colors and textures for facility structures should be based on an onsite assessment of the proposed project site, rather than on assumptions about appropriate colors and textures for the region as a whole.

Limitations

Some structures may have functional requirements that preclude painting, staining, or coating (such as solar collectors); safety considerations that dictate high-contrast colors (such as white wind turbines); or other relevant environmental considerations (e.g., electric transmission conductor visibility to birds; see BMP 6.4.10). Other structures have paint color schemes dictated by state or local laws.

A typical BLM landscape with relatively little variety of form, line, color, and texture. (Credit: BLM.)

6.4.2 Select Materials and Surface Treatments to Repeat the Form, Line, Color, and Texture of Surrounding Landscape

Project Phase: Siting and Design

Materials and surface treatments for structures and roads should repeat and/or blend with the existing form, line, color, and texture of the surrounding landscape. For example, if the project will be viewed against an earthen or other non-sky background, appropriately colored materials should be selected to help blend structures with the project's backdrop. Where appropriate, roads should be surfaced with material compatible in color with the local environment.

This color-treated monopole transmission tower repeats the line and color of the surrounding vegetation effectively, even at a short viewing distance. Only the horizontal line contrast from reflections of sunlight on the upper sides of the crossbars stands out from the background. (Credit: John McCarty, BLM.)

Notes

Choosing materials and surface treatments to repeat and/or blend with the form, line, color, and texture of the surrounding landscape reduces the visual contrast of project elements with their backdrop, thereby reducing visibility and lowering potential impact. Appropriate colors for smooth surfaces often need to be two to three shades darker than the background color to compensate for shadows that darken most textured natural surfaces. In some instances, successful blending of project elements with the surrounding landscape can render the project elements nearly invisible to casual observers.

Limitations

Some structures may have functional requirements that preclude painting, staining, or coating; safety considerations that dictate high-contrast colors; or other relevant environmental considerations. Other structures have paint color schemes dictated by state or local laws.

6.4.3 Consider Seasonal Changes and Seasons of Heaviest Use in Choosing Material Colors and Textures

Project Phase: Siting and Design

The identification of appropriate colors and textures for facility materials should take into account both summer and winter appearance, as well as seasons of peak visitor use.

The muted greens of the structures at this facility are not conspicuous when viewed against the fall coloration of nearby foliage. (Credit: BLM.)

Notes

In landscapes with vegetation colors and textures that vary markedly by season, and/or are subject to significant snow cover, the identification of colors and textures for facility materials should normally favor those colors and textures that are present during periods of peak visitor use.

Limitations

The colors and textures of materials may be limited by technical or other (e.g., safety) considerations.

6.4.4 Color Treat Structures to Reduce Contrasts with Existing Landscape

Project Phase: Siting and Design

Unless safety or functional requirements preclude it, all structures, including but not limited to buildings, tanks, fences and railing, poles, aboveground pipes and culverts, and reverse sides of signs and guardrails, should be color treated to reduce contrasts with existing landscape, using the most suitable color selected from the BLM Standard Environmental Color Chart CC-001 (see BMP 6.4.6).

This untreated galvanized structure contrasts strongly with its surroundings and is also a potential source of strong glare. (Credit: BLM.)

Notes

A key visual impact mitigation method is to paint, stain, or coat any surfaces of facility structures that could be a source of color contrast with the surrounding landscape. Even small surfaces such as the backs of road signs can create noticeable color contrasts, and many of these contrasts can easily be reduced through the application of a suitable paint, stain, or other coating that is carefully selected to blend effectively with surrounding landscape elements.

These structures have been painted with a BLM standard environmental color, and are difficult to distinguish from the surrounding vegetation. (Credit: John McCarty, BLM.)

Limitations

Some structures may have functional requirements that preclude painting, staining, or coating; safety considerations that dictate high-contrast colors; or other relevant environmental considerations. Other structures have paint color schemes dictated by state or local laws.

This high-profile white tank contrasts strongly with its surroundings. A low-profile color-treated tank would produce much lower contrasts. (Credit: BLM.)

This structure has been painted with a BLM standard environmental color to reduce visual contrasts with the surrounding vegetation. (Credit: BLM.)

The white backs of the road signs contrast strongly with the backdrop. Painting the backs of the signs could have easily avoided the strong color contrasts. (Credit: BLM.)

The reverse side of the sign at lower right has been painted to reduce potential glare and to blend with the surrounding landscape. Lower color contrast could have been achieved through a better color choice. (Credit: BLM.)

6.4.5 Use Non-reflective Materials, Coatings, and/or Paint

Project Phase: Siting and Design

Materials, coatings, or paints that have little or no reflectivity should be used on structures including, but not limited to, buildings, tanks, fences and railing, poles, aboveground pipes and culverts, and reverse sides of signs and guardrails. Semi-gloss finishes should be used rather than flat or gloss finishes. Substation equipment should be specified with a low-reflectivity, neutral finish. Insulators at substations and on takeoff equipment should be non-reflective and non-refractive. The surfaces of substation structures should be given low-reflectivity finishes with neutral colors to minimize the contrast of the structures with their backdrops. Chain-link fences surrounding the substations should have a dulled, darkened finish to reduce contrast.

Reflected light from surfaces of just a few square inches of uncoated metal repeated on thousands of solar panel mounting structures creates an arresting high-contrast visual display. (Credit: Robert Sullivan, Argonne National Laboratory.)

Notes

Even very small surfaces such as the backs of road signs or fence rails can create noticeable glinting, or even glare that is visible for very long distances, particularly in the clean, dry air and strong sunlight of the western states. The application of non-reflective or low-reflectivity surface treatments can greatly reduce the occurrence of glinting and glare, but it is important to treat every surface that feasibly can be treated. Treatments should not be limited to metal or "silvered" surfaces; research has shown that almost any smooth surface, regardless of material type or color (even black) may cause glinting and glare in certain lighting conditions and viewing angles.

White power conversion units (inverters) at thin-film PV facility contrast strongly with vegetative backdrop. (Credit: Robert Sullivan, Argonne National Laboratory.)

Limitations

Some structures may have functional requirements that preclude the use of non-reflective or low-reflectivity surface treatments.

The power conversion units (inverters) at this thin-film PV facility were painted to match the vegetative background, greatly reducing the color contrast, and are difficult to see. Note however, how conspicuous the white monopole transmission towers are against the mountain backdrop. (Credit: Robert Sullivan, Argonne National Laboratory.)

6.4.6 Select Surface Treatment Colors from the BLM Standard Environmental Colors Chart

Project Phase: Siting and Design

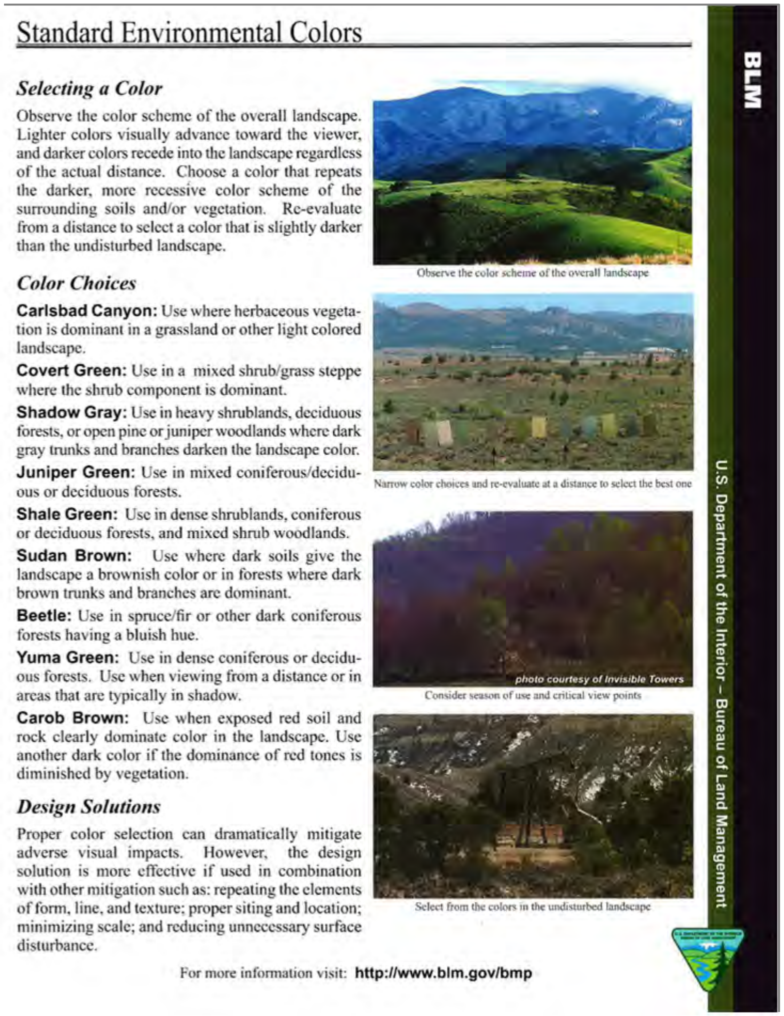
Colors for paints, stains, coatings, and other surface color treatments to be used on structures should be selected from the BLM Standard Environmental Colors Chart.

Notes

The BLM Standard Environmental Colors Chart CC-001 provides nine standard color choices for use in selecting the most appropriate color(s) for facilities located on lands managed by the BLM. The nine colors on the chart are those that were found to be the most effective in reducing color contrast within the various landscape settings that make up the BLM-administered lands. The instructions on the CC-001 Color Chart should be followed carefully. As a rule of thumb, selected colors should be darker than the background colors to account for natural shadows, normal fading, and weathering. Lighter colors should be avoided. Holding the color chart up to the background from a distance and squinting may help in identifying the predominant background color. The chart also includes a description of various vegetated backgrounds and colors that are typically best suited for use in those backgrounds.

Limitations

Pre-fabricated materials may not be available in colors used on the BLM Standard Environmental Colors Chart. Exact color matching of the manufactured paint, stain, or coating with the desired color may be difficult. Safety considerations may require use of particular colors not found on the Standard Environmental Colors Chart.


Standard Environmental Colors

BLM

U.S. Department of the Interior – Bureau of Land Management

Selecting a Color

Observe the color scheme of the overall landscape. Lighter colors visually advance toward the viewer, and darker colors recede into the landscape regardless of the actual distance. Choose a color that repeats the darker, more recessive color scheme of the surrounding soils and/or vegetation. Re-evaluate from a distance to select a color that is slightly darker than the undisturbed landscape.

Color Choices

Carlsbad Canyon: Use where herbaceous vegetation is dominant in a grassland or other light colored landscape.

Covert Green: Use in a mixed shrub/grass steppe where the shrub component is dominant.

Shadow Gray: Use in heavy shrublands, deciduous forests, or open pine or juniper woodlands where dark gray trunks and branches darken the landscape color.

Juniper Green: Use in mixed coniferous/deciduous or deciduous forests.

Shale Green: Use in dense shrublands, coniferous or deciduous forests, and mixed shrub woodlands.

Sudan Brown: Use where dark soils give the landscape a brownish color or in forests where dark brown trunks and branches are dominant.

Beetle: Use in spruce/fir or other dark coniferous forests having a bluish hue.

Yuma Green: Use in dense coniferous or deciduous forests. Use when viewing from a distance or in areas that are typically in shadow.

Carob Brown: Use when exposed red soil and rock clearly dominate color in the landscape. Use another dark color if the dominance of red tones is diminished by vegetation.

Design Solutions

Proper color selection can dramatically mitigate adverse visual impacts. However, the design solution is more effective if used in combination with other mitigation such as: repeating the elements of form, line, and texture; proper siting and location; minimizing scale; and reducing unnecessary surface disturbance.

Observe the color scheme of the overall landscape

Narrow color choices and re-evaluate at a distance to select the best one

photo courtesy of Invisible Towers

Consider season of use and critical view points

Select from the colors in the undisturbed landscape

For more information visit: **http://www.blm.gov/bmp**

BLM Standard Environmental Color Chart CC-001, front, with color choice descriptions. (Credit: BLM.)


Standard Environmental Colors

Carlsbad Canyon

Covert Green

Shadow Gray

Juniper Green

Shale Green

Sudan Brown

Beetle

Yuma Green

Carob Brown

The **Standard Environmental Colors** chart was developed to assist with color selection to minimize the visual contrast of a facility in the landscape.

In order to ensure color accuracy, use an original color chart to match paint. When matching the color chip, request the paint company to have their computer scan set on "natural light." Compare the new paint sample to the color chip under indirect natural sunlight. Use semi-gloss paint, where appropriate, to enhance durability yet reduce reflectivity. Select colors a shade or two darker than the surrounding landscape to account for natural shadows, normal fading, and weathering.

Order **Standard Environmental Colors** charts by emailing your request to: Printed Material Distribution System (PMDS), **BLM_NOC_PMDS@blm.gov** or fax to 303-236-0845. Provide the quantity requested along with a contact name, physical address (no P.O. Boxes), and telephone number. For more information or questions, please call 202-785-6574.

Standard Environmental Color Chart CC-001: June 2008

BLM/WY/ST-08/015+8450

BLM Standard Environmental Color Chart CC-001, back, with color chips and instructions. (Credit: BLM.)

6.4.7 Test Color Selections

Project Phase: Siting and Design

Color choices should be tested experimentally under field conditions by applying actual paint on equipment. Observations should be made from key observation points (KOPs) under different lighting conditions during the prime visitor use season.

BLM standard environmental color panels are used to identify the best match between facility colors and the surrounding landscape. (Credit: BLM.)

Notes

Color choices should be tested in the field before large-scale implementation. Original color choices may reflect temporary lighting conditions or temporary vegetative color variations, and sample paint chips may not always accurately reflect the color used in production. It is important to assess the color choices as they would be seen from KOPs, because different distances and viewing angles may change the apparent color and the degree of effective blending with the backdrop.

Tanks painted with two BLM standard environmental colors. The darker color is a better match for this landscape. (Credit: BLM.)

6.4.8 Color Treat Grouped Structures Using the Same Color

Project Phase: Siting and Design

Grouped structures should be color treated using the same color to reduce visual complexity and color contrast.

These grouped structures have been painted a variety of colors that do not match each other. (Credit: BLM.)

These grouped structures have been painted the same color to reduce visual contrasts with each other and with the surrounding vegetation. (Credit: BLM.)

Notes

Choosing the same color for grouped structures avoids strong color contrasts that can attract and hold visual attention, and promotes the idea that the facility was carefully planned and designed to fit into the surrounding landscape.

Limitations

Some structures may have functional requirements that preclude painting, staining, coating, or other color treatments; safety considerations that dictate high-contrast colors; or other relevant environmental considerations. Other structures have paint color schemes dictated by state or local laws.

These structures have been painted the same color to reduce visual contrasts with each other and with the surrounding landscape. (Credit: BLM.)

Photograph of existing infrastructure at a geothermal plant, and a photosimulation showing the beneficial effects of painting facility components to reduce color contrasts with existing landscape (BMP 6.4.4), using the most suitable color selected from the BLM Standard Environmental Color Chart (BMP 6.4.6), and painting grouped structures the same color (BMP 6.4.8). The chosen color (Shadow Gray) is darker than the background color to compensate for shadows that darken most textured natural surfaces (BMP 6.4.2), and is a good match for both the creosote bush vegetation and the existing gray transmission towers. (Credit: Argonne National Laboratory).

6.4.9 Color Treat Exposed Rock Faces

Project Phase: Construction

The color contrast resulting from the exposure of unweathered rock on excavated rock faces should be removed by color treating with an oxidizing color treatment.

Application of oxidizing color treatment on excavated rock face. (Credit: Craig Johnson, Logan Simpson Design, Inc.)

Notes

Oxidizing color treatments can accelerate natural weathering processes to restore the natural appearance of rock faces. Available chemicals include pH-neutral products that can be applied in a single application without protective gear, and that do not harm vegetation or wildlife. Some color treaments can be applied to a wide variety of materials, such as galvanized metal.

Limitations

In areas with loose, scaling rock, untreated rock surfaces may become exposed after rock stain treatment, thereby causing strong color contrasts.

6.4.10 Color Treat Transmission Towers to Reduce Contrasts with Existing Landscape

Project Phase: Siting and Design

Electric transmission towers should be color treated to reduce contrasts with the existing landscape. Monopole towers should have a low-reflectivity treatment in the most suitable color selected from the BLM Standard Environmental Color Chart CC-001. Lattice towers should receive a non-specular treatment, typically a darkened gray color. Where transmission facilities using monopole towers are located within the same ROW or corridor, the color treatment should match the existing facilities within the ROW, unless they contrast with the visual backdrop. Electricity transmission facilities should utilize non-specular conductors and non-reflective coatings on insulators.

Glare from untreated galvanized guyed lattice transmission towers in low-angle sunlight. (Credit: BLM.)

Notes

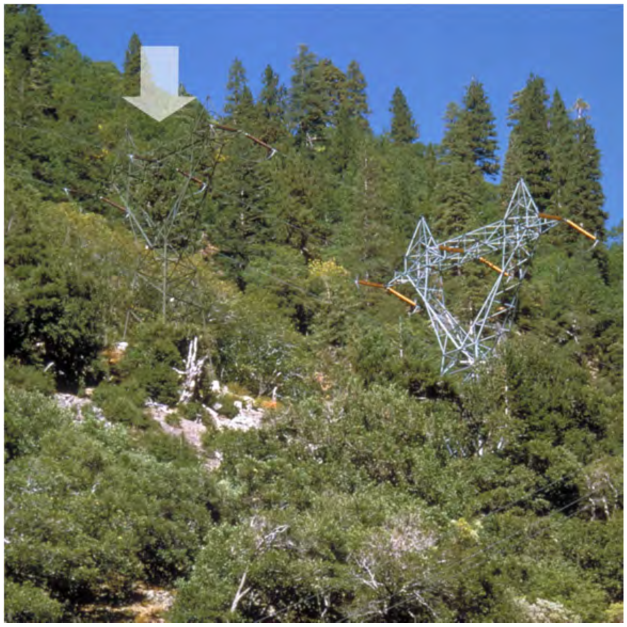
The large height, size, and solid form of monopoles combined with the strong vertical line contrasts they introduce into landscapes makes the use of appropriate color treatment particularly important for projects where monopole transmission towers are used. The solid surfaces of monopoles can be highly reflective if the surfaces are light in color and do not employ low-reflectivity coatings. The use of untreated galvanized monopoles should be avoided in all circumstances. White monopole towers should also be avoided. Weathering steel structures (e.g., COR-TEN) are preferable to untreated galvanized or white towers, but are best suited to a limited range of high-relief landscapes with minimal vegetation, where the predominant natural colors range from reds to darker browns. Lattice transmission towers are typically less visible in the landscape than monopoles, especially at longer distances, and in some instances can be rendered nearly invisible by surface treatment that darkens their color and lowers their reflectivity.

Untreated galvanized monopole transmission towers (left) and lattice towers (right). Note monopole crossbar reflectivity even in distant background, and greater visual weight of monopoles beyond the immediate foreground. (Credit: Robert Sullivan, Argonne National Laboratory.)

