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Visibility and Visual Characteristics of the Crescent Dunes Solar Energy Power Tower Facility

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NOTATION

The following is a list of the acronyms, abbreviations, and units of measure used in this report.

ACRONYMS AND ABBREVIATIONS

Argonne	Argonne National Laboratory
AVR	Average Visibility Rating
BLM	Bureau of Land Management
CDSEF	Crescent Dunes Solar Energy Facility
CEC	California Energy Commission
DOE	U.S. Department of Energy
EIS	Environmental Impact Statement
FAA	Federal Aviation Administration
FVR	Final Visual Report
GIS	Geographic Information System
ISEGS	Ivanpah Solar Electric Generating System
KOP	key observation point
NPCA	National Parks Conservation Association
NPS	National Park Service
NREL	National Renewable Energy Laboratory
NZILA	New Zealand Institute of Landscape Architects
PAV	potentially affected viewshed
PEIS	Programmatic Environmental Impact Statement
PV	photovoltaic
ROD	Record of Decision
SO	study observation
SOP	study observation point
VIA	visual impact assessment

UNITS OF MEASURE

ft	foot (feet)	m	meter(s)
ha	hectare(s)	mi	mile(s)
km	kilometer(s)		

VISIBILITY AND VISUAL CHARACTERISTICS OF THE CRESCENT DUNES SOLAR ENERGY POWER TOWER FACILITY

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ABSTRACT

This report presents the results of a study conducted to document the visibility and visual characteristics of the Crescent Dunes Solar Energy Facility (CDSEF), a utility-scale solar power tower facility, located on land administered by the U.S. Department of the Interior Bureau of Land Management, near the city of Tonopah in south central Nevada. Study activities consisted of field observations of the CDSEF, comparison of the observations made in the field with the visual contrast assessments and visual simulations in the CDSEF Draft Environmental Impact Statement (Draft EIS) and supporting documents created prior to CDSEF construction, and an assessment of the efficacy of visual impact mitigation measures undertaken to reduce visual impacts. A total of 28 observations of the CDSEF were made from 21 locations within 67.5 mi (miles) (108.6 km) of the facility in the course of one week in August 2016, including 19 daytime observations with the CDSEF operating, six daytime observations with the CDSEF offline, and three observations of the CDSEF lighting at night. The study found that the CDSEF was a major source of visual contrast for observations up to 25 mi (40 km), and was easily visible at 67.5 mi (108.6 km). Glare from individual heliostats was occasionally visible, and glare from sunlight reflected from the surface of power block components was frequently observed. The CDSEF lighting was plainly visible at night at an observation distance of approximately 29 mi (47 km). The CDSEF is substantially brighter and is seen more clearly in the field than in photographs or in the prepared visual simulations in the Draft EIS. The simulations of the CDSEF in the Draft EIS under-represented the actual visual contrast from the project, and the contrast ratings in the Draft EIS predicted substantially lower levels of visual contrast than were actually observed for the operating facility. Visual impact mitigation measures undertaken for the facility were judged effective in reducing both daytime and nighttime visual contrasts from the facility; however, some potential improvements to mitigation were identified. The results of this study are in general agreement with a similar study conducted for the Ivanpah Solar Electric Generating System (ISEGS) in southern California. The results of the current study, however, greatly increased the maximum distance recorded for clear visibility of a commercial-scale power tower facility, not because of inherent differences between visual contrasts between the facilities, but more likely because it was feasible to observe the CDSEF from a much greater distance than the ISEGS facility. Also, far fewer incidents of heliostat glare were observed during the CDSEF observations than during the ISEGS observations.

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EXECUTIVE SUMMARY

This report summarizes the results of a study conducted by the Environmental Science Division of Argonne National Laboratory (Argonne) for the U.S. Department of the Interior Bureau of Land Management (BLM). The study documented the visibility and visual characteristics of a utility-scale solar power tower facility located on BLM-administered land in south central Nevada. The Crescent Dunes Solar Energy Facility (CDSEF) is the second operational solar power tower facility on BLM-administered lands. The study documented the visual characteristics of the CDSEF using ground-based field observations, assessed the occurrence of glare caused by the facility in these observations, assessed the effects of distance on the visibility of the facility, and assessed the visibility of CDSEF lighting at night. The study also compared visual simulations of the proposed CDSEF, prepared for the CDSEF Draft Environmental Impact Statement (Draft EIS), to photographs of the operating CDSEF, and to its appearance as observed in the field by the naked eye.