Limitations

In some sensitive locations, particularly in important bird migration pathways, flight paths, or concentrated use areas (e.g., wetlands, aquatic habitats, or rookeries), coordination between resource specialists should identify and resolve potential conflicts regarding conductor visibility, wildlife impacts, and conformance to VRM objectives.

Weathered lattice tower and white monopole. An additional lattice tower is visible in the background to the left of the large lattice tower. (Credit: Robert Sullivan, Argonne National Laboratory.)



The color-treated lattice tower to the upper left of the untreated tower blends in very well with the surrounding landscape, and could easily be missed by a casual viewer. (Credit: John McCarty, BLM.)

COR-TEN monopole in a high-relief landscape with minimal vegetation, and where the predominant natural color is red. (Credit: John McCarty,BLM.)

Color-treated monopole towers blend in well with the surrounding landscape, resulting in substantially lower visual contrast. (Credit: BLM.)

Failure to employ non-specular conductors for this transmission line result in high visual contrast in sunny conditions. (Credit: Robert Sullivan, Argonne National Laboratory.)

6.4.11 Use Camouflage and/or Disguise Strategies for Close KOPs in Highly Sensitive Viewsheds

Project Phase: Siting and Design

Color camouflage technology applications and/or disguise strategies should be considered for structures within sensitive viewsheds and with visibility distance between 0.25 and 2 mi. BLM guidance on the use of color to mitigate visual impacts should be consulted.

Color camouflage application on tank. (Credit: BLM.)

Notes

In certain situations where project elements must be sited within close proximity to highly sensitive viewpoints, color camouflage technology applications and/or disguise strategies can be used to reduce visibility and visual contrast.

Limitations

The BLM has tested camouflage technology applications and disguise for certain structures. This research has shown that camouflage technology applications and disguise strategies are only effective in certain circumstances, and are most effective at viewing distances between 0.25 and 0.75 mi.

6.4.12 Maintain Painted, Stained, or Coated Surfaces Properly

Project Phase: Operations

Painted, stained, or coated surfaces should be kept in good repair, and the surface treatment should be reapplied when necessary, as the surface color fades or the coating flakes or otherwise deteriorates.

Notes

The contrast reduction effectiveness of surface treatments depends of the condition of the surface treatment. If the surface color fades too much, color contrast may increase. If the surface coating flakes, the underlying structure's surface may be exposed, potentially increasing contrast and causing glinting or glare. Damaged surface coatings may also make the facility look unkempt or poorly maintained.

Limitations

Some coatings may be difficult to apply in field settings.

6.5 Lighting

These BMPs help ensure that projects minimize night-sky impacts through proper lighting design and usage.

6.5 Lighting	Siting and Design	Construction	Operations	Decommissioning and Reclamation
6.5.1 Prepare a Lighting Plan (p 208)	●			
6.5.2 Use Audiovisual Warning System (AVWS) Technology for Hazard Lighting on Structures Taller than 200 ft (p 210)	●			
6.5.3 Use Full Cutoff Luminaires (p 211)	●			
6.5.4 Direct Lights Properly to Eliminate Light Spill and Trespass (p 213)	●	●		
6.5.5 Use Amber instead of Bluish-White Lighting (p 214)	●			
6.5.6 Minimize Lighting Usage during Construction and Operations (p 215)		●	●	
6.5.7 Use Vehicle-Mounted Lights or Portable Light Towers for Nighttime Maintenance Activities (p 218)			●	

6.5.1 Prepare a Lighting Plan

Project Phase: Siting and Design

A lighting plan should be prepared documenting how lighting will be designed and installed to minimize night-sky impacts and impacts on nocturnal wildlife during construction and operations. The lighting plan should specify the following:

(1) Number of lights and lumen output of each—Minimum number of lights and the lowest luminosity consistent with safe and secure operation of the facility;

(2) Alternatives to lighting—Retro-reflective or luminescent markers in lieu of permanent lighting where feasible;

(3) Fixture design—Lights of the proper design, shielded to eliminate uplight, placed and directed to eliminate light spill and trespass to offsite locations;

(4) Lamp color temperature—Lights of the proper color to minimize night-sky impacts;

(5) Standard operating procedures—Minimization of unnecessary lighting use through alternatives to permanent lighting, such as restricting lighting usage to certain time periods;

(6) Any activities that may be restricted to avoid night-sky impacts; and

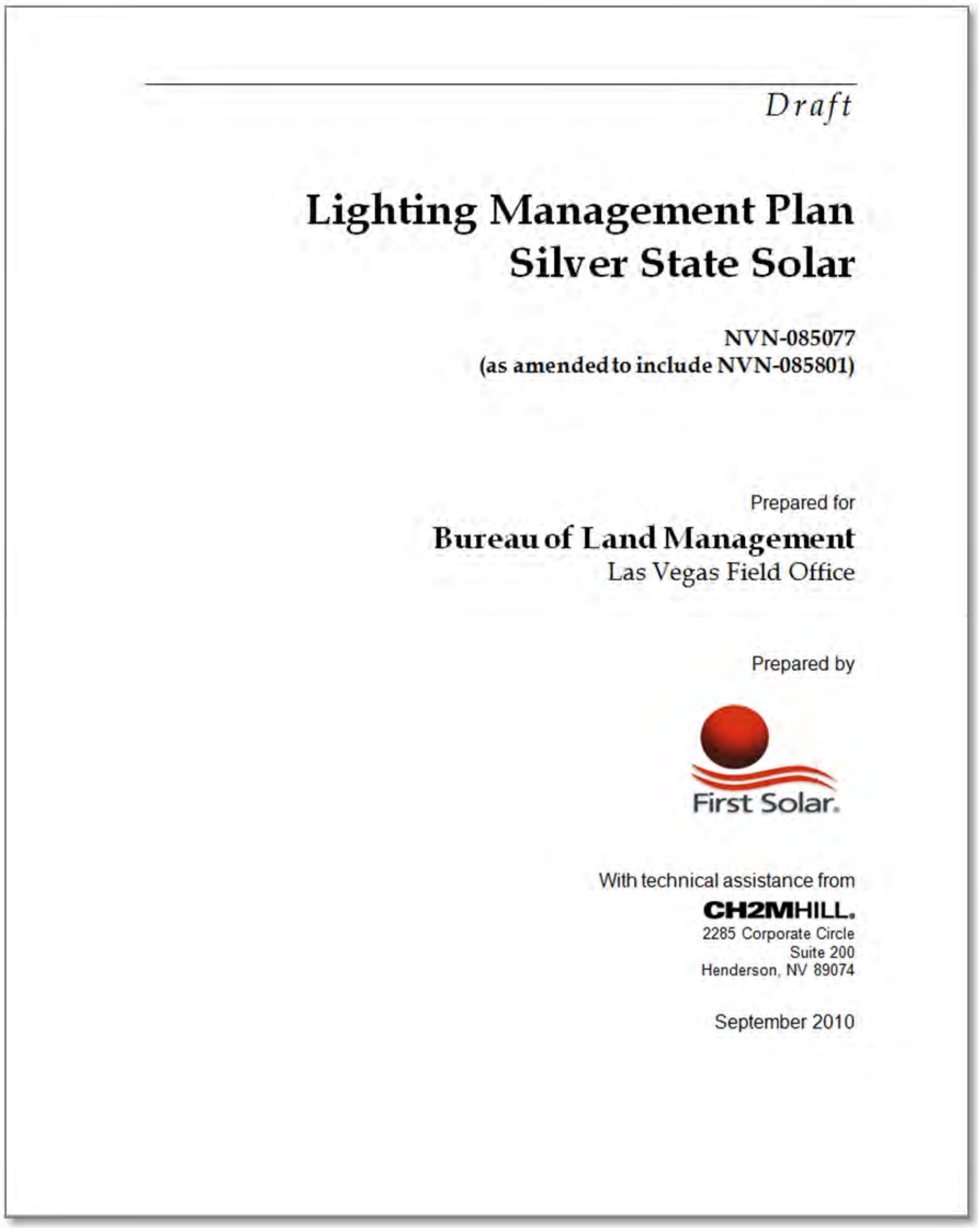
(7) A process for promptly addressing and mitigating complaints about potential lighting impacts.

Notes

The dark night skies of many parts of the western United States are valued by residents and visitors to the region and are a tourist amenity in some areas, particularly in the southwestern deserts. Poorly designed outdoor lighting can impact areas tens of miles away. Not only is light pollution from facility and activity lighting a negative visual impact, it also can be a concern for nocturnal wildlife. A quality lighting plan helps ensure that unneeded lighting is avoided; lights are properly placed, shielded, and used; and there is a process in place to resolve issues raised by local stakeholders concerning lighting.

Limitations

Safety and security must be considered in developing a lighting plan for facilities and access roads. The FAA and other agencies may have regulations governing lighting practices that must be considered in designing facility lighting.



Draft

Lighting Management Plan
Silver State Solar

NVN-085077
(as amended to include NVN-085801)

Prepared for
Bureau of Land Management
Las Vegas Field Office

Prepared by

First Solar.

With technical assistance from
CH2MHILL.
2285 Corporate Circle
Suite 200
Henderson, NV 89074

September 2010

Lighting management plan for a solar facility. (Credit: BLM.)

6.5.2 Use Audiovisual Warning System (AVWS) Technology for Hazard Lighting on Structures Taller than 200 ft

Project Phase: Siting and Design

If the FAA approves AVWS technology for general use, it should be used for structures exceeding 200 ft in height. If the FAA denies a permit for use of this technology, the project developer should limit the amount of lighting to the minimum required by the FAA, in order to minimize visibility beyond that required to meet safety requirements.

Conventional hazard navigation lights atop wind turbines. (Credit: Terry DeWan, Terrence J. DeWan & Associates.)

Notes

AVWS is a radar-based obstacle avoidance system that activates obstruction lighting and audio signals only when an aircraft is in close proximity to an obstruction on which an AVWS unit is mounted, such as a wind turbine. The obstruction lights and audio warnings are inactive when aircraft are not in proximity to the obstruction. Currently, the FAA may approve use of AVWS on a case-by-case basis. If approved for general use by the FAA, the use of AVWS technology would greatly reduce the night-sky impacts of lighting from tall structures and would also reduce avian mortality.

Limitations

As of the publication of the BMP publication, the use of AVWS technology for any structures other than communication towers is under FAA evaluation. In the interim, projects proposing the use of AVWS technology are reviewed on a case-by-case basis until the FAA makes a final suitability determination.

6.5.3 Use Full Cutoff Luminaires

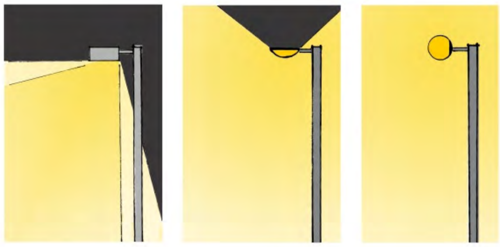
Project Phase: Siting and Design

Except as required to meet the minimum safety and security requirements (e.g., collision markers required by the FAA, or other emergency lighting triggered by alarms), all permanent lighting should use full cutoff luminaires, which are fully shielded (i.e., not emitting direct or indirect light above an imaginary horizontal plane passing through the light source), and must meet the Illuminating Engineering Society (IES) glare requirement limiting intensity of light from the luminaire in the region between 80° and 90° from the ground. All fixtures must be mounted properly, at the proper angle.

Unshielded lighting makes this substation a strong source of glare. However, the skyglow visible above the mountains is not from this facility; it is from the Las Vegas metropolitan area, approximately 13 mi north of the facility. (Credit: Marc Sanchez, BLM.)

Notes

Lights pointed upward are major contributors to light pollution, and lights pointed horizontally can be visible for many miles in open, flat landscapes. An essential component of night-sky impact mitigation for facility lighting is the use of properly shielded and mounted lighting fixtures. These fixtures greatly reduce skyglow from upward pointing light, as well as light trespass from light falling outside the desired area of illumination. In addition, full cutoff lighting reduces glare for workers, creating a safer and more comfortable working environment.



Light fixtures. Only the light at left is a full-cutoff luminaire; the other lights cast light upward and are more likely to cause skyglow, light trespass, and glare. (Credit: Lindsey Utter, Argonne National Laboratory.)

The terms “fully shielded luminaire” and “full cutoff luminaire” are often used interchangeably, but they are not identical. All full cutoff luminaires are fully shielded, but not all fully shielded luminaires are full cutoff. Full cutoff luminaires limit glare from the luminaire between 80° and 90° from the ground; a luminaire could be fully shielded but not meet the glare limitation requirements between 80° and 90° that are required to meet the IES full cutoff designation.

The IES recently adopted a new system for rating luminaires, the Backlight, Uplight, and Glare (BUG) rating system. In the new IES BUG luminaire rating system (IES TM-15), luminaires are rated by the amount of light they produce in different angular zones around the light source. In the BUG rating system, lights at renewable energy facilities should have a U rating of 1 or below, and a G rating of 2 or below.

Limitations

The FAA and other agencies may have regulations governing lighting practices that must be considered in designing facility lighting. FAA consultation may be required and/or desirable in the early stages of both wind and solar power tower facilities.

6.5.4 Direct Lights Properly to Eliminate Light Spill and Trespass

Project Phase: Siting and Design, Construction

Construction and permanent lighting should be mounted and directed to focus light only on the intended area, and to avoid light spill and offsite light trespass. Lights pointing upward or horizontally should be avoided.

Nighttime shot of a building at a solar PV facility. The lights are shielded and are directing light downward and only to the immediate vicinity of the building; however, there may be more lights than the minimum needed. The building appears to be unoccupied; if so, motion sensors could be used to reduce lighting further. (Copper Mountain Solar Facility, near Boulder City, Nevada. Credit: Marc Sanchez, BLM.)

Notes

Lights pointed upward are major contributors to light pollution, and lights pointed horizontally can be visible for many miles in open, flat landscapes. Pointing lights only where needed helps to reduce light spill into areas where it is not needed and light trespass that crosses property boundaries.

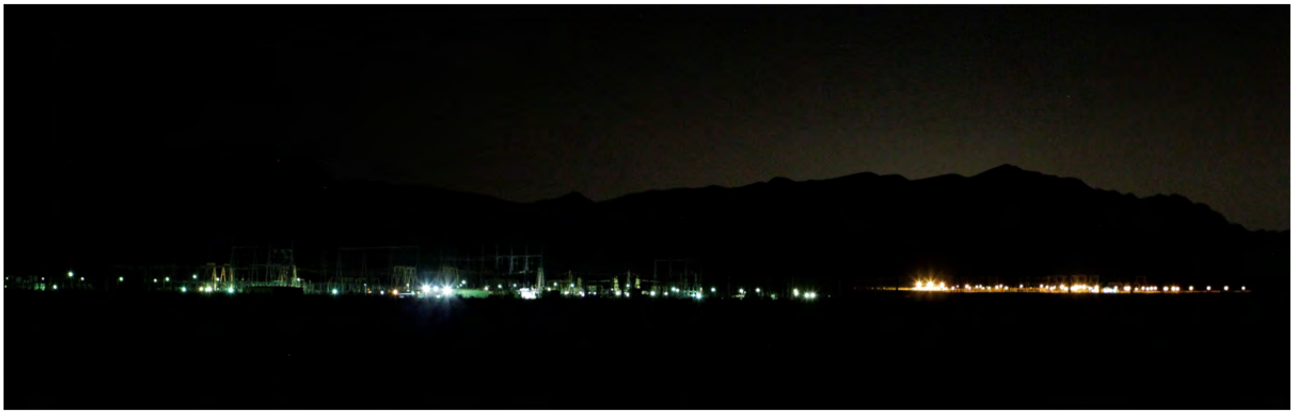
Limitations

Safety or functional considerations may dictate lighting practices that result in some light spill or light trespass.

6.5.5 Use Amber instead of Bluish-White Lighting

Project Phase: Siting and Design

When accurate color rendition is not required (e.g., roadway, basic security), lighting should be amber in color, using either low-pressure sodium lamps or yellow LED lighting, or an equivalent. When white light is required for accurate color rendition, it should be less than or equal to 3500° Kelvin color temperature (warm-white). Bluish-white lighting should not be used in permanent outdoor lighting.



This image shows a mix of bluish-white and warm-white lighting at two substation facilities. The skyglow visible above the mountains is from the Las Vegas metropolitan area. (Credit: Marc Sanchez, BLM.)

Notes

The use of low-pressure sodium lamps, yellow LED lighting, or an equivalent reduces skyglow and wildlife impacts. Bluish-white lighting is more likely to cause glare and attract insects, and is associated with other human physiological issues.

Limitations

Lighting that is amber or warm-white in color sometimes requires a special order from lighting manufacturers.

6.5.6 Minimize Lighting Usage during Construction and Operations

Project Phase: Construction, Operations

Consistent with safety requirements, lighting use should be minimized during construction and operations.

During construction, localized and portable lighting should be used where and when the work is occurring. Lighting should be powered by generators and have switches to cut power when lighting is not required during construction.

Lighting for facilities should not exceed the minimum number, intensity, and coverage required for safety and basic security. All area lighting should be divided into separately controlled zones to focus lighting on smaller areas where tasks are being performed and to avoid illuminating unused space. Area lighting should be controlled by timers, sensors, or switches available to facility operators; dusk-to-dawn lighting controlled by photocell alone should not be allowed except where required for safety. The facility operators should identify those components/structures that do not require continuous lighting for safety reasons. Area lights should only be switched on when there is a specific need (e.g., cleaning mirrors and panels at a solar facility, pumping fuel, persons occupying an area, or alarm situation). When not needed, lights should be switched off. Exceptions to switched-off lighting for safety purposes should be articulated in the lighting plan (see BMP 6.5.1). Focused task lighting, portable light towers, or flashlights should be used instead of area lighting, and retro-reflective or luminescent markers should be used in lieu of permanent lighting where feasible.

Nighttime shot of a geothermal power plant located near El Centro, California. Better lighting practices could substantially reduce light pollution from this facility. (Credit: Warren Gretz, NREL.)

Notes

Dark night skies are a highly valued amenity in many parts of the American west. Many industrial facilities have too much lighting, well beyond that needed for safety, security, and efficient conduct of work. Poorly designed outdoor lighting can impact areas tens of miles away. In addition to causing light pollution, excessive lighting can cause hazards for nocturnal wildlife, waste energy and money, and even create safety and security hazards by causing excessive glare. Facilities should use the minimum lighting levels consistent with safety and security requirements.

Nighttime shot of the power block and part of the cooling tower at a solar parabolic trough facility. Bright lights combined with many complex, highly reflective surfaces makes this facility lighting easily visible at distances greater than 10 mi (Nevada Solar One, near Boulder City, Nevada. Credit: Marc Sanchez, BLM.)

Limitations

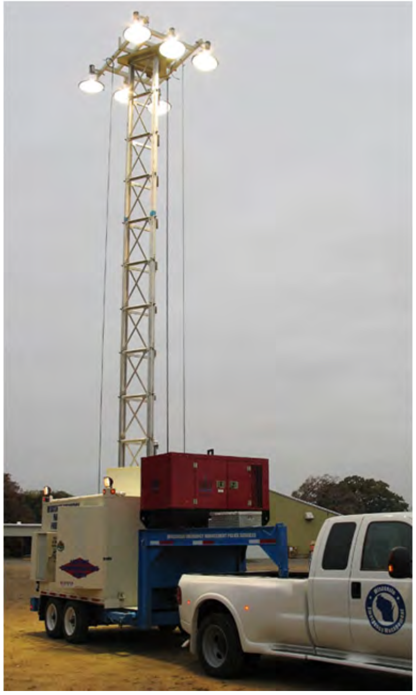
Safety and security must be considered in designing and using lighting. The FAA and other agencies may have regulations governing lighting practices that must be considered in designing facility lighting and regulating lighting usage. Solar thermal facilities (parabolic trough, compact linear Fresnel lens, and power tower) have power blocks that require substantially more lighting for safety and inspection purposes.

Nighttime shot of a large substation. Numerous bright, poorly shielded lights make this facility a strong source of glare and light spill. (Eldorado Valley, near Boulder City, Nevada. Credit: Marc Sanchez, BLM.)

6.5.7 Use Vehicle-Mounted Lights or Portable Light Towers for Nighttime Maintenance Activities

Project Phase: **Operations**

Vehicle-mounted lights or portable light towers are preferred over permanently mounted lighting for nighttime maintenance activities. If possible, such lighting should be equipped with hoods or louvers and be aimed toward the ground to avoid causing glare and skyglow.



Portable light tower. (Credit: Wisconsin Department of Military Affairs.)

Notes

Using properly placed vehicle-mounted lights or portable light towers puts the light only where it is needed, reducing overall lighting usage. Pointing the lights toward the ground is important, because research has shown that vehicle headlights can be visible for many miles in the open landscapes and clear air of the western United States.

Limitations

Use of vehicle lighting must be consistent with safety requirements. Some maintenance activities may have lighting requirements that make vehicle-mounted lighting impractical.

6.6 Avoiding Unnecessary Disturbance

These BMPs help to avoid or minimize land and other types of disturbance.

6.6 Avoiding Unnecessary Disturbance	Siting and Design	Construction	Operation	Decommissioning and Reclamation
6.6.1 Minimize Project Footprint and Associated Disturbance (p 220)		●		
6.6.2 Avoid Unnecessary Road Improvements (p 221)		●		
6.6.3 Use Penalty Clauses to Protect High-Value Landscape Features (p 222)		●		
6.6.4 Confine Construction Activities and Facilities to Pre-Defined Areas (p 223)		●		
6.6.5 Provide Construction Personnel with Avoidance Area Maps (p 224)		●		
6.6.6 Do Not Apply Paints or Permanent Discoloring Agents to Rocks or Vegetation to Mark Survey Limits (p 225)		●		
6.6.7 Require Overland Driving Where Re-contouring Is Not Required (p 226)		●		
6.6.8 Use Air Transport to Erect Transmission Towers (p 227)		●		

6.6.1 Minimize Project Footprint and Associated Disturbance

Project Phase: Construction

Minimize the project footprint and associated disturbance during and after construction. The number, size, and length of roads, temporary fences, laydown areas, and borrow areas should be minimized. Existing rocks, vegetation, and drainage patterns should be preserved to the maximum extent possible. All construction and maintenance activities should be conducted in a manner that will minimize disturbance of vegetation, soils, drainage channels, and intermittent and perennial stream banks.

Notes

Unnecessary site disturbance can be a major source of visual contrasts. As a general rule, the project footprint and associated disturbance during and after construction should be minimized. Reducing the project footprint and minimizing disturbance of vegetation, soils (particularly in areas with highly contrasting subsoil color), drainage channels, and stream banks directly reduces the extent of visual contrast and hence visual impacts, as well as having numerous other environmental benefits.

Limitations

Site characteristics, and technical and environmental considerations, may limit the ability to reduce a project's footprint during construction.

6.6.2 Avoid Unnecessary Road Improvements

Project Phase: Construction

Existing roads should be left in as close to an undeveloped condition as possible.

Notes

Existing roads should be left in as close to an undeveloped condition (i.e., two-track road) as possible without creating environmental degradation (e.g., erosion or rutting from poor water drainage) or unsafe conditions.

Limitations

Load-bearing and safety considerations may require road upgrading. Some roads used for routine inspection and maintenance will require all-weather accessibility.

6.6.3 Use Penalty Clauses to Protect High-Value Landscape Features

Project Phase: Construction

Use penalty clauses to protect high-value trees and other landscape elements in areas with high visual sensitivity.

This high-value tree was protected during road construction. (Credit: BLM.)

Notes

In areas of very high visual sensitivity, the use of penalty clauses to protect highly valued trees or other scenic elements may be justified.

Limitations

The use of penalty clauses should be restricted to areas of the highest visual sensitivity.

6.6.4 Confine Construction Activities and Facilities to Pre-Defined Areas

Project Phase: Construction

Personal vehicles, sanitary facilities, and work areas should be confined to clearly delineated construction boundaries specified in the plan of development. For construction and prolonged operations and maintenance projects, maintenance equipment, materials, and vehicles should be stored at the sites where activities will occur, or at specified maintenance yards.

Limits of construction activities are clearly marked at this site. (Credit: John McCarty, BLM.)

Notes

The limits of construction activity areas should be predetermined and demarcated, with activity restricted to and confined within those limits. Confining equipment, vehicles, and activities to pre-defined areas will result in less vegetation and ground disturbance, as well as reducing visual clutter.

6.6.5 Provide Construction Personnel with Avoidance Area Maps

Project Phase: Construction

Provide maps of avoidance areas to construction personnel; the maps should include established work zones and ROW areas where overland travel should be avoided. Use survey staking to delineate avoidance areas in conjunction with avoidance area maps.

Providing construction personnel with avoidance area maps will reduce unnecessary disturbance of vegetation and soil. (Credit: U.S. Fish and Wildlife Service.)

Notes

Ensuring that construction personnel have clear maps of avoidance areas will reduce unnecessary vegetation and soil disturbance, and potentially associated erosion- and dust-related visual impacts.

6.6.6 Do Not Apply Paints or Permanent Discoloring Agents to Rocks or Vegetation to Mark Survey Limits

Project Phase: Construction

Neither paint nor permanent discoloring agents should be applied to rocks or vegetation to indicate survey limits.

Notes

Paint, especially on rocks, can be visible for years. Use stakes and flagging instead. Lime or chalk could also be used, provided the activity relying on such marks is completed before the next rain event.

Use of stakes and flagging rather than paint on vegetation. (Credit: BLM.)

6.6.7 Require Overland Driving Where Re-contouring Is Not Required

Project Phase: Construction

Allow only overland driving in areas where recontouring is not required.

Overland driving: seismic vibrator trucks. (Credit: BLM.)

Notes

In areas where recontouring is not required, disturbance should be limited to overland driving, to minimize changes in the original land contours. Large rocks and vegetation may be moved within these areas to allow vehicle access.

Limitations

Project and other environmental considerations may preclude overland driving; in some areas, roads will be required. Long, straight-line routes should be avoided, because in some landscapes (e.g., pinyon-juniper areas) the vegetation disturbance may leave long-lasting visible scars.

6.6.8 Use Air Transport to Erect Transmission Towers

Project Phase: Construction

In areas of the highest visual sensitivity, air transport capability should be used to mobilize equipment and materials for clearing, grading, and erecting transmission towers.

Notes

The use of air transport capability preserves the natural landscape conditions between tower locations, and may reduce the need for construction roads.

Limitations

Using air transport for transmission towers is expensive, and is generally reserved for the most sensitive or difficult-to-access areas. Maximum weight limitations may preclude air transport of heavy equipment.

Helicopter transporting pre-assembled transmission tower. (Credit: Bonneville Power Administration.)

6.7 Soils, Erosion, and Dust Management

These BMPs help to avoid or reduce visual impacts from wind and water erosion through dust control, erosion and sediment control, and topsoil management.

6.7 Soils, Erosion, and Dust Management	Siting and Design	Construction	Operations	Decommissioning and Reclamation
6.7.1 Implement Dust and Wind Erosion Control Measures (p 230)		●	●	●
6.7.2 Implement Erosion and Sediment Control Measures (p 232)		●	●	●
6.7.3 Implement Temporary and/or Permanent Soil Stabilization Measures (p 235)		●		
6.7.4 Strip, Stockpile, and Stabilize Topsoil for Re-spreading (p 237)		●		
6.7.5 Segregate Topsoil and Reapply to Disturbed Areas (p 239)		●		

6.7.1 Implement Dust and Wind Erosion Control Measures

Project Phase: Construction, Operations, Decommissioning

Dust abatement measures should be implemented in arid environments and areas with air quality regulations (i.e., air quality non-attainment and maintenance areas) to minimize the impacts of vehicular and pedestrian traffic, construction, and wind on exposed surface soils. This may also require limiting the types of equipment, vehicle speeds, and routes utilized during construction. Open-bodied trucks that transport materials that could be sources of airborne dust should be covered while transporting the materials. Access roads, onsite roads, and parking lots should be surfaced with aggregate with hardness sufficient to prevent vehicles from crushing the aggregate and thus causing dust. Access roads and other areas of ground disturbance within the construction limits should be watered, as needed, to avoid the creation of dust. All soil disturbance activities and travel on unpaved roads should be suspended during periods of high winds. In areas subject to wind erosion, appropriate BLM-approved measures, such as the application of fine water spray, plastic sheeting, mulch, gravel, chemical soil stabilizers, or chemical dust suppressants, should be used to reduce impacts. Stockpiles should be sprayed with water, covered with tarpaulins, and/or treated with appropriate dust suppressants, especially in preparation for high-wind or storm conditions.

Wind-blown dust from unpaved roads may be a significant source of visual contrast. (Credit: BLM.)

Application of dust palliative. (Credit: Alaska Department of Environmental Conservation, Division of Air Quality.)

Notes

Windblown dust can be highly visible, and is a particular problem in the arid southwestern states. Dust abatement and wind erosion control measures reduce visual impacts, improve air quality, and provide numerous other benefits.

Limitations

There may be limitations to the amount of water that can be applied for dust abatement based on soil type. Only BLM-approved products must be used, as certain chemical dust suppressants may not be allowed.

6.7.2 Implement Erosion and Sediment Control Measures

Project Phase: Construction, Operations, Decommissioning

Erosion and sediment control measures should be in place and functioning before construction or decommissioning activities occur. Preserve as much existing vegetation as possible. Sediment controls should be installed and maintained along the site perimeter on all down-gradient sides of the construction. Sediment barriers may include sediment fences, berms, and straw wattles. Run-on/run-off control measures should include slope drains, check dams, surface roughening, and bank stabilization. Slash and boulders should be placed at the side or downslope of roads to act as a sediment filter. To reduce the potential for erosion, all existing road drainage structures should be maintained or repaired during construction and during operation and maintenance activities.

Sediment discharge into lakes, streams, and rivers causes visual impacts in addition to water quality problems. (Credit: John McCarty, BLM).

An example of erosion control good practices: the reseeded area is fenced off and the silt fence left in place until vegetation is re-established. (Credit: BLM.)

Notes

Soil erosion can cause substantial visual impacts through vegetation loss, gullying, soil deposition, sedimentation of water, and tracking of mud on roadways.

Limitations

EPA and/or states require permit coverage, including the creation of a Stormwater Pollution Prevention Plan, prior to the disturbance of an acre or more. BLM may require certified weed-free straw to prevent introduction of invasive or noxious species.

An example of erosion control good practices: straw bales used for downslope sediment control. (Credit: BLM.)

Although imperfectly installed, this combination of straw bales and silt fence is holding back a large amount of water and sediment. (Credit: John McCarty, BLM.)

An example of erosion control good practices: seeded straw erosion control matting on road embankment. (Credit: John McCarty, Colorado Department of Transportation.)

6.7.3 Implement Temporary and/or Permanent Soil Stabilization Measures

Project Phase: Construction

Temporary and/or permanent soil stabilization measures should be applied immediately on all disturbed areas as grading progresses and on all roadways. These measures should be utilized appropriately until construction is complete, and all vegetation is established. Temporary slope stabilization measures may include covering exposed soil with plastic sheeting, straw mulching, or other approved measures. To reduce the potential for erosion, riprap, boulders, and vegetation can be used to stabilize slopes.

A stabilized and seeded slope. (Credit: BLM.)

Notes

Loose soil must be protected from washing away in heavy rains to avoid soil deposition, sedimentation of water, and tracking of mud on roadways. In some situations chemical solutions can be used to stabilize soils.

Limitations

The transport of other materials to the site (e.g., riprap) and their use for soil stabilization itself causes some environmental impacts; at some point, the soil stabilization benefits gained may be outweighed by the impacts of implementing the procedures. A site-specific analysis of the potential benefits and costs must be made. Potential effects of chemical soil stabilization solutions on native vegetation and other sensitive environmental features in the immediate area may preclude the use of these soil stabilization agents.

Slash used to stabilize slope below a road cut. (Credit: BLM.)

6.7.4 Strip, Stockpile, and Stabilize Topsoil for Re-spreading

Project Phase: Construction

Strip, stockpile, and stabilize topsoil from a site before excavating earth for facility construction. Avoid screening stockpiled topsoil. Stockpiled soil should be placed in a stable location and configuration. Soil stockpiles should have temporary stabilization or covering at the end of each workday. Sediment fences should be installed around stockpiles. Topsoil piles should not be left in sensitive viewing areas.

Stockpiled topsoil. In this case, composted sewage sludge (two darker piles in foreground) was mixed with soil from the topsoil stockpile behind and to the left of the mixed soil/compost piles. (Credit: John McCarty, Colorado Department of Transportation.)

Notes

Topsoil is often better than subsoil for revegetation purposes, and should be saved for spreading on disturbed areas. Depth of existing topsoil should be measured prior to stripping to assure complete salvage of suitable soils. Topsoil should not be screened because retaining the original soil components will help re-establish the surface texture that existed prior to disturbance. Topsoil quality should also be tested in the event additional topsoil must be obtained to complete reclamation. Test results will facilitate specifying appropriate soil quality for any additional topsoil.

Topsoil piles can be a source of visual impacts if left in visually sensitive areas and must be protected from erosion, because they can be a source of fugitive dust that creates an additional visual impact. Apply an approved erosion control stabilizer or approved seed mix as a temporary erosion control mix on the stockpiled soil to control fugitive dust and preserve topsoil quantity. Carefully controlling the slopes of the piles and selecting their locations on the site can control both sediment production from storm-water runoff and windblown fugitive dust. Viability of topsoil is may be adversely affected by excessive stockpile depth (>5–8 ft) and the length of time the soil is stockpiled (>1 year).

Stockpiled topsoil, surrounded by a silt fence intended to control offsite soil transport during heavy rains. (Credit: BLM.)

6.7.5 Segregate Topsoil and Reapply to Disturbed Areas

Project Phase: Construction

Topsoil from cut and fill activities should be spread on freshly disturbed areas to reduce color contrast, re-establish surface textures, and aid rapid re-vegetation. Topsoil should be placed at natural slope angles. For road construction, excess fill should be used to fill uphill-side swales to reduce slope interruptions that would appear unnatural, as well as to reduce fill piles. Prior to reapplication, topsoil stockpiled for excessively long periods should be retested for quality in comparison to pre-construction soil.

Excess fill being removed for offsite storage. (Credit: BLM.)

Notes

Topsoil should be spread on disturbed areas to reduce contrasts and hasten revegetation; if spread on slopes and cuts, it should approximate the original contours.

Limitations

Excess topsoil should not be spread in undisturbed areas or deposited in wetlands, lakes, or streams.

6.8 Vegetation Management

These BMPs concern vegetation protection, vegetation clearing techniques, and measures to promote successful revegetation.

6.8 Vegetation Management	Siting and Design	Construction	Operations	Decommissioning and Reclamation
6.8.1 Prepare a Reclamation Plan (p 242)	●			
6.8.2 Design Vegetative Openings to Mimic Natural Openings (p 244)	●			
6.8.3 Use Partial ROW Clearing and Feather Edges of Transmission ROWs (p 248)	●			
6.8.4 Preserve Existing Vegetation (p 251)		●	●	
6.8.5 Use Retaining Walls, Berms, Fences, and Markings to Protect Trees and Other Scenic Features (p 253)		●		
6.8.6 Avoid Slash Piles in Sensitive Viewing Areas; Chip Slash for Mulch to Hide Fresh Soil (p 255)		●		
6.8.7 Mulch Cleared Areas, Furrow Slopes, and Use Planting Holes (p 257)		●		●
6.8.8 Use Pitting and Vertical Mulching to Facilitate Revegetation and Discourage Vehicle Traffic (p 260)		●		●
6.8.9 Revegetate Using Salvaged Native Plants and Approved, Weed-free Seed Mixes (p 262)		●		●
6.8.10 Transplant Vegetation from Cleared Areas (p 263)		●		
6.8.11 Monitor and Maintain Revegetated Areas until Vegetation Is Self-Sustaining (p 264)		●		●

6.8.1 Prepare a Reclamation Plan

Project Phase: Siting and Design

A reclamation plan should be prepared in consultation with BLM when necessary. The plan should address surface reconstruction and stabilization, topsoil management, soil preparation and seed mix(es), and invasive plant management. The Authorized Officer should approve any changes to the plan, such as changes to the seed mix(es).

Notes

A well-designed and executed reclamation plan should re-establish the visual qualities of form, line, color, and texture, while limiting vegetation loss and the spread and establishment of invasive plant species, as well as helping to control soil erosion and windblown fugitive dust. Because adjacent, non-federal lands could also be affected by the revegetation actions, consultation with state authorities such as the department of natural resources or state soil conservation service may be helpful.

Limitations

The reclamation plan must be consistent with fire safety requirements, and support safe facility operation.