A similar study was conducted in 2014 for the Ivanpah Solar Electric Generating System (ISEGS) facility on BLM-administered land in southern California (Sullivan and Abplanalp 2015). ISEGS was the first operational solar power tower facility on BLM-administered lands. The ISEGS facility is much larger than CDSEF; includes three operating receiver towers and power blocks (CDSEF has one receiver tower and power block); and differs in other respects from CDSEF, such as in the design of the receivers and the lack of tanks for storage of heat transfer fluid. Similar to the ISEGS study, the current study was undertaken primarily to further establish baseline descriptions of the visual contrasts from utility-scale power towers, which previous studies (including the ISEGS study) have identified as having the largest potential for causing visual impacts among the three primary utility-scale solar technologies (photovoltaic, parabolic trough, and power tower). In addition, the CDSEF visibility study also addresses the efficacy of visual impact mitigation measures undertaken at CDSEF, and also includes a preliminary assessment of artificial lighting impacts associated with the CDSEF.

Study activities consisted of:

1. Daytime field observations of the CDSEF to assess visibility and visual characteristics;

2. Nighttime field observations of the CDSEF to assess visibility and visual characteristics of facility lighting;

3. Comparison of the observations made in the field with the contrast assessments and simulations in the CDSEF Draft EIS and supporting documents created for CDSEF prior to its construction; and

4. Assessment of the efficacy of visual impact mitigation measures employed at the CDSEF to avoid and reduce the visual impacts created by the construction and operation of the CDSEF.

A total of 28 field observations of the CDSEF were made from 21 locations within 68 mi (109 km) of the facility in the course of one week in August 2016, including 19 daytime observations with the CDSEF operating, six daytime observations with the CDSEF offline, and three observations of the CDSEF lighting at night. The study observation points (SOP) included locations selected to facilitate observing the facility from different distances and directions, but also included points at approximately the same distances as key observation points (KOP) used for visual impact assessment and simulation in the Draft EIS. The facility was observed primarily during the day, at different times of day, from a variety of angles and elevations, and primarily under sunny conditions. The daytime field observations included photography, descriptive narratives of sources of visual contrast from the facilities, and visibility determination using a formal process developed by Argonne for the ISEGS study and other studies of energy facility visibility.

Significant findings from the field observations and contrast assessment comparisons include the following:

- Similar to ISEGS, reflected sunlight from the receiver was the primary source of visual contrast from the operating CDSEF under sunny conditions, regardless of viewing distance or viewing geometry.

- Unlike ISEGS, reflected sunlight from the receiver rarely caused discomfort for observers, regardless of distance.

- In unobstructed views, the CDSEF was found to be a major source of visual contrast for most observations up to 25 mi (40 km).

- The CDSEF facility, including the heliostat field, was plainly visible at 67.5 mi (108.6 km), and may be visible for a substantially greater distance.

- Unlike ISEGS, glare from individual heliostats was rarely visible; however, glare was often observed associated with power block components. Both types of glare were significantly less bright than the glare from heliostats at ISEGS.

- “Dust halos,” relatively faint patches of light reflected from atmospheric dust, were frequently visible around the operating receiver tower, and were visible at distances as great as 29 mi (47 km). Dust halos were much more prominent when the facility was offline.

- At night, lighting at CDSEF was plainly visible at a distance of 29 mi (47 km), and may be visible for a substantially greater distance.

- The CDSEF is substantially brighter and is seen more clearly in the field than in photographs of the facility or in simulations based on photographs.

- The simulations of the CDSEF in the CDSEF Draft EIS and supporting documents had relatively minor problems with spatial accuracy but significant problems with realism, primarily because they showed the reflected light from the receiver to be much less bright than it appears in reality.

- The contrast ratings in the CDSEF Draft EIS predicted substantially lower levels of visual contrast than were actually observed for the operating facility.

- Visual impact mitigation measures used for CDSEF include painting/coating structures to blend with the existing landscape and using full-cutoff lighting. These mitigation measures were judged to be effective at reducing visual contrasts; however, the CDSEF still creates large visual contrasts at long distances both day and night. Some visual impact mitigation measures were inconsistently applied and some additional visual impact mitigation measures could likely have reduced observed visual contrasts from the CDSEF.