Appendix C

SEED MIX			
COMMON NAME	SCIENTIFIC NAME	VARIETY	POUNDS of PLS/ACRE
Indian ricegrass	*Achnatherum hymenoides*	*Paloma*	1.5
Fringed Sage	*Artemisia frigida*		0.25
Prairie Sage	*Artemisia ludoviciana*		0.25
Wyoming big sagebrush	*Artemisia tridentata ssp. wyomingensis*		1
Fourwing saltbrush	*Atriplex canescens*	*Rincon*	1.5
Shadscale saltbrush	*Atriplex confertifolia*		1.5
Sideoats Grama	*Bouteloua curtipendula*	*Vaughn or Niner*	1.5
Winterfat	*Ceratoides lanata*		0.5
Thickspike Wheatgrass	*Elymus lanceolatus*	*Critana*	1.5
Galleta grass	*Hilaria jamesii*	*Viva*	1
Western wheatgrass	*Pascopyrum smithii*	*Arriba*	2
Sandberg bluegrass	*Poa secunda*		0.5
Bluebunch wheatgrass	*Pseudoroegneria spicata*	*P-7*	1.5
Scarlet globemallow	*Sphaeralcea coccinea*		0.25
Alkali Sacaton	*Sporobolus airoides*	*Sakado*	0.25

**The suggested seed mix was developed in collaboration with DOW, BLM, Field Experts and Otak.*

Notes:
- All seed to be broadcast over scarified soils, lightly raked.
- All seeded areas not mulched with the debris from hydro-axing shall be mulched with certified weed free straw at a rate of 2 tons/acre.
- All straw mulched areas are to be secured with a Plantago insular tackifier per manufacturer specifications
- Biosol fertilizer shall be incorporated into the tackifier slurry at a rate of 1,500 lbs./acre.
- Application soil surface shall then be roughened with pitting or gouging, to increase water retention and seed germination. In the case of slopes steeper than 3:1, mini-benches shall be created and are not exceed 6 inches in vertical dimension.
- Seeding shall take place between September 1 to March 1.

Source for all non-named varieties of forb, grass and shrub seed should meet the following environmental characteristics, if not collected from a comparable environment such as the south facing slope of the Roan Cliffs or Hogback formation within Garfield County, Colorado:

Annual precipitation of 10 – 20 inches
Elevation 5,500 feet about sea level (+ or – 1,000')
Locations – West of the Continental Divide in the States of Colorado, Wyoming, Idaho, New Mexico, and Utah.

All forb, grass and shrub seed labels shall conform to the applicable portions of the Federal and Colorado seed Act as well as contain the following seed collection site description information:

Elevation
State
County
Date of collection
Date tested

The Contractor shall furnish to the Authorized Officer a signed statement certifying that the seed furnished is from a lot that has been tested by a recognized laboratory for seed testing within six months prior to the date of commencement of seeding operations, except for forb and woody plant seed. All forb and woody plant seed shall have been tested by a registered seed technologist within one year prior to the date of commencement of seeding operations.

The Contractor shall also adhere to the BLM Instruction Memorandum No. 2006-073, Weed-Free Seed Use on Lands Administered by the BLM, located in Appendix G.

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This visual mitigation plan includes instructions for using a seed mix that will balance recognized valued resources, including visual aesthetics, wildlife, soil, and water. (Credit: Otak, Inc.)

6.8.2 Design Vegetative Openings to Mimic Natural Openings

Project Phase: Siting and Design

Openings in vegetation for facilities, structures, and roads, should be feathered and shaped to repeat the size, shape, and characteristics of naturally occurring openings.

Notes

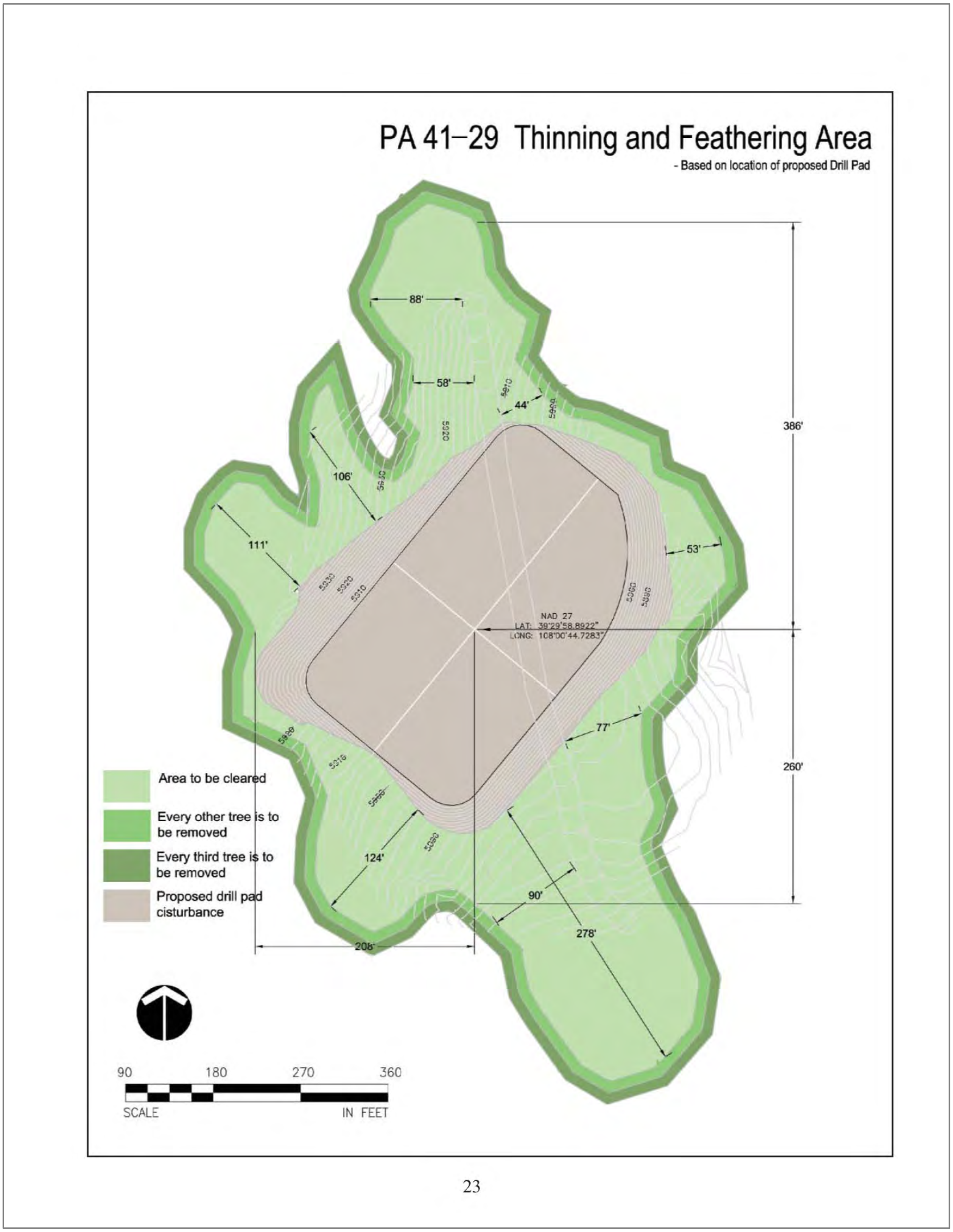
Feathering the edges of openings in vegetation and shaping clearings to mimic natural openings reduces strong line contrasts from straight cuts through vegetation, but more importantly, reduces the perception that the facility was imposed on the landscape rather than fit into it.

The clearing for the transmission tower was shaped to blend in well with the naturally occurring clearings in the surrounding area. (Credit: BLM.)

The clearings for transmission towers in this photo were shaped to blend in well with the naturally occurring clearings on the hillside. Although the conductors are plainly visible in this lighting, the dark tower color makes the towers difficult to see against the dark colors and varied textures of the vegetation. (Credit: BLM.)

Limitations

In some circumstances, functional requirements or safety considerations may dictate specific vegetation clearing practices, especially where space is limited. In some cases, feathering the edges of openings may not be permitted.



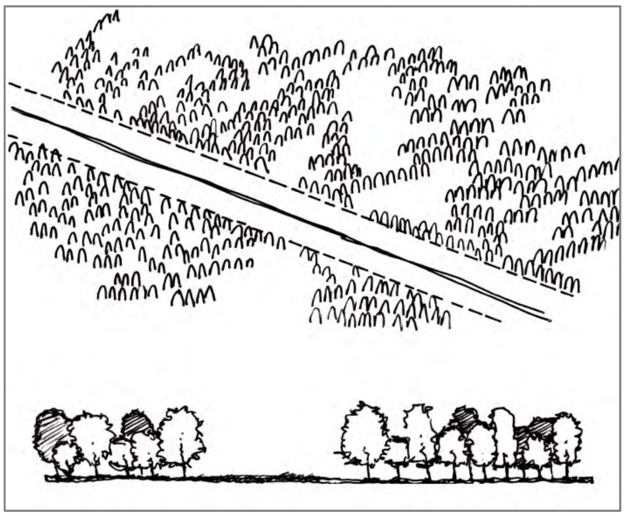
Thinning and feathering plan for a clearing for a facility. (Credit: Otak, Inc.)

The vegetation management strategy in this visual mitigation plan includes "organic" openings that mimic natural openings, areas of thinning and feathering, and preservation of individual trees. (Credit: BLM.)

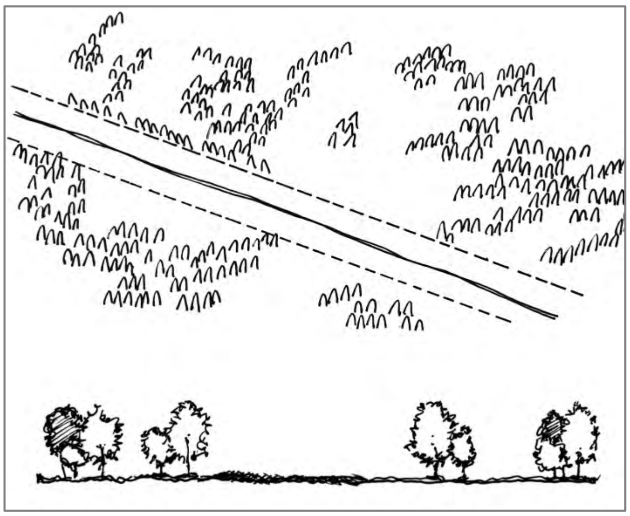
6.8.3 Use Partial ROW Clearing and Feather Edges of Transmission ROWs

Project Phase: Siting and Design

The vegetation management plan for transmission ROWs and other features in forested areas should incorporate partial ROW clearing where feasible, including topping rather than removing trees that exceed the allowable height and leaving irregular edges within the ROW. Trees that would not present a safety or engineering hazard or otherwise interfere with operations should be left on the ROW. The plan should also specify feathering of ROW edges (i.e., the progressive and selective thinning of trees) combined with mixing of tree heights to create an irregular vegetation outline.



Cutting vegetation only at the edge of the ROW can create a strong line contrast between vegetation and the cleared ROW that can be visible for many miles. (Credit: Lindsey Utter, Argonne National Laboratory.)



Partial ROW clearing and feathering of ROW edges creates a more natural appearance. (Credit: Lindsey Utter, Argonne National Laboratory.)

Notes

If vegetation management creates a "hard edge" between the cleared area and the surrounding vegetation, strong linear contrasts are created that are non-natural in appearance and may be visible for very long distances, especially for views along or parallel to the ROW. Partial ROW clearing and feathering of ROW edges may result in reduced vegetation disturbance (and therefore less slash), the appearance of narrower

ROWs, better screening, and a more natural-looking appearance. Feathering and clearing activities may need to extend beyond the designated ROW.

Limitations

The Federal Energy Regulatory Commission and North American Electric Reliability Council have strict vegetation management standards for transmission ROWs, which are intended to ensure safe and reliable electric transmission; vegetation management practices in transmission ROWs must adhere to these standards.

The vegetation management strategy in this visual mitigation plan includes areas of thinning and clearing along a ROW, and preservation of existing vegetation. (Credit: BLM.)

6.8.4 Preserve Existing Vegetation

Project Phase: Construction, Operations

Mowing on BLM lands. (Credit: BLM.)

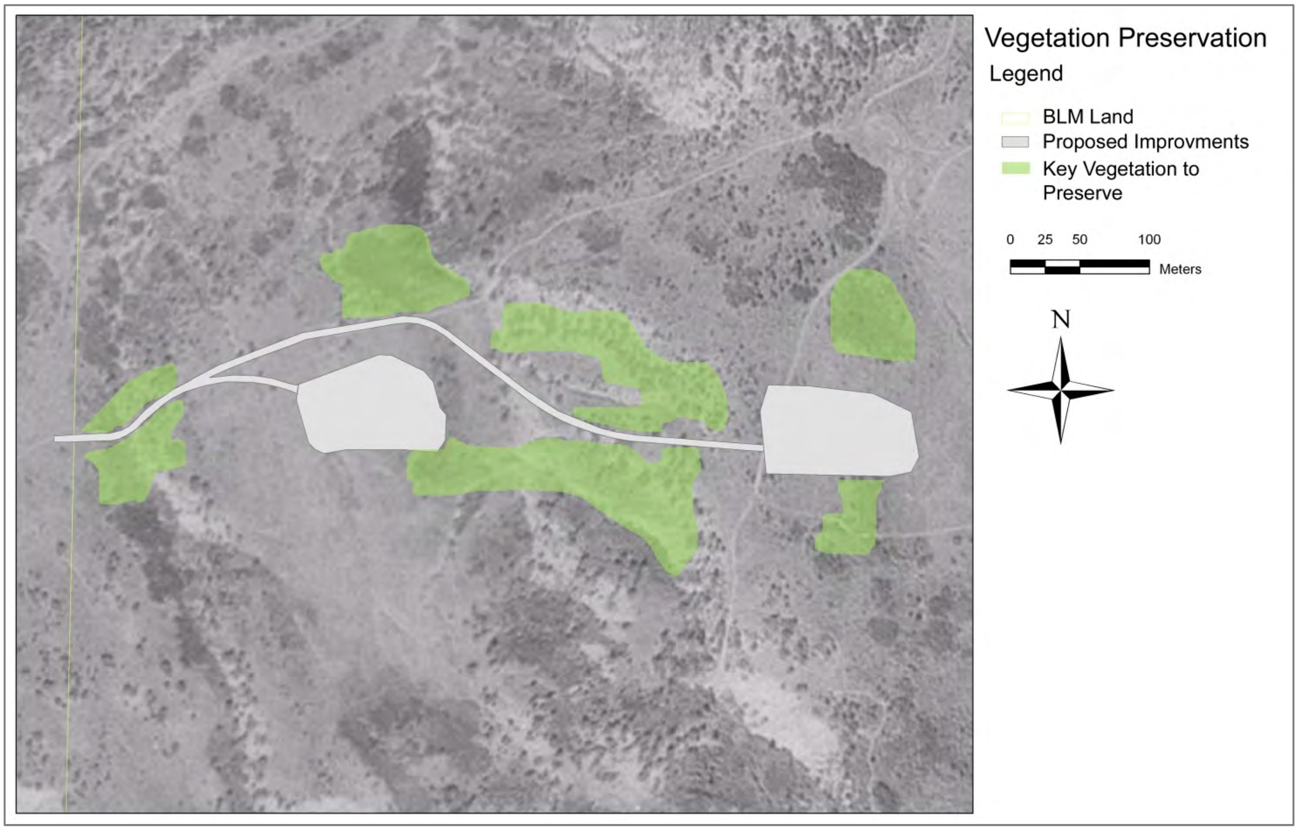
Vegetation clearing should be minimized. Brush-beating, mowing, or using protective surface matting rather than removing vegetation should be employed. Trim trees in preference to cutting trees, and cut trees in preference to bulldozing them. In construction areas where recontouring is not required, cut vegetation crowns/roots should be left undisturbed to avoid root damage and to allow for re-sprouting. Installation of underground features (e.g., buried power and signal cables) should be completed using directional drilling rather than excavation, and compatible utilities should share underground ROWs/trenches. Vegetation management during construction should include repairing soil compaction (e.g., by aeration or sand addition after construction activities have ceased). Road maintenance activities should avoid blading existing forbs and grasses in ditches and adjacent to roads.

Notes

Minimizing vegetation disturbance not only reduces an obvious source of visual contrast (primarily color and texture contrast) associated with vegetation removal and the resulting exposure of soil colors and textures, but also has other visual benefits, such as reducing erosion that can cause negative visual impacts, and reducing the likelihood of visual contrasts associated with the introduction of invasive vegetation. Of course, minimizing vegetation disturbance has numerous non-visual benefits, such as preserving wildlife habitat and water quality.

Limitations

Technical and safety concerns may require complete vegetation removal in a variety of situations for a least some portion of a project site. For example, it may be necessary to remove vegetation that could be fuel for fires, especially in areas traveled by vehicles with hot exhausts and/or catalytic converters. Vegetation that would interfere with equipment motion (e.g., solar collector tracking) or transport would also be removed.



This BLM plan specifies preservation of existing vegetation. (Credit: BLM.)

6.8.5 Use Retaining Walls, Berms, Fences, and Markings to Protect Trees and Other Scenic Features

Project Phase: Construction

In order to protect valuable trees and other scenic attributes, clear only to the edge of the designed grade manipulation and not beyond through the use of retaining walls or berms to protect tree roots and stems from construction activities. Use fences or markings to delineate trees or other features within the project site that should be preserved.

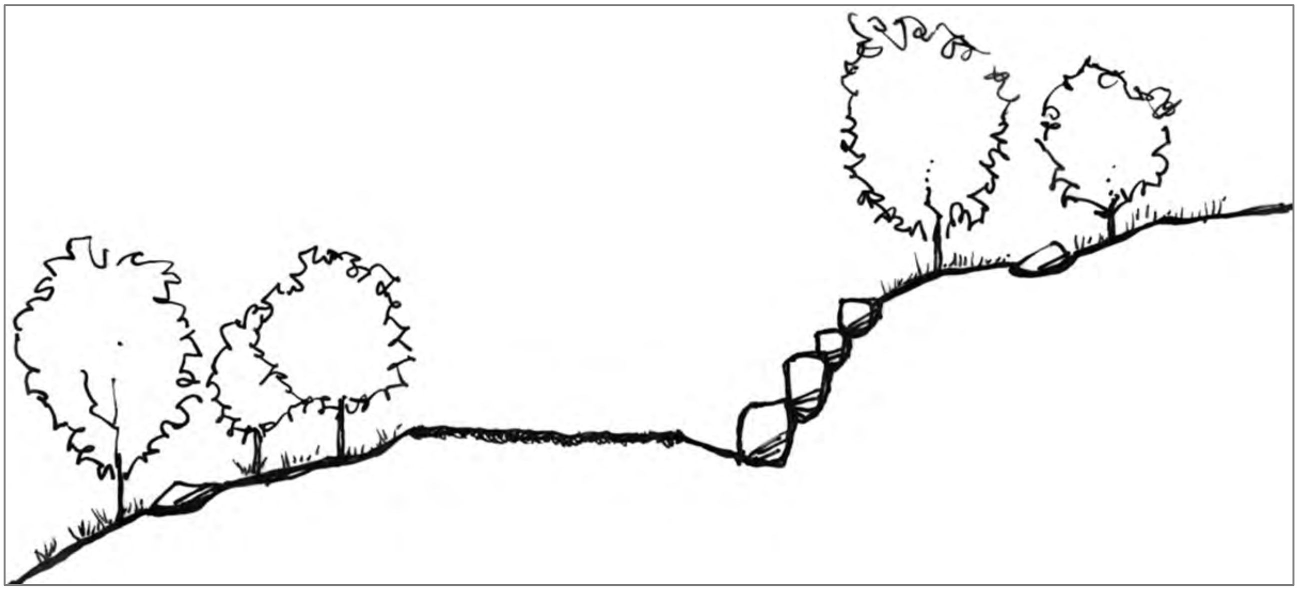
Marking a specimen tree for preservation. (Credit: Colorado Department of Transportation.)

Notes

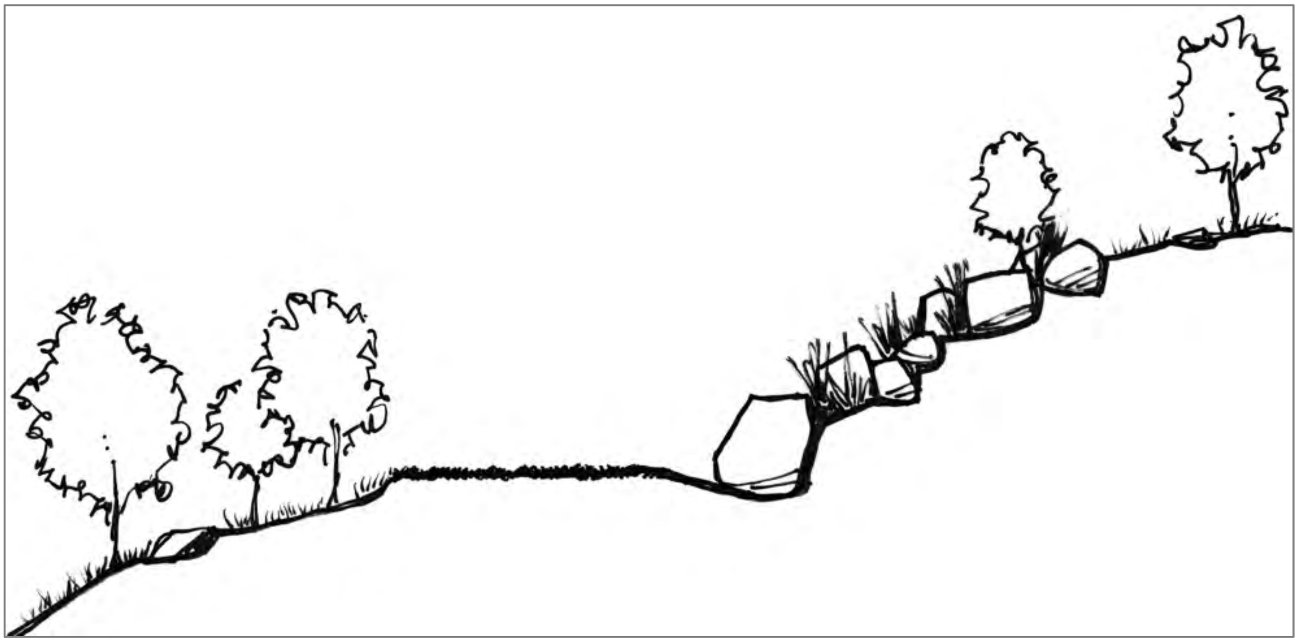
Retaining walls can help to retain existing vegetation, reduce the amount/extent of earthwork, reduce surface disturbance, and protect roots.

Limitations

Technical and safety concerns may require complete vegetation removal in a variety of situations for at least some portion of a project site. For example, for fire safety and protection of personnel operating manual switches and relays, onsite power management areas and substations (transformers, inverters, relays, etc.) should be kept free of vegetation.



Temporary retaining wall used to protect trees during construction. (Credit: Lindsey Utter, Argonne National Laboratory.)



Permanent retaining wall used to protect trees after construction phase. (Credit: Lindsey Utter, Argonne National Laboratory.)

6.8.6 Avoid Slash Piles in Sensitive Viewing Areas; Chip Slash for Mulch to Hide Fresh Soil

Project Phase: Construction

Slash piles should not be left in sensitive viewing areas. Slash from vegetation removal should be mulched and spread to cover fresh soil disturbances (i.e., the preferred methodology) or should be buried.

Chipping slash to eliminate slash piles. (Credit: NPS.)

Notes

Slash piles may be unsightly in and of themselves, but also give the project an "unfinished" look. Using slash for mulch can immediately reduce color and texture contrast of exposed soils, and reduces erosion, aids in moisture retention, and provides organic matter that aids revegetation, which ultimately reduces long-term visual impacts. Other options for slash disposal include selling vegetation for fuel value or pulping.

Limitations

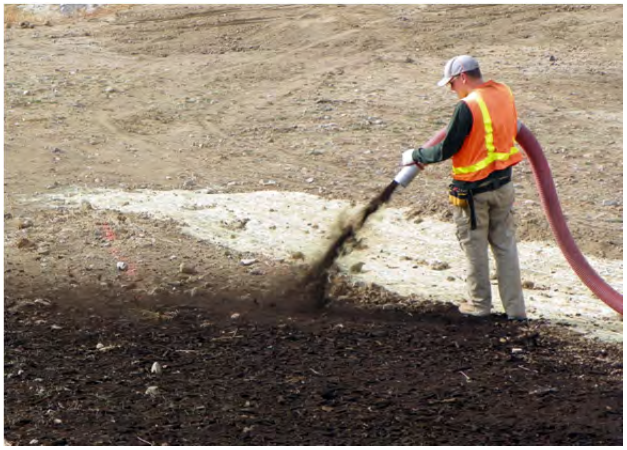
Mulch should not be spread on undisturbed areas or wetlands. In some situations, there may be more mulch from slash than the available cleared area can accommodate, in which case burial or offsite disposal may be necessary.

6.8.7 Mulch Cleared Areas, Furrow Slopes, and Use Planting Holes

Project Phase: Construction

Where existing vegetation in areas to be cleared is of appropriate size and density, it should be mulched and spread. Furrow slopes (i.e., cut grooves or create narrow, shallow trenches), and use planting holes or planting pockets (to be filled in with growing media) on slopes.

Mulch application. (Credit: Natural Resources Conservation Service.)



Compost blanket application. (Credit: Tom Gore, Altitude Training.)

Notes

Mulching cleared areas can immediately reduce color and texture contrast of exposed soils, but also reduces erosion, aids in moisture retention, and provides organic matter that aids revegetation, which ultimately reduces long-term visual impacts. Furrowing slopes and providing planting pockets or holes also aids revegetation, providing similar long-term visual contrast reduction. Mulch should be certified as weed-free when possible.

Limitations

Mulch should not be spread on undisturbed areas or wetlands. Mulch can also act as a fire fuel—discretion must be exercised when placing mulch at or near energized equipment where sparking/arcing is possible, or near hot equipment.

Furrowing slopes results in increased water retention, reduced erosion, and better revegetation. (Credit: John McCarty, Colorado Department of Transportation.)

Preparing furrows along a slope to plant bare-root stock. (Credit: John McCarty, Colorado Department of Transportation.)

Preparing a planting pocket. (Credit: John McCarty, Colorado Department of Transportation.)

Planting a conifer in a planting pocket. (Credit: John McCarty, Colorado Department of Transportation.)

A successfully revegetated area after re-establishing surface texture, seeding, planting, and maintenance. (Credit: John McCarty, Colorado Department of Transportation.)

6.8.8 Use Pitting and Vertical Mulching to Facilitate Revegetation and Discourage Vehicle Traffic

Project Phase: **Construction, Decommissioning**

Disturbed surfaces with compacted soils, such as abandoned roads, should be revegetated using pitting and vertical mulching techniques. Pits should be dug 6 to 12 in. deep and spaced approximately 12 in. apart. Dead brush, bunch grasses, and various woody materials and rocks gathered from nearby areas should then be placed onto the ground surface, as well as upright, into the soil (vertical mulching).

Pitting an abandoned roadway. (Credit: BLM.)

Notes

Pitting decompacts the soil and creates depressions for windblown seeds and water to collect, thereby encouraging seed germination and seedling survival. Vertical mulching (1) captures and stabilizes windblown soil and seed; (2) slows water movement and increases soil water retention; (3) provides shade and cover for germinating seeds and seedlings; (4) increases soil organic matter; (5) provides habitat for animals and insects; and (6) discourages vehicle traffic.

In order to help conceal areas of vegetation loss and soil disturbance, limbs, other vegetation, and rocks used for vertical mulching should be scattered in a natural-appearing arrangement. Vegetation used should match the color and texture of the vegetation in nearby areas as closely as possible, and should be “planted” at the same density as in nearby areas.

Vertical mulch in an abandoned roadway. (Credit: BLM.)

Limitations

In some environments, particularly the desert southwest, successful revegetation is difficult; in recognition of this limitation, avoidance of these areas should be considered.

6.8.9 Revegetate Using Salvaged Native Plants and Approved, Weed-free Seed Mixes

Project Phase: Construction, Decommissioning

Disturbed surfaces should be revegetated using salvaged native vegetation or using BLM-approved seed mixes consisting of weed-free native grasses, forbs, and shrubs representative of the surrounding and intact native vegetation composition. The seed should be appropriate to the geographic and elevation characteristics of the area to be seeded. The seed should be tested for viability no more than 1 year prior to application. The seed mix should be specified as pure live seed (PLS) pounds per acre and seed delivered should be labeled as to the content (species, PLS). Certified "noxious weed-free" seed must be used on all areas to be restored. Other construction material, such as fill and straw mulch, should also be free of noxious weed seed.

Reseeding a ROW on BLM-administered land. (Credit: BLM.)

Notes

Using salvaged native vegetation may greatly speed revegetation, helping to restore the textures and colors of native vegetation more rapidly than starting from seed. Using native plants and seed helps ensure that revegetated areas will blend in visually with the surrounding landscape, and reduces the likelihood of invasive plant colonization that can introduce contrasting colors and textures, among other negative visual and non-visual impacts. Vegetation management during construction should include repairing soil compaction (e.g., by aeration or sand addition after construction activities have ceased).

Limitations

In some environments, particularly the desert southwest, successful revegetation with native seed mixes is difficult, and in recognition of this limitation, avoidance of these areas should be considered.

6.8.10 Transplant Vegetation from Cleared Areas

Project Phase: Construction

Vegetation from areas that are to be cleared or thinned for construction or visual mitigation should be transplanted into areas that were disturbed and cleared during construction.

Transplanting dormant vegetation. (Credit: John McCarty, Colorado Department of Transportation.)

Notes

Where feasible, transplanting existing vegetation will restore the landscape's visual character more quickly than seeding, particularly in arid regions.

Limitations

Some species are unlikely to survive transplanting under any circumstances. Smaller specimens may have a greater chance of survival than larger specimens. In some environments, particularly the desert southwest, successful transplanting may be difficult, and transplanted plants may require maintenance to ensure survival.

6.8.11 Monitor and Maintain Revegetated Areas until Vegetation Is Self-Sustaining

Project Phase: Construction, Decommissioning

The project developer should monitor and maintain revegetated surfaces. Corrective measures should be conducted as needed until a self-sustaining stand of vegetation is re-established and visually adapted to the undisturbed surrounding vegetation. No new disturbance should be created during operations without completion of a VRM analysis and approval by the authorized officer.

Notes

Poorly maintained revegetation efforts may lead to invasive plant colonization, erosion, and dust, all of which have negative visual impacts and negative effects on wildlife, air and water quality, and other resources.

Limitations

In some environments, particularly the desert southwest, successful revegetation may be difficult, and may take years. Maintaining revegetation efforts long after the other decommissioning procedures have concluded will be difficult, and may need to be incorporated as a condition of the lease.

6.9 Reclamation

These BMPs promote successful interim and long-term reclamation through good recountouring practices, site preparation to promote revegetation, and removal of structures and surface treatments.

6.9 Reclamation	Siting and Design	Construction	Operations	Decommissioning and Reclamation
6.9.1 Review Predevelopment Visual Conditions after Construction (p 266)		●		
6.9.2 Begin Site Reclamation during Construction and Operations, Immediately after Disturbances (p 268)		●	●	
6.9.3 Recontour Disturbed Areas to Approximate Natural Slopes (p 270)		●		●
6.9.4 Scarify/Roughen Cut Slopes and Recontoured Areas (p 272)		●		●
6.9.5 Salvage and Replace Rocks, Brush, and Woody Debris (p 274)		●		●
6.9.6 Sculpt and Shape Bedrock Landforms (p 275)		●		
6.9.7 Remove Two-Track Roads (p 279)		●		●
6.9.8 Close and Remediate Unused Access Roads (p 281)			●	●
6.9.9 Remove Above-Ground and Near-Ground Structures (p 283)				●
6.9.10 Remove or Bury Gravel and Other Surface Treatments (p 284)				●

6.9.1 Review Predevelopment Visual Conditions after Construction

Project Phase: Construction

Predevelopment visual conditions and the inventoried visual quality rating and scenic integrity should be reviewed after construction.

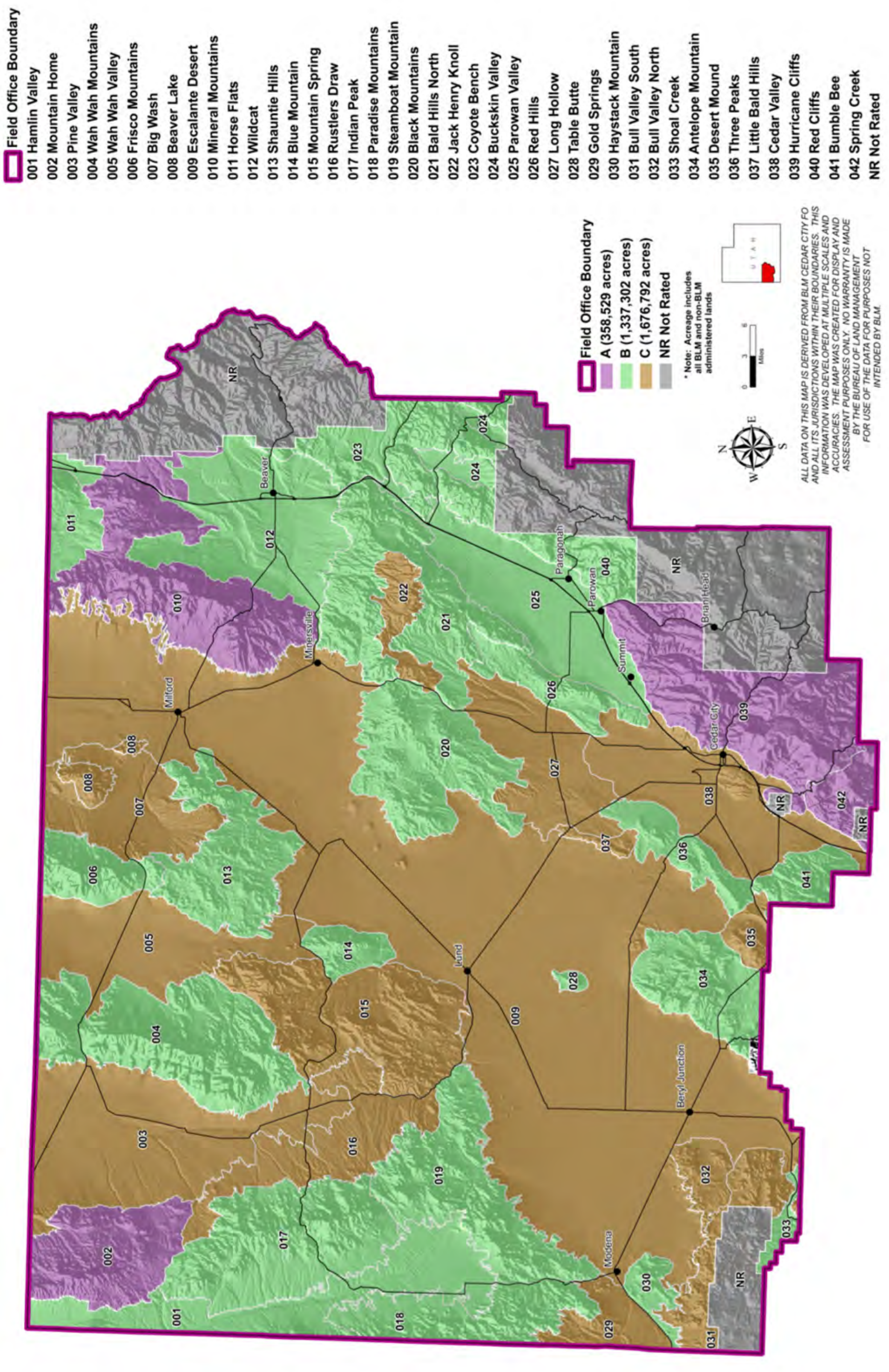
BLM VRI Scenic Quality Rating Unit photo. (Credit: BLM.)

Notes

Predevelopment visual conditions and the inventoried visual quality rating and scenic integrity should be reviewed after construction to assess the degree of change, in order to help implement appropriate mitigation and identify any additional mitigation needed. Mitigation efforts should be directed at restoring the visual elements of form, line, color, and texture as closely as possible to predevelopment conditions or to the current surrounding landscape conditions, whichever achieves the best visual quality and most ecologically sound outcome.

Limitations

Restoration of predevelopment conditions may not be feasible or even possible in some instances, for example, if extensive landforming has been required. During facility operations, vegetation clearing may need to be maintained for technical or safety reasons, for example, tree clearing (especially to remove upwind interferences with wind farms) or vegetation clearing (e.g., for fire safety around thermoelectric technologies such as CSP and geothermal).



BLM Scenic Quality Rating map. (Credit: BLM.)

6.9.2 Begin Site Reclamation during Construction and Operations, Immediately after Disturbances

Project Phase: Construction, Operations

Begin site reclamation activities during construction and during operations, as soon as possible after disturbances.

Had this pipeline installation been remediated immediately after construction, the visual impacts of erosion and weed infestation might have been avoided. (Credit: BLM.)

Notes

Reclamation of the areas disturbed during project construction or operations should begin immediately after the disturbance to reduce the likelihood of visual contrasts associated with erosion and invasive plant infestation, and to reduce the visibility of affected areas. Disturbed surfaces should be restored as closely as possible to their original contour or planned finished grade and revegetated immediately after construction in that area is completed. Action should be prompt in order to limit erosion and accelerate restoration of the preconstruction color and texture of the landscape. Interim restoration should also be undertaken during the operating life of the project, as soon as possible after disturbances occurring during operations.

Other interim visual reclamation efforts may include treatments such as thinning and feathering vegetation along project edges, enhanced contour grading, salvaging landscape materials from within construction areas, invasive plant control, or special revegetation, as approved by the BLM. In addition to reducing visual impacts during construction processes that often go on for years, undertaking these activities during construction takes advantage of the availability of equipment and labor already onsite, thereby achieving cost savings.

These interim reclamation activities should be included in the project construction plans and specifications.

Limitations

Weather, soil conditions, ecological considerations, and technical considerations may delay interim reclamation activities.

6.9.3 Recontour Disturbed Areas to Approximate Natural Slopes

Project Phase: Construction, Decommissioning

Recontour soil borrow areas, cut and fill slopes, berms, waterbars, and other disturbed areas to approximate naturally occurring slopes.