- The study findings have important implications for conducting visual impact assessments for proposed solar power tower facilities, in terms of the distance away from the facility used for the assessment of impact analysis, the importance of accurate and realistic simulation of visual impacts, and the need for effective mitigation of artificial lighting impacts associated with the facilities.

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1 INTRODUCTION

This introductory section presents the need for and purpose of the study, scope, intended use and users of the study results, and the report organization.

1.1 NEED AND PURPOSE FOR THE STUDY

This study is the second major undertaking to assess the visibility and visual characteristics of a utility-scale solar power tower facility for the purpose of visual impact assessment and mitigation. A similar study was conducted in 2014 for the Ivanpah Solar Electric Generating System (ISEGS) facility on BLM-administered land in southern California (Sullivan and Abplanalp 2015).

As noted in the ISEGS study (Sullivan and Abplanalp 2015), utility-scale solar energy facilities include large-scale, complex, and visually distinctive man-made structures that often contrast strongly with the surrounding landscape. The solar reflector/collector arrays and other surfaces of solar facility components may be highly reflective, adding substantially to their visibility. The visual contrasts caused by the facilities may detract from the visual qualities of the landscape view, particularly if viewers value the landscape for its natural-appearing character. If the visual contrasts created by solar facilities are perceived negatively, opposition to proposed solar projects may result, which can result in costly delays or even cancellation of projects.

As discussed in the ISEGS study (Sullivan and Abplanalp 2015) and in various reports prepared for DOE (DOE 2012a; Sullivan and Abplanalp 2013; Hartmann et al. 2016), visual impacts from utility-scale solar facilities are a potential obstacle to siting solar facilities and associated transmission infrastructure, and are of concern to the public and other stakeholders. Utility-scale solar facilities have been identified as causing substantial visual impacts in natural settings (BLM 2010a; CEC 2010; DOE 2012b; Testa 2012; CEC 2013), and stakeholder opposition, resulting from perceived negative visual impacts, has resulted in the cancellation of at least one utility-scale solar project in the United States to date (Trout 2015), and contributing to the cancellation of others such as the Silurian Valley Solar project (BLM 2014). Local governments, such as San Bernardino and Sonoma Counties in California, have passed ordinances restricting commercial solar facilities, specifically to protect scenic resources, among other values (San Bernardino County Sentinel 2013; Sonoma County 2013). Concerns over potential negative visual impacts of large solar facilities are also routinely expressed by tribes, local governments, environmental groups, and the National Park Service (NPS) during the environmental impact assessment processes that are required for these types of facilities (Basin and Range Watch 2010; DOE 2012b; NPCA 2012; Colorado River Indian Tribes 2013; Kessler 2013; NPS 2013).

In response to these stakeholder concerns and the need for accurate information about the visual impacts of solar facilities required to prepare visual impact assessments for proposed facilities, the BLM, DOE, and the National Park Service (NPS) have funded studies to better identify and describe the impacts of utility-scale solar energy facilities (Sullivan 2011; Sullivan et al. 2012a; Sullivan and Abplanalp 2013). Other studies funded primarily by DOE have investigated the occurrence of glare from solar energy facilities, primarily in the context of health and safety concerns rather than visual impacts (Barrett 2013; Ho et al. 2009, 2011; Ho and Khalsa 2010; Ho 2011, 2012; Ho and Sims 2013; Ho et al. 2014).

The earlier studies conducted by Argonne National Laboratory (Argonne) for BLM and NPS included documenting the visibility, visual characteristics, and visual contrasts associated with power tower facilities, but the projects studied were either not operational or were relatively small-scale in terms of power output (20 MW or less) (Sullivan 2011; Sullivan et al. 2012a; Sullivan and Abplanalp 2013). These studies (including the ISEGS study) did establish that solar power tower facilities have the largest potential for causing visual impacts among the three primary utility-scale solar technologies (photovoltaic, parabolic trough, and power tower).

The ISEGS was the first operational solar power tower facility on BLM-administered lands. The ISEGS facility began normal operation in 2013. ISEGS is a 3,500 acre (1,416 hectare [ha]), 392 MW solar power tower facility in the Ivanpah Valley southwest of Las Vegas, Nevada, and was the first large solar power tower facility to come online, thus providing an important opportunity to identify potential sources of visual impacts associated with large-scale power tower facilities. In response, Argonne conducted an in-depth study of the visibility and visual characteristics of the ISEGS facility, as documented by Sullivan and Abplanalp (2015). Figure 1.1-1 is a photograph of the operating ISEGS facility.