Slope recontouring to approximate naturally occurring slopes during road reclamation. (Credit: BLM.)

Notes

Contouring to approximate naturally occurring slopes reduces form contrasts between disturbed areas and the natural environment.

Limitations

Naturally occurring contours and slopes may be difficult to recreate in some circumstances; for example, if substantial grade alterations are necessary to install a permanent road with adequate grades and shoulder slopes, or if rock outcrops were removed.

Slope recontouring for road reclamation. (Credit: John McCarty, Colorado Department of Transportation.)

The recontoured slope for this reclaimed road blends in well with the naturally occurring slope. (Credit: BLM.)

6.9.4 Scarify/Roughen Cut Slopes and Recontoured Areas

Project Phase: Construction, Decommissioning

Cut slopes and recontoured areas should be randomly scarified and roughened to reduce texture contrasts with existing landscapes and aid in revegetation.

This roughened slope will revegetate faster and more completely than a smooth slope. (Credit: BLM.)

Notes

Contouring to a rough texture traps seeds and water and discourages off-road travel, thereby facilitating revegetation and reducing visual impacts associated with erosion. Trackwalking, a process by which a tracked vehicle is "walked" up and down cut-and-fill slopes to create shallow tractor cleat imprints that trap seeds and moisture, thereby increasing germination and establishment, may be used in areas where soils are already compacted, as is the case on many construction sites.

Limitations

Because trackwalking involves heavy equipment, it can increase soil compaction, and the practice is best suited to sites where soils are already compacted. Trackwalking should not be used where soils have been deeply ripped and roughened, as it may compact the loosened soil and make the surface smoother than it would otherwise be. Trackwalking is not appropriate for long, steep slopes. The track impressions may not be rough enough to trap the large volume of fast-moving stormwater that may occur on long, steep slopes in large rainstorms.

Trackwalking: a tracked vehicle is "walked" up and down cut-and-fill slopes, leaving a pattern of tractor cleat imprints that traps seeds and moisture, increasing germination and establishment. (Credit: Tom Gore, Altitude Training.)

Trackwalking close up: the tractor cleat imprints are an inch or two deep, and their orientation helps slow water runoff and erosion while trapping seed and increasing soil moisture to aid germination and seedling growth. (Credit: Tom Gore, Altitude Training.)

6.9.5 Salvage and Replace Rocks, Brush, and Woody Debris

Project Phase: Construction, Decommissioning

Rocks, brush, and woody debris should be salvaged and replaced to approximate pre-project visual conditions.

The placement of salvaged woody debris in this reclaimed road helped to restore natural textures and colors to the reclaimed area. (Credit: John McCarty, BLM.)

Notes

The replacement of rocks, brush, and woody debris will help "soften" the color and texture contrasts associated with project-related vegetation clearing and site grading to re-establish the pre-disturbance surface character. In addition, restoring brush and woody debris reduces wind and water erosion, and may improve water retention, aiding revegetation.

Limitations

Ecological and safety concerns may preclude full restoration of rocks, brush, and woody debris.

The placement of salvaged rocks on this slope helps to restore a more natural appearance to the reclaimed area, and holds soil in place for successful revegetation. (Credit: John McCarty, Colorado Department of Transportation.)

6.9.6 Sculpt and Shape Bedrock Landforms

Project Phase: Construction

Natural or previously excavated bedrock landforms should be sculpted and shaped when excavation of these landforms is required.

Failure to replace the rock shelf properly has caused erosion and visual contrasts in form, line, color, and texture that are visible for long distances. (Credit: BLM.)

Notes

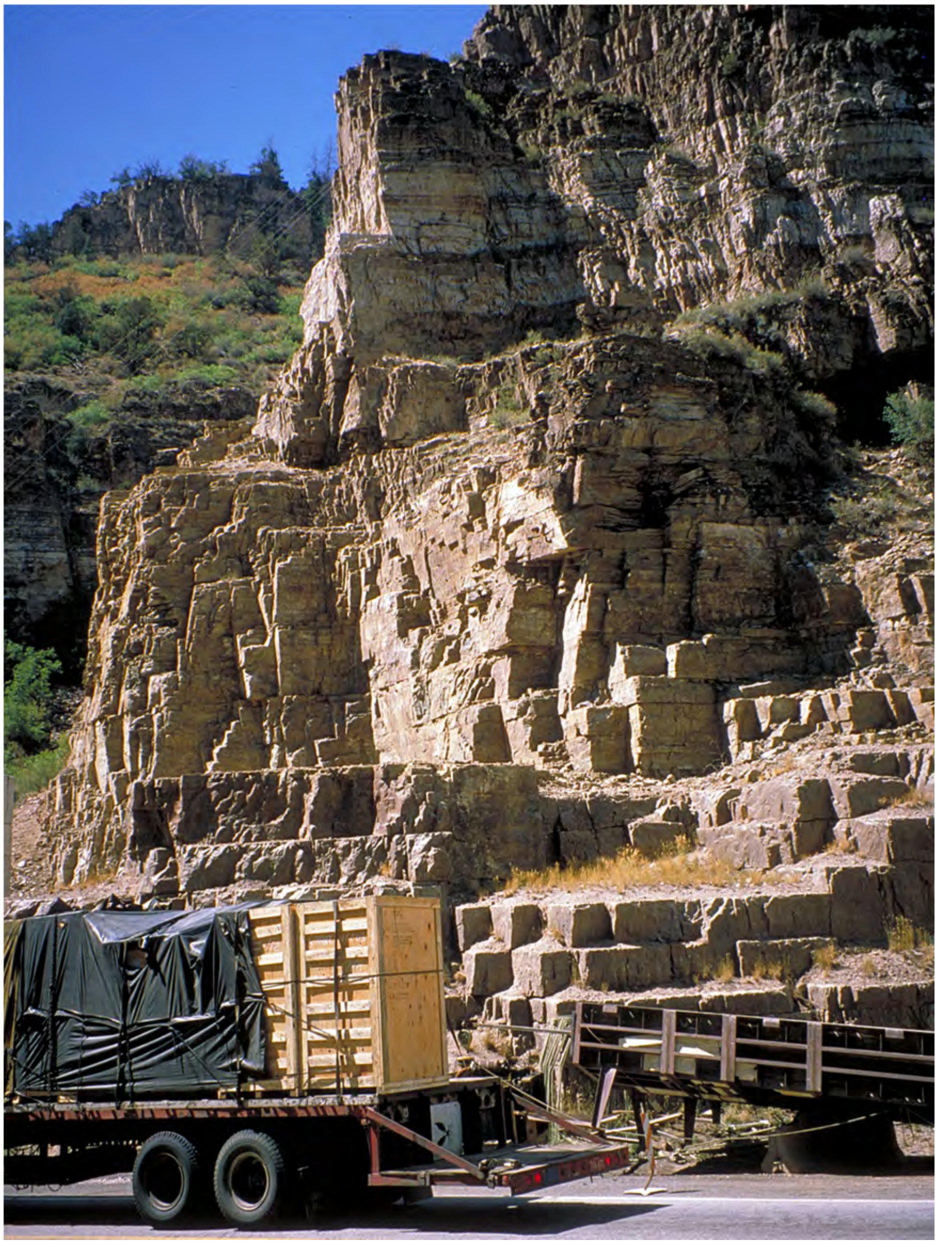
Backslopes, benches, and vertical variations should be integrated into a final landform that repeats the natural shapes, forms, textures, and lines of the surrounding landscape. The earthen landform should be integrated and transitioned into the excavated bedrock landform. Sculpted rock face angles, bench formations, and backslopes should adhere to the natural bedding and fracture planes of the natural bedrock geology. Extensive rock faces should be broken up by benches placed such that they repeat lines of naturally occurring strata. Half-cast drill traces from pre-split blasting should not remain evident in the final rock face.

Limitations

In some areas, the geology will make sculpting and shaping bedrock difficult because of concerns about landform and rock face stability, and the presence of thick overburden.

Half cast drill traces in sandstone have an obvious artificial appearance. (Credit: U.S. Department of Transportation Federal Highway Administration.)

Proper replacement of this rock shelf preserves the form, line, and texture of the original rock shelf, and color contrast will be greatly reduced when revegetation occurs. (Credit: John McCarty, Colorado Department of Transportation.)



Rock sculpting in progress. (Credit: Colorado Department of Transportation.)

A freshly shaped and sculpted rock cut. (Credit: John McCarty, BLM.)

After revegetation, a properly shaped and sculpted rock cut blends in well with the surrounding landscape. (Credit: BLM.)

6.9.7 Remove Two-Track Roads

Project Phase: Construction, Decommissioning

Temporary two-track roads should be removed, and the land should be restored to its natural state, as soon as possible.

A two-track road built to provide access to a transmission ROW. (Credit: USDA Forest Service.)

Notes

Temporary roads needed for construction should be removed as quickly as possible after construction is completed.

Limitations

Some construction roads may be needed for ROW maintenance. If the necessity for an all-weather access road arises, the operator must consult with the surface management agency to determine whether all or a portion of the road needs to be upgraded.

6.9.8 Close and Remediate Unused Access Roads

Project Phase: Construction, Decommissioning

All new access roads that are not needed or required for maintenance should be closed using the most effective and least environmentally damaging methods appropriate to that landscape setting.

Closed and remediated road. (Credit: BLM.)

Notes

Closure and remediation of new access roads that are not needed or required for maintenance limits new or improved accessibility into formerly difficult-to-access areas; increased accessibility to such areas often results in increased visual impacts, and may also have other negative consequences, such as vegetation damage and soil erosion.

Limitations

Operation of geothermal plants is likely to involve abandonment of some of the initial wells and construction of new wells during the operating life of the plant. Access roads will be required for those well installations throughout the course of the plant's operating life.

Road removal in progress. The flat road surface is roughened, rocks are added, and vegetation transplanted from the edges of the ROW. (Credit: BLM.)

6.9.9 Remove Above-Ground and Near-Ground Structures

Project Phase: Decommissioning

Most above-ground structures and near-ground pipelines, conduits, and other connecting structures should be removed upon completion of a project.

Culvert removal during road decommissioning. (Credit: Washington State Recreation and Conservation Office.)

Notes

Removal of above-ground structures avoids long-term negative visual impacts.

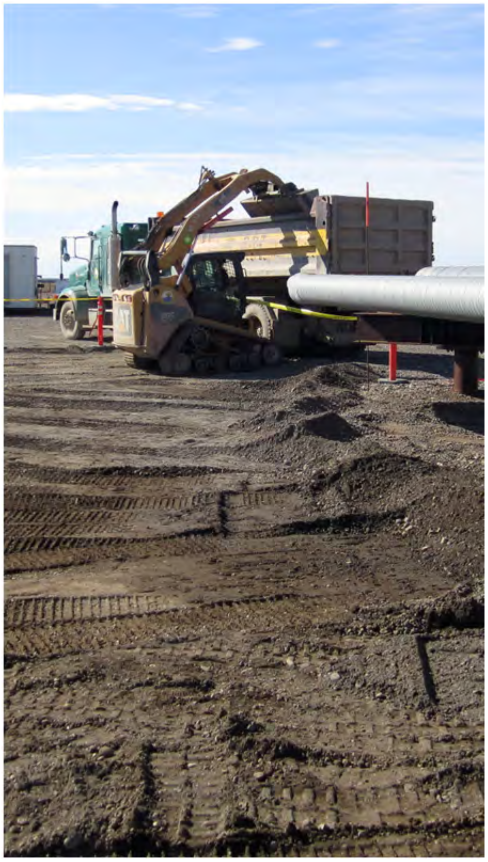
Limitations

Exceptions may be necessary for massive structures or certain underground structures. The BLM has approved abandonment in place (or required only partial removals of buried objects to specified depths) for structures that would not interfere with revegetation or future land uses and that have adequate environmental remediation. Consultation on removal/abandonment requirements will be necessary.

6.9.10 Remove or Bury Gravel and Other Surface Treatments

Project Phase: Decommissioning

Gravel and other surface treatments should be removed or buried as part of project decommissioning.



Gravel pad removal. (Credit: Alaska Department of Environmental Conservation.)

Notes

Removal of gravel and other surface treatments such as concrete or asphalt avoids long-term color and texture contrasts and associated potentially negative visual impacts. If these materials are buried, they should be buried to a depth of 3 ft or more, if possible.

Limitations

Burial of surface treatments may be infeasible or undesirable for a variety of technical and environmental reasons (e.g., where surface treatements contain chemicals that might contaminate soil), and must be approved by the BLM.

6.10 Good Housekeeping

These BMPs address measures to keep the site clean and orderly during construction, operations, and decommissioning.

6.10 Good Housekeeping	Siting and Design	Construction	Operations	Decommissioning and Reclamation
6.10.1 Develop "Housekeeping" Procedures (p 286)		●	●	●
6.10.2 Maintain a Clean Worksite (p 287)		●	●	●
6.10.3 Prohibit Onsite Burning (p 289)		●	●	●
6.10.4 Use Exit Tire Washes and Vehicle Tracking Pads to Reduce the Tracking of Sediment onto Roads (p 290)		●		●
6.10.5 Remove or Avoid Slash Piles (p 292)		●		
6.10.6 Clean Off-Road Equipment (p 294)		●	●	●
6.10.7 Remove Stakes and Flagging (p 295)		●		●
6.10.8 Use Fabric-Covered Fences to Conceal Material Storage Yards and Laydown Yards (p 296)		●		
6.10.9 Actively Maintain Operating Facilities (p 298)			●	

6.10.1 Develop "Housekeeping" Procedures

Project Phase: Construction, Operations, Decommissioning

"Housekeeping" procedures should be developed for the project to ensure that the project site and lands adjacent to the project site are kept clean of debris, garbage, graffiti, fugitive trash, or waste generated onsite; procedures should extend to control of "trackout" of dirt on vehicles leaving the active construction site and controlling sediment in stormwater runoff.

Clear communication about good housekeeping procedures is essential. (Credit: Lake County Stormwater Management Commission.)

Notes

A plan for minimizing waste generation and for regular cleanup of debris and trash should be in place throughout all onsite phases of the project. The plan should incorporate regulatory requirements associated with the interim storage of wastes on the site and an applicable General Stormwater Permit. Onsite debris and trash is unsightly and projects a bad image of the project and the developer; it also can be an environmental, safety, and wildlife hazard.

6.10.2 Maintain a Clean Worksite

Project Phase: Construction, Operations, Decommissioning

Facilities and offsite surrounding areas should be kept clean of debris, fugitive trash or litter, and graffiti. Surplus, broken, and used materials and equipment of any size should not be allowed to accumulate. Scrap heaps and materials dumps should be prohibited. Materials storage yards should be kept to a minimum.

Debris pile at an operating geothermal plant creates an eyesore. (Credit: BLM.)

Notes

The worksite must be kept clean through a combination of regular cleanup, waste minimization, and carefully planned onsite materials storage. The worksite should be routinely inspected to ensure that material, debris, trash, and litter are not becoming a worksite issue.

Limitations

Active construction sites involve considerable visual clutter, including temporary piles of debris.

A clean and orderly worksite has fewer negative visual impacts and promotes a positive image of the developer and the BLM. (Credit: Robert Sullivan, Argonne National Laboratory.)

6.10.3 Prohibit Onsite Burning

Project Phase: Construction, Operations, Decommissioning

The burning of trash should be prohibited during construction, operations, and decommissioning; trash should be stored in containers and/or hauled offsite.

Onsite burning creates smoke plumes that can be visible for miles. (Credit: State of Washington Department of Ecology.)

Notes

Burning trash onsite produces smoke that can be visible for long distances; it is also a source of odors and potentially toxic fumes, as well presenting a fire hazard.

Limitations

Depending on circumstances, burning of wood debris may be the most environmentally preferred option.

6.10.4 Use Exit Tire Washes and Vehicle Tracking Pads to Reduce the Tracking of Sediment onto Roads

Project Phase: Construction, Decommissioning

Construction sites should have entrances, exits, and parking areas with exit tire washes and/or vehicle tracking pads to reduce the tracking of sediment onto roads; these areas should be kept clean.

An exit tire wash removes dust, soil, mud, and other materials from trucks to minimize potential trackout of material onto roadways. (Credit: Tom Gore, Altitude Training.)

Notes

Trackouts of mud and other debris onto a high-speed highway represent a significant safety hazard for vehicles traveling that highway, and may also introduce sediment into nearby water bodies. Safety and water quality protection are the primary reasons exit tire washes and vehicle tracking pads are installed at construction sites; however, trackouts are unsightly, and tracked soil is also a potential transport mechanism for invasive species. The use of exit tire washes and vehicle tracking pads will avoid or reduce the visual contrasts that result from tracking of sediment onto roads; avoid or reduce the visual contrasts that may result from invasive plants; and help preserve the visual quality of water bodies where sediment from trackouts could degrade water clarity.

Limitations

Tire washes may be unnecessary or undesirable in desert environments. Both tire washes and vehicle tracking pads introduce their own visual contrasts, which could be substantial in some settings.

A vehicle tracking pad is typically a stabilized pad of coarse aggregate over a geotextile base installed at construction site exits to roadways. When vehicles drive over the pad, the tires sink into the rock slightly and mud on the tires is removed. (Credit: Tom Gore, Altitude Training.)

6.10.5 Remove or Avoid Slash Piles

Project Phase: Construction

Remove slash from view during construction activities. In particular, slash should not be left in sensitive viewing areas. Alternatively, where feasible, avoid slash piles by chipping and spreading slash on disturbed soils to reduce erosion, restore organic matter, and reduce color and texture contrasts.

Slash stored in an already disturbed area, away from visually sensitive locations. (Credit: BLM.)

Notes

Slash piles add visual clutter to a project site, and are obvious reminders of environmental effects of the project.

Limitations

Depending on site vegetation, there may be too much slash to avoid slash piles completely, at least temporarily. Freshly chipped wood may create color contrasts with soils and vegetation; however, the color of the chipped wood will fade with time. If slash is made available to the public for firewood, then slash piles may be located in accessible (and visible) areas. Fire safety control may preempt certain slash control strategies. Chipped wood and slash can attract undesired insect infestations (e.g., bark beetles).

6.10.6 Clean Off-Road Equipment

Project Phase: Construction, Operations, Decommissioning

The responsible party should clean all equipment that may operate off-road or disturb the ground before beginning construction, operation and maintenance activities, or decommissioning. This process cleans tracks and other parts of the equipment that could trap soil and dust.

Notes

Cleaning off-road equipment reduces trackouts and dust that not only can cause visual impacts, but also can present safety hazards, impact water quality, and spread invasive species.

6.10.7 Remove Stakes and Flagging

Project Phase: Construction, Decommissioning

All stakes and flagging should be removed from the construction area and disposed of in an approved facility.

Notes

Highly reflective flagging can be visible for long distances, and flagging and stakes can persist in certain environments for years. They are easily removed, however, as part of "good housekeeping" procedures.

Limitations

For temporary onsite haul roads, highly visible staking and flagging may be important to help drivers stay on stable ground. Staking is also critical to site preparation when grade changes are required or sensitive areas must be marked to avoid disturbance (e.g., sage-grouse nesting areas). Stakes and flags should be removed once their purpose is met.

6.10.8 Use Fabric-Covered Fences to Conceal Material Storage Yards and Laydown Yards

Project Phase: Construction

During construction, temporary chain-link fences surrounding the material storage yards and laydown yards should be covered with fabric.

A fabric-covered temporary chain-link fence surrounding an equipment and materials storage yard provides effective screening for visual clutter behind the fence. (Credit: Robert Sullivan, Argonne National Laboratory.)

Notes

Use of fabric coverings on construction fences will limit views into visually cluttered material storage yards and laydown areas, resulting in a more unified and tidy appearance.

Limitations

In areas of high winds, fabric-covered fences may be blown over. Slits or holes in the fabric may be required to allow wind to pass through. Fences are only effective for screening when observers are at the same or lower elevation than the facility (i.e., fabric-covered fences will not be effective screens for views from elevated KOPs).

6.10.9 Actively Maintain Operating Facilities

Project Phase: Operations

Operating facilities should be actively maintained during operation.

A well-maintained solar facility. (Credit: Robert Sullivan, Argonne National Laboratory.)

Notes

Maintenance should be part of the mitigation strategy. Well-maintained structures, facilities, and landscapes contribute to the overall quality of a landscape. Poorly maintained structures and landscapes reduce the visual quality of a landscape and can result in "eyesores." Maintenance activities and schedule should be addressed in the construction plan approval process.

Limitations

Weather conditions may temporarily interfere with certain maintenance activities. For example, applying/repairing paints and corrosion control coatings is usually temperature and humidity dependent.

BMP Source Documents

***Note to Reader:* The following sources were consulted when compiling the BMPs in this publication. It is likely that at the time of publication that some of these Web pages may no longer be available or their URL addresses may have changed.**

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Acronym List

AVWS	Audio Visual Warning System
BLM	Bureau of Land Management
BMP	best management practice
BUG	Backlight, Uplight, and Glare
CLFR	compact linear Fresnel reflector
CPV	concentrating photovoltaic
CSP	concentrating solar power
DOI	Department of the Interior
EPACT 2005	Energy Policy Act of 2005
FAA	Federal Aviation Administration
FLPMA	Federal Land Policy and Management Act of 1976
GIS	geographic information systems
GPS	global positioning system
HTF	heat transfer fluid
IES	Illuminating Engineering Society
KOP	key observation point
LED	light-emitting diode
MW	megawatt(s)
NEPA	National Environmental Policy Act of 1969
NHPA	National Historic Preservation Act of 1966
NPS	National Park Service
NREL	National Renewable Energy Laboratory

O&M	operation and maintenance
PLS	pure live seed
POD	Plan of Development
PV	photovoltaic
RMP	resource management plan
ROW	right-of-way
SEGS	Solar Electric Generating System
SLRU	sensitivity level rating unit
SQRU	scenic quality rating unit
STG	steam turbine generator
USFWS	U.S. Fish and Wildlife Service
VCR	visual contrast rating
VIA	visual impact assessment
VRI	visual resource inventory
VRM	visual resource management

Glossary

Access road
Gravel or dirt road (rarely paved) that provides overland access to transmission line and pipeline rights-of-way and facilities for construction, inspection, maintenance, and decommissioning.

Aeration
The process by which atmospheric air enters the soil. The rate and amount of aeration depends on the size and continuity of the pore spaces within the soil and the degree of water logging.

Aggregate
Mineral materials such as sand, gravel, crushed stone, or quarried rock used for construction purposes.

Air-cooled
See Dry-cooling system.

Air quality
Measure of the health-related and visual characteristics of the air to which the general public and the environment are exposed.

All-American Road
A road recognized by the United States Department of Transportation under the National Scenic Byways Program as possessing two of six "intrinsic qualities," including archeological, cultural, historic, natural, recreational, and/or scenic quality. *See* National Scenic Byway.

Ancillary structure
Additional built feature (i.e., a substation).

Array
The positioning and spatial arrangement of energy collection devices (wind turbines or solar energy collectors [mirrors, heliostats, or panels]) of an energy facility, or the energy collection devices themselves, referred to collectively.

Atmospheric refraction
The deviation of light from a straight line as it passes through the atmosphere due to the variation in air density as a function of altitude.

Audio Visual Warning System (AVWS)
A navigation hazard warning system that activates obstruction lighting and audio signals to alert aircraft pilots of potential collisions with tall obstacles, typically wind turbines or communications towers.

Authorized Officer
BLM employee responsible for exercising BLM's enforcement authority to require compliance with the terms and conditions of a ROW grant (or grants).

Avian
The scientific classification for all bird species.

Azimuth
The horizontal angular distance from a reference direction, usually the northern point of the horizon, to the point where a vertical circle through a celestial body (e.g., the sun) intersects the horizon, usually measured clockwise.

Backdrop
The landscape, seascape, or sky visible directly behind the visible elements of a facility, as seen from a particular viewpoint.

Backlit
A lighting condition in which the side of an object facing the viewer is shaded, and sunlight or daylight is visible behind the object, causing it to appear in silhouette.

Backslope
In road engineering, the slope above the roadway in a road cut. The backslope extends from the top of the cut at the existing grade to the bottom of the ditch or edge of the shoulder on the inside of the road.

Bedding plane
A distinct surface of contact between two sedimentary rock layers.

Bedrock
General term referring to the solid rock or ledge underlying other unconsolidated material (soil, loose gravel, etc.).

Bench
A relatively level step, excavated into a slope on which fill is to be placed. Its purpose is to provide a firm, stable contact between the existing material and new fill that is to be placed on top of the bench.

Berm
An artificially constructed continuous ridge or bank of earth, usually constructed and located to reduce erosion or screen an object from view.

Best Management Practice (BMP)
A practice or combination of practices that are determined to provide the most effective, environmentally sound, and economically feasible means of managing an activity and mitigating its impacts.

Blackbody radiation
The electromagnetic radiation that would be emitted from an ideal object (blackbody) capable of absorbing all radiant energy that falls upon it.

Blade
The aerodynamic structure on a wind turbine that catches the wind. Most utility-scale wind turbines have three blades.

Blade glint
A brief bright and sometimes repetitious reflection of sunlight from the surface of rotating wind turbine blades. *See* Glint; Glare.

Borrow area
A pit or excavation area used for obtaining earth materials (borrow) such as sand or gravel for use in construction.

Brush-beating
Mowing of shrubs to reduce height.

Catalytic converter
An antipollution device on an automotive exhaust system.

Check dam
A small, temporary water control structure that is constructed across a swale or channel and used to slow the velocity of concentrated water flows to help reduce erosion.

Closed-loop cooling system
Also known as a wet, closed-cycle cooling system, a system that circulates water between a steam condenser and a cooling tower to cool steam condensate at a thermoelectric power plant; the circulating water interacts with a counterflow (or crossflow) of ambient air at the cooling tower and is cooled through the principle of evaporation, at which point a small fraction of the water is evaporated. The evaporated amount is continually replaced to maintain the total volume of water in the system.

Clutter
See Visual clutter.

Color
The property of reflecting light of a particular intensity and wavelength (or mixture of wavelengths) to which the eye is sensitive. It is the major visual property of surfaces.

Compact Linear Fresnel Reflector (CLFR)
A type of concentrated solar power (CSP) technology similar to a parabolic trough design but using flat parallel mirrors, in which the sun's heat energy is reflected onto a receiver positioned above the mirrors and containing water; the water is converted to steam and delivered to a steam turbine-generator (STG) for production of electricity.

Compost blanket
A layer of loosely applied composted material placed on the soil in disturbed areas to reduce stormwater runoff and erosion. The material reduces runoff, and promotes stormwater infiltration and revegetation.

Concentrating Solar Power (CSP)
A solar energy system that uses mirrors or lenses to concentrate sunlight, or solar thermal energy, onto a collector. The heat from the concentrated sunlight is used to generate electricity through steam generation or by mechanical means.

Conductor
A substance or body that allows an electrical current to pass continuously along it. Electrical equipment receives power through electrical conductors.

Conservation easement
Easement restricting a landowner to land uses that are compatible with long-term conservation and environmental values.

Constructed landform
A manmade land feature that replicates the irregular shapes of natural slopes.

Construction staging area
A designated area where vehicles, supplies, and construction equipment are positioned for access and use at a construction site; in some cases a location at or very near where facility components will be installed, used for component assembly.

Contour grading
Changing the ground level to create curvilinear slopes rounded into existing terrain to produce a contoured and smooth transition from cut or fill faces to natural ground or abutting cut or fill surfaces.

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

Cooling tower
A structure in which heat used in electricity generation in thermal power plants (including certain types of solar and geothermal power plants) is removed from hot condensate.

Cultural resources
Archaeological sites, structures, or features; traditional use areas; and Native American sacred sites or special use areas that provide evidence of the prehistory and history of a community.

Culvert
A pipe or covered channel that directs surface water through a raised embankment or under a roadway, from one side to the other.

Cumulative impacts
The impacts assessed in an environmental impact statement that could potentially result from incremental impacts of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (federal or nonfederal), private industry, or individual undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Cut-and-fill
The process of earth grading by excavating part of a higher area and using the excavated material for fill to raise the surface of an adjacent lower area.

Decommissioning
All activities necessary to take a facility out of service and dispose of its components after its useful life.

Digital terrain mapping
Representation of the earth's surface for a geographic area stored in a digital file containing regularly spaced point locations with an elevation attribute.

Directional drilling
The practice of drilling non-vertical wells, where the well bore is oriented laterally or at a slant from vertical; also called slant drilling.

Dish engine
A CSP technology that produces electricity, typically in the range of 3 to 25 kW, by using a single parabolic mirror or, more typically, a parabolic array of mirrors to reflect sunlight to heat a working gas (typically hydrogen) in a closed container, causing it to expand and drive a reciprocating engine connected to an electric generator. The dish engine is unique among CSP systems because it uses mechanical energy rather than steam to produce electricity.

Distance Zones
A set of pre-determined distances from a viewpoint. In the BLM's visual resource management system, landscapes are subdivided into threee distanced zones based on relative visibility from travel routes or observation points. The three zones are foreground-middleground, background, and seldom seen. The foreground-middleground zone includes areas seen from highways, rivers, or other viewing locations that are less than 3–5 mi away. Seen areas beyond the foreground-middleground zone but usually less than 15 mi away are in the background zone. Areas not seen as foreground-middleground or background (i.e., hidden from view) are in the seldom-seen zone.

Disturbed land
Land in which a discrete event or process has altered the land surface, the soil, and/or the vegetation.

Drilling (geothermal)
Boring into the earth to access geothermal resources.

Drill rig (geothermal)
Machinery (typically oil and gas drilling equipment that has been modified to meet geothermal requirements) used to bore through the ground to locate geothermal resources (hot water or steam).

Dry cooling
See Dry cooling system.

Dry cooling system
Also known as dry closed-loop cooling; a technology for rejecting heat from the steam condensate of a thermoelectric plant. Cooling water circulates in a closed loop between a steam condenser, where it accepts heat from steam condensate, and a dry condenser located outdoors. Fans are used to establish a flow of ambient air across the surface of the dry condenser, allowing the heated cooling water inside the dry condenser to transfer heat to the ambient air before cycling back to the steam condenser.

Dual flash
A configuration at a geothermal plant in which water leaving a separator is directed to another separator, where a lower pressure generates additional steam production.

Dust suppressant
Products (water, salts, synthetic emulsions) that abate dust by changing the physical properties of the soil surface, typically used on construction sites and unpaved roads; also referred to as a "dust palliative."

Effects
Environmental consequences (the scientific and analytical basis for comparison of alternatives) that occur as a result of a proposed action. Effects may be direct (caused by the action and occurring at the same time and place), indirect (caused by the action but occurring later in time or farther removed in distance, but still reasonably foreseeable), or cumulative (incremental impacts of the action when added to other past, present, and reasonably foreseeable future actions).

Emissivity
The relative power of a surface to emit heat by radiation.

Equipment and materials storage yard
An area at a construction site where materials other than individual components needed for construction are kept, and where construction-related wastes are temporarily stored.

Erosion
The wearing away of land surface by wind or water, intensified by land-clearing practices related to farming, residential or industrial development, road building, or logging.

Facility
An existing or planned location or site at which prime movers, electric generators, and/or equipment for converting mechanical, chemical, solar, thermal, and/or nuclear energy into electric energy are situated, or will be situated. A facility may contain more than one generator of either the same or different prime mover type.

Feathering
A technique for reducing a strong line of visual contrast by creating a more natural look along a vegetative edge through the retention of a mix of existing trees and shrubs in different sizes.

Fill
Manmade deposits of soil, rock, and/or waste material.

Flagging
Tape, stakes, or other materials (but not including paints or coatings) used in surveying and construction to mark important locations.

Footprint
The land or water area covered by a project. This includes direct physical coverage (i.e., the area on which the project physically stands) and direct effects (i.e., the disturbances that may directly emanate from the project, such as noise).

Forbs
Herbaceous (non-woody), broad-leaved flowering plants; non-graminoid (grasses, sedges, and rushes) herbaceous plants.

Form
The mass or shape of an object or objects that appears unified, such as a vegetative opening in a forest, a cliff formation, or a water tank.

Fracture plane
A surface of fracture representing a more-or-less clean-cut break in the rock body.

Frontlit
A lighting condition in which the side of an object facing the viewer is fully illuminated by light coming from behind the viewer.

Fugitive dust
The dust released from any source other than a definable point source such as a stack, chimney, or vent. Sources include construction activities, storage piles, and roadways.

Galvanized (metallic surface)
A metal surface (particularly iron or steel) coated with zinc.

Generation (electricity)
The process of producing electric energy by transforming other forms of energy; also, the amount of electric energy produced, expressed in watt-hours (Wh).

Geothermal
Of or related to the Earth's interior heat.

Geothermal energy
Natural heat from within the Earth, captured for the production of electric power. This energy may be in the form of steam, hot water, or the thermal energy contained in rocks at great depths.

Geothermal fluid
Hot, mineral-rich liquid or vapor that is the carrier medium that brings geothermal energy up through wells from the subsurface to the surface.

Geothermal pipeline system
A network of pipe that connects the power plant with production and injection wells.

Geothermal plant
A power plant in which the prime mover is a steam turbine. The turbine is driven either by steam produced from hot water or by natural steam that derives its energy from heat found in rocks or fluids at various depths beneath the surface of the earth. The energy is extracted by drilling and/or pumping.

Geothermal production
Electricity produced from the heat energy of the earth. This energy may be in the form of steam, hot water, or the thermal energy contained in rocks at great depths.

Geothermal steam
Steam drawn from deep within the earth.

Geysers, the
A large geothermal steam field located north of San Francisco.

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

Glint
A momentary flash of light resulting from a spatially localized reflection of sunlight. *See* Glare.

Grading
Mechanical process of moving earth to change the degree of rise or descent (slope) of the land in order to establish good drainage and otherwise suit the intent of a landscape design.

Ground receptor
Hikers, off-highway vehicle users, equestrians, and other visitors viewing the landscape from a normal human height above ground level, that can be impacted by renewable energy activities.

Grubbing
Removal of stumps, roots, and vegetable matter from the ground surface after clearing and prior to excavation.

Hazard navigation lighting
The illumination of an object for increased conspicuity to ensure the safety of air or water navigation, or the lighting equipment used to achieve this purpose.

Heat transfer fluid (HTF)
Fluid that transfers heat generated at the solar collectors or in geothermal systems to a heat exchanger where steam is produced to run a steam generator.

Heliostat
A power tower facility component consisting of a large, nearly flat mirror, usually on a tracker, pedestal, or other support structure, that allows it to continuously reflect the sun's rays over the course of the day onto a central receiver at the top of a centrally positioned tower.

Historic Trails
Routes of travel that commemorate historic (or prehistoric) trails of local, state, regional, or national significance.

Horizon line
The apparent line in the landscape formed by the meeting of the visible land surface and the sky.

Horizontal angle of view
The compass direction of the view from a viewer to a viewed object. The horizontal angle determines which side of the facility is in view, as well as the angle of the object's vertical surfaces with respect to the viewer.

Hub
The central portion of the rotor to which the blades of a wind turbine are attached.

Hybrid (wet-dry cooling) system
A variation on a dry cooling system. In a hybrid system, small amounts of water are sprayed as a fine mist into the flow of ambient air being directed over the surface of a dry condenser. The water evaporates, cooling the air as it does so. Alternatively, water is deluged over the surface of the dry condenser where it evaporates after interacting with the overflowing ambient air stream, cooling that air. Wet/dry hybrid systems consume only minor amounts of water (compared to wet closed-loop cooling) but offer significantly better performance than dry cooling systems, especially in hot climates with low relative humidity.

Impact
The effect, influence, alteration, or imprint caused by an action.

Intermittent stream
A stream that flows for a portion of the year but occasionally is dry or reduced to a pool stage when losses from evaporation or seepage exceed the available streamflow.

Invasive species
Any species, including noxious and exotic species, that is an aggressive colonizer and can out-compete indigenous species.

Inventory Observation Point (IOP)
In the BLM's visual resource inventory process, a location from which a scenic quality rating is conducted. An IOP is either an important viewpoint or is representative of the scenic quality rating unit being evaluated for scenic quality.

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.

Landform
Any recognizable physical form of the earth's surface, having a characteristic shape. Landforms include major forms such as plains, plateaus, and mountains, and minor forms such as hills, valleys, slopes, and moraines. Taken together, the landforms make up the surface configuration of the earth.

Landmark
A visually prominent physical feature of a landscape that attracts visual attention, such as a peak, knob, lake, or waterfall.

Landscape
The expanse of visible scenery including landforms, waterforms, vegetation, and manmade 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.

Land use
A characterization of land in terms of its potential utility for various activities, or the activities carried out on a given piece of land.

Laydown area
An area that has been cleared for the temporary storage of equipment and supplies for a construction activity; a location where individual components for use in construction are initially offloaded from their transport vehicle. To ensure accessibility and safe maneuverability for transport and offloading of vehicles, laydown areas are usually covered with rock and/or gravel.

Light-emitting diode (LED) lighting
A solid-state lamp that uses light-emitting diodes as the source of light.

Light fixture
An electrical device used to create artificial light and/or illumination.

Light pollution
Any adverse effect of manmade 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.

Light trespass
See Light spill.

Line
The path, real or imagined, that the eye follows when perceiving abrupt differences in form, color, or texture. Within landscapes, lines may be found as ridges, skylines, the edges of structures, the edges of water bodies, changes in vegetative types, or individual trees and branches.

Low-pressure sodium lamp
An energy-efficient form of outdoor lighting in which a lamp contains neon gas that lights at a relatively low temperature. As the temperature increases, sodium in the lamp begins to vaporize and creates a monochromatic yellow light.

Lumen
A unit of illumination; the amount of illumination of a unit area of spherical surface, due to a light of a unit intensity placed at the center of the sphere.