The ISEGS study included field observations of the ISEGS facility and comparison of the observations made in the field with the visual contrast assessments and visual simulations in the ISEGS Final Environmental Impact Statement (ISEGS Final EIS) and supporting documents created prior to ISEGS construction. Important ISEGS study results included the following:

1. ISEGS was found to be a major source of visual contrast for all observations up to 20 mi (32 km), and was easily visible at 35 mi (56 km).

FIGURE 1.1-1 ISEGS Facility

2. Glare from individual heliostats was frequently visible, and often brighter than the reflected light from the receivers. Heliostat glare caused discomfort for one or more viewers at distances up to 20 mi.

3. The ISEGS power blocks were brightly lit at night, and were conspicuous at the observation distance of approximately 6 mi (10 km).

4. The ISEGS facility appeared substantially brighter and was seen more clearly in the field than in photographs of the facility or in the prepared simulations, which were based on photographs.

5. The simulations of the ISEGS facility in the ISEGS Final EIS sometimes lacked spatial accuracy and realism.

6. The evaluated simulations generally under-represented the actual visual contrast from the project, and some of the contrast ratings in the ISEGS Final EIS predicted substantially lower levels of visual contrast than were actually observed for the operating facility.

While the ISEGS study clearly advanced the state of knowledge regarding the visual properties of utility-scale solar power tower facilities, and assessment of their visual contrasts, it could not be assumed that those same visual characteristics and observed visual phenomena would be shared by other power tower facilities, such as CDSEF, that employ different project designs and layouts. The ISEGS facility is one the first examples of the new generation of power tower facilities being built in the southwestern United States, and its unique visual characteristics affect the nature and magnitude of its associated visual impacts. The ISEGS facility is much larger than CDSEF; it includes three operating receiver towers and power blocks, compared to CDSEF's one receiver tower and power block; and differs in other respects from CDSEF, such as the design of the receivers, and the lack of tanks for storage of heat transfer fluid.

While it is difficult to accurately predict the appearance of future projects in a rapidly evolving field such as solar energy facility design, facilities with two-tank direct energy storage and concrete towers better represent the current operating and proposed power tower designs than the ISEGS facility. The CDSEF visibility study was undertaken to begin the process of developing a larger sample of facilities to serve as the basis for validating assumptions about the visual characteristics of other power tower projects. In addition, the CDSEF visibility study addresses the efficacy of measures undertaken to mitigate the visual impact of CDSEF, and includes a preliminary assessment of artificial lighting impacts associated with the CDSEF. This information is needed to develop accurate visual impact assessments (VIA) for proposed projects and to develop siting and mitigation strategies to minimize the visual impacts of this type of solar energy facility.

1.2 SCOPE

The field observations of the CDSEF were made in the course of four days and two nights between August 8 and August 11, 2016. A total of 28 observations of the CDSEF were made from 21 locations, at distances from less than one mile to 67.5 mi (108.6 km) from the facility. A total of 19 daytime observations were made with the CDSEF operating (so that the receiver and heliostats were illuminated by direct or reflected sunlight), six daytime observations were made with the CDSEF offline (so that the receiver and heliostats were not illuminated), and three observations were made of the CDSEF lighting at night. The study was limited to observation and description of visual contrasts (changes in the visual environment, i.e., changes to what is seen) rather than impacts (changes in scenic values and human reaction to visual contrasts).

1.3 INTENDED USES AND USERS

This study identifies the visual characteristics of a large utility-scale power tower solar energy facility and the visual contrasts associated with its operation. The study results can be used to:

1. Better understand the nature of daytime and night-time visual contrasts associated with utility-scale power tower solar facilities, and the mechanisms by which these facilities cause visual contrasts that generate visual impacts;

2. Compare the visual contrasts associated with utility-scale power tower solar facilities that utilize different facility designs and layouts;

3. Identify an appropriate area of potential effect for VIAs;

4. Assess the accuracy of visual simulations of power tower facilities in VIAs;

5. Assess the effectiveness of visual impact mitigation measures;

6. Develop ideas for new mitigation measures;

7. Identify