Luminaire
A complete lighting unit consisting of a lamp (or lamps) and the parts designed to distribute the light, to position and protect the lamp(s), and to connect the lamp(s) to the power supply. Also referred to as a light fixture. A full cutoff luminaire limits glare between 80° and 90° from the ground. A fully shielded luminaire emits no direct uplight, but does not limit glare between 80° and 90° from the ground.

Luminescent
Emitting light not caused by heat.

Luminosity
The brightness of a light source of a certain wavelength as it appears to the eye.

Mirror
A reflecting surface of one of various physical shapes (parabolic, nearly flat, or flat) used to reflect and/or concentrate the sun's energy to specific locations within solar energy facilities.

Mitigation
A method or process by which impacts from actions can be made less injurious to the environment through appropriate protective measures.

Mitigation measures
Methods or actions that will reduce adverse impacts from facility development. Mitigation measures can include best management practices, stipulations in BLM ROW agreements, siting criteria, and technology controls.

Mulch
Straw, shredded hardwood, or any other similar light, porous, organic substance that is spread to hinder weed growth and preserve moisture, or prevent erosion.

Nacelle
The housing that protects the major components (e.g., generator and gear box) of a wind turbine.

National Historic Preservation Act (NHPA)
A federal law providing that property resources with significant national historic value be placed on the *National Register of Historic Places*. It does not require permits; rather, it mandates consultation with the proper agencies whenever it is determined that a proposed action might impact a historic property.

National Historic Trails
Trails determined to have national historical significance, designated by Congress under the National Trails System Act of 1968 and that following, as closely as possible, on federal land, the original trails or routes of travel.

National Monuments
An area owned by the Federal Government and administered by the National Park Service, the BLM, the U.S. Fish and Wildlife Service, and/or U.S. Forest Service for the purpose of preserving and making available to the public a resource of archaeological, scientific, or aesthetic interest. National monuments are designated by the U.S. President, under the authority of the American Antiquities Act of 1906, or by Congress through legislation.

National Recreation Area
An area designated by Congress to assure the conservation and protection of natural, scenic, historic, pastoral, fish, and wildlife values, and to provide for the enhancement of recreational values.

National Register of Historic Places (NRHP)
A comprehensive list of districts, sites, buildings, structures, and objects that are significant in American history, architecture, archaeology, engineering, and culture. The NRHP is administered by the National Park Service, which is part of the Department of the Interior.

National Scenic Byway
A road recognized by the United States Department of Transportation under the National Scenic Byways Program as possessing one of six "intrinsic qualities," including archeological, cultural, historic, natural, recreational, and/or scenic quality. The National Scenic Byways Program was established by Congress in 1991 to preserve and protect the

nation's scenic but often less-traveled roads and promote tourism and economic development. The program is administered by the Federal Highway Administration. *See* All-American Road.

Native American
Of, or relating to, a tribe, people, or culture that is indigenous to the United States.

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

Noxious weeds
A plant species that has been designated by country, state, provincial, or national agricultural authority as injurious to agricultural and/or horticultural crops, natural habitats and/or ecosystems, and/or humans or livestock. Typically, noxious weeds grow aggressively, multiply quickly without natural controls, and adversely affect native habitats and native flora and fauna.

Ocular
Of or pertaining to the eye.

Operator
A person driving or controlling a piece of construction equipment.

Overburden
Rock or soil overlying a mineral deposit, archaeological site, or other underground feature or resource.

Parabolic trough
A type of CSP solar energy technology that uses parabola-shaped mirrors to concentrate sunlight on a receiver filled with a heat transfer fluid that subsequently transfers the heat it absorbs to water to produce steam to drive an STG to produce electricity. Parabolic trough systems typically mount the mirrors on a support that can track the sun's apparent east-to-west movement across the sky over the course of the day to increase solar energy capture.

Penalty clause
A statement in a contract that allows one party to charge extra money if the other party fails to follow the terms of the contract.

Perennial streams
Streams that flow continuously, because they lie at or below the groundwater table that constantly replenishes them.

Photovoltaic (PV)
Technology that utilizes semiconducting materials that convert sunlight directly into electricity.

Photovoltaic (PV) panel
A device for generating electricity using PV energy conversion, consisting of a (typically) flat, rectangular glass-covered sheet of PV materials that may consist of multiple solar cells organized into interconnected modules in

crystalline silicon PV panels or a sheet of PV materials in thin-film PV panels. Solar panels are typically mechanically fastened to a support structure, electrically interconnected, and designed to provide a field-installable unit.

Pipeline
A line of pipe with pumping machinery and apparatus for conveying liquids, gases, or finely divided solids between distant points.

Plan of Development (POD)
A document submitted to the BLM to obtain authorization to use federal lands for construction, operation, and maintenance of a renewable energy project. Includes engineering design information and mitigation measures.

Plant
A facility that is the location of prime movers, electric generators, and auxiliary equipment for converting mechanical, chemical, solar, thermal, and/or nuclear energy into electric energy. A plant may contain more than one type of prime mover.

Plume
A visible discharge of vapor and/or particulate matter from a given point of origin, for example, water vapor from a cooling tower.

Power block
The power plant system at which electrical power is generated. It includes the steam heat exchanger where the steam is produced, the STG that produces electricity, and the electrical equipment contained in a substation.

Power plant
A central generating facility that produces energy.

Power tower
A type of CSP technology composed of many large, sun-tracking mirrors (heliostats) that focus sunlight on a receiver at the top of a centrally located tower. The sunlight heats up a heat transfer fluid in the receiver, which then is used to generate steam (or directly heats water to produce steam) that powers an STG to produce electricity. Power tower systems can also be equipped with molten salt in which the heat generated at the receiver can be stored for delayed production of electricity.

Power tower system
See Power tower.

PV inverter
A device that converts direct current from PV arrays into utility-grade alternating current.

Receiver
A component of a solar energy facility that receives solar energy and converts it to useful energy forms, typically heat.

Reclamation
The restoration of land and water resources and the environment previously degraded by the adverse effects of an activity.

Recontouring
Changing of the ground level in a disturbed area to create curvilinear slopes that are blended into existing terrain. Recontouring takes place after a disturbance that changes the existing land contours.

Reflective
Capable of physically reflecting light or sound.

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

Re-injection line
Pipeline to return used geothermal fluids to the geothermal reservoir.

Renewable energy
Energy derived from resources that are regenerative or that cannot be depleted. Renewable energy resources include wind, solar, biomass, geothermal, and moving water.

Resource Mangement Plan (RMP)
A comprehensive land use plan for how BLM district or field offices will manage public land and federal minerals within district/field office boundaries for a period of 10–20 years. Decisions made in an RMP, once finalized, serve as the basis for every on-the-ground action the BLM field office(s) take(s), until it is time for the RMP to be revised again.

Retaining wall
A containment system that is built to resist lateral pressure, especially a wall built to prevent the advance of a mass of earth.

Retinal irradiance
Emission of rays of light to the retina of the eye.

Retro-reflective
A descriptive term for surfaces that reflect light back toward the light source with a minimum scattering of light.

Revegetation
The process of replanting on disturbed land. This may be a natural process produced by plant colonization and succession, or an artificial (manmade), accelerated process designed to replace vegetation that has been damaged, destroyed, or removed due to wildfire, mining, flood, development, or other causes.

Right-of-way (ROW)
Public land authorized to be used or occupied pursuant to a ROW grant. A ROW grant authorizes the use of a ROW over, upon, under, or through public lands for construction, operation, maintenance, and termination of a project.

Riprap
A layer of large un-coursed stones or broken rock.

Rotor nose cone
The exterior housing attached to the rotor hub after the blades have been installed in a wind turbine.

Scarify
To loosen topsoil or break up the soil surface to improve conditions for seed germination or vegetation planting. Also refers to nicking or abrading the hard seed coat of some plant species to aid germination.

Scenic integrity
The degree of "intactness" of a landscape, which is related to the existing amount of visual disturbance present. Landscapes with higher scenic integrity are generally regarded as more sensitive to visual disturbances.

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

Scenic quality rating
An assessment of scenic quality. In the BLM's VRI process, public lands are given an A, B, or C rating based on the apparent scenic quality, which is determined 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.

Sedimentation
The removal, transport, and deposition of sediment particles by wind or water.

Sediment fence
A temporary barrier used in construction; consists of filter fabric stretched and attached to support posts to detain small amounts of silt or soil in runoff from disturbed areas. Also referred to as a silt fence.

Seed mix
A composition of plant seeds typically developed through specifications that describe material and physical requirements.

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

Setback
The distance of a structure or other feature from the property line or other feature.

Shadow flicker
Refers to the flickering effect that occurs when a wind turbine casts shadows over structures and observers at times of day when the sun is directly behind the turbine rotor relative to the observer's position.

Shrubland
An area where shrubs are the dominant form of vegetation.

Sidelit
A lighting condition in which the side of an object facing the viewer is partly illuminated and partly shaded because sunlight is falling more or less perpendicular to the line of sight between the viewer and the object.

Site planning
The organizational stage in the design process that considers land use zoning, access, circulation, drainage, and other factors.

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

Skylining
Siting of a structure on or near a ridgeline so that it is silhouetted against the sky.

Slash
Any treetops, limbs, bark, abandoned forest products, windfalls, or other debris left on the land after timber or other forest products have been cut.

Soil stabilizer
A chemical that alters the engineering property of a natural soil; used to stabilize slopes and prevent erosion.

Solar array
See Solar collector array.

Solar collector
A component of a solar energy facility that receives solar energy and converts it to useful energy forms, typically heat or electricity. Major components include panels (for PV facilities) and mirrors or reflectors (for CSP facilities), additional features designed to further concentrate the incident sunlight (in some facilities), and a receiver or tube containing a heat transfer fluid.

Solar collector array
That portion of the solar energy facility containing components that track and/or capture sunlight and convert it to other useful forms of energy, typically heat or electricity. Solar collector arrays are typically composed of panels (for PV facilities), parabolic mirrors or heliostats (for CSP facilities), receivers containing some form of heat transfer fluid, and support structures and controls that allow the panels (for certain types of PV facilities) or mirrors to track the sun over the course of the day to maximize solar energy capture. Together, all components of the solar array make up what is known as the solar field of a solar energy facility.

Solar dish
A solar energy technology in which a parabolic mirror or a parabolic array of mirrors concentrates the rays of the sun to drive an external combustion engine (typically a Stirling engine).

Solar energy technology
Technology associated with any engineered method for harnessing, storing, and using the sun's energy.

Solar insolation
A measure of radiant energy from the sun received on a given surface area in a given time.

Specially designated areas
Land areas that have received recognition or designation because they possess unique or important resource values. Examples of BLM-administered specially designated areas include components of the BLM National Landscape Conservation System, areas of critical environmental concern, special recreation management areas, and areas with wilderness values. These areas may have been designated by Congress or by the BLM. Some specially designated areas are administered by the U.S. Forest Service, U.S. Fish and Wildlife Service, National Park Service, or states. While these areas would not generally be available for development of energy resources, they could be located near energy development areas and could be subjected to visual impacts associated with energy development on nearby lands.

Specular reflection
Also known as direct reflection, regular reflection, or mirror reflection. The reflection of electromagnetic rays without scattering or diffusion. In specular reflection, the angle at which the wave is incident on the reflecting surface is equal to the angle at which it is reflected from that surface. *See* Glint; Glare.

Staging area
A designated area where construction equipment is temporarily stored (usually only during the construction phase).

Steam field
Area where steam is drawn from deep within the earth for the purpose of providing geothermal energy.

Steam plumes
Visible water vapor emissions caused by the evaporative cooling system in a geothermal or solar energy plant.

Stormwater permit
A legal document from the state or Environmental Protection Agency (EPA) regional office submitted by the party in control of construction plans and specifications prior to any stormwater discharge from any construction activities.

Strata
Single, distinct layers of sediment or sedimentary rock.

Straw wattle
A long, tubular roll of weed-free straw wrapped in plastic netting used for erosion control.

Substation
An electrical system used to switch generators, equipment, and circuits or lines in and out of a system. It is also used to change alternating-current voltages from one level to another. A substation consists of one or more transformers and associated switchgear.

Sun angle
The angle of the sun above the horizon of the earth and its bearing (azimuth).

Swale
A low place in a tract of land. A wide, shallow ditch, usually grassed or paved.

Target height
The approximate height of an object of interest in the landscape that is added to the surface elevation in a viewshed analysis.

Terrain
Topographic layout and features of a tract of land or ground.

Texture
The visual manifestations of light and shadow created by the variations in the surface of an object or landscape.

Texture contrasts
Visual contrasts between different objects or landscapes resulting from different visual manifestations of texture.

Thermal expansion
Increase in volume of a material as its temperature is increased.

Thermoelectric technology
Energy technologies that generate electricity produced by heat from sources such as hot water or hot gases (e.g., steam).

Topographic relief
The elevation of a land surface relative to the surrounding ground level.

Topography
The shape of the earth's surface; the relative position and elevations of natural and manmade features of an area.

Topping
Removal or trimming of the upper canopy of a tree.

Tower
The base structure that supports and elevates a wind turbine rotor and nacelle.

Trackout
Material such as soil or rock that is transported via vehicle tires onto roadways or other paved surfaces.

Transmission (electric)
The movement or transfer of electric energy over an interconnected group of lines and associated equipment between points of supply and points at which it is transformed for delivery to consumers or is delivered to other electric systems. Transmission is considered to end when the energy is transformed for distribution to the consumer. Also the interconnected group of lines and associated equipment that performs this transfer.

Transmission line
A set of electrical current conductors, insulators, supporting structures, and associated equipment used to move large quantities of power at high voltage, usually over long distances (e.g., between a power plant and the communities that it serves).

Transmission tower
A support structure for lines (conductors) that transmit high-voltage electricity from the transformer to the electric distribution system.

Tribe
Term used to designate a federally recognized group of American Indians and their governing body. Tribes may be comprised of more than one band.

Turbine
A machine for generating rotary mechanical power from the energy of a stream of fluid (such as wind, water, steam, or hot gas), in which a stream of fluid turns a bladed wheel, converting the kinetic energy of the fluid flow into mechanical energy available from the turbine shaft. Turbines are considered the most economical means of turning large electrical generators. *See* Wind turbine.

Turbine array
Any number of wind energy conversion devices that are connected together to provide electrical energy.

Utility (electric)
A company that engages in the generation, transmission, and/or distribution of electricity.

Utility-scale
Descriptive term for energy facilities that generate large amounts of electricity that is delivered to many users through transmission and distribution systems.

Vapor plume
Air, super-saturated with water vapor and often containing solid, liquid, or gaseous contaminants, that is vented from industrial processes and is visible because it contains water droplets.

Vegetation
Plant life or total plant cover in an area.

Vertical angle of view
A viewer's elevation with respect to a viewed object: whether the viewer is elevated with respect to the object, lower in elevation than the object, or level with the object.

Viewer height
The approximate height of a standing adult's eyes, by convention generally between 5 and 6 ft, that is added to the viewpoint elevation in a viewshed analysis.

Viewing geometry
The spatial relationship of viewer to the viewed object (e.g., a renewable energy facility), including the vertical angle of view and the horizontal angle of view.

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.

Viewshed limiting factors
Variables that determine the nature and size of the viewshed from a given viewpoint, within the maximum distance of analysis set by the user, so called because they define the spatial limits of the viewshed. Viewshed limiting factors include the following: topography, vegetation, structures, viewer height, target height, earth curvature, and atmospheric refraction.

Visibility factors
Variables that determine and affect the visibility and apparent visual characteristics of an object in a landscape setting. Visibility factors include viewshed limiting factors that define the potentially visible area, viewer characteristics, distance, viewing geometry, background/backdrop, lighting, atmospheric conditions, and the object's visual characteristics.

Visual absorption capability
The physical capacity of a landscape to accept human alterations without loss of its inherent visual character or scenic quality.

Visual acuity
The acuteness or clarity of vision.

Visual attention
Noticing and focusing of vision on a particular object or landscape element.

Visual clutter
The complex visual interplay of numerous disharmonious landscape characteristics and features resulting in a displeasing view.

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

Visual Contrast Rating (VCR)
An assessment of the visual contrast between a project and the surrounding landscape. In the BLM's VCR process, the contrast is measured by comparing the project features with the major features in the existing landscape. The basic design elements of form, line, color, and texture are used to make this comparison and to describe the visual contrast created by the project.

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

Visual impact 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.

Visualization
Development of an image (usually using computer hardware and software) that simulates the visual appearance of a proposed facility as it would appear after its construction, as it would be seen from a specified viewpoint.

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

Visual order
An arrangement of visual elements in a landscape.

Visual resource
Any objects (manmade 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 that are 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 in nature 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 the project may have on these values. Management decisions in the RMP must reflect the value of visual resources. The value of the visual resource may be the driving force for some management decisions. There are four VRM classes (I, II, III, and IV).

Visual resource management class I
Objective is to preserve the existing character of the landscape. The level of change to the characteristic landscape should be very low and must not attract attention.

Visual resource management class II
Objective is to retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen but must not attract the attention of the casual observer. Any

changes must repeat the basic elements of form, line, color, and texture found in the predominant natural landscape features.

Visual resource management class III
Objective is to partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate. Management activities may attract attention but should not dominate the view of the casual observer. Changes should repeat the basic elements of form, line, color, and texture found in the predominant natural landscape features.

Visual resource management class IV
Objective is to provide for management activities that require major modification of the existing character of the landscape. The level of change to the characteristic landscape can be high.

Visual Resource Management System
BLM's system for minimizing the visual impacts of surface-disturbing activities and maintaining scenic values for the future. The inventory and planning actions taken to identify visual values and to establish objectives for managing those values; also the management actions taken to achieve the visual management objectives.

Visual sensitivity
Public concern for the maintenance of scenic quality in a particular landscape setting.

Visual uniformity
The quality or state of appearing to be similar in visual characteristics.

Visual value
See Scenic value.

Waterbar
A rock, earthen, or log barrier, or excavated channel, angled across a trail to divert the runoff water off of the trail.

Weed
A plant considered undesirable, unattractive, or troublesome, usually introduced and growing without intentional cultivation.

Well test (geothermal)
Drilling into the ground to analyze the potential energy yield and water temperature for geothermal energy production.

Wet cooling system
See Closed-loop cooling system.

Wild and Scenic River
A designation (under the Wild and Scenic Rivers Act of 1968) for certain rivers that are to be preserved for possessing outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values. A

river or river section may be designated by Congress or the Secretary of the Interior. National Wild and Scenic rivers are managed by agencies of the federal or state governments.

Wind energy
The kinetic energy of wind converted into mechanical energy by wind turbines (i.e., blades rotating from a hub) that drive generators to produce electricity for distribution. *See* Wind power.

Wind farm
One or more wind turbines operating within a contiguous area for the purpose of generating electricity.

Wind power
Power generated using a wind turbine to convert the mechanical power of the wind into electrical power. *See* Wind energy.

Wind turbine
A term used for a device that converts wind energy into mechanical energy that is used to produce electricity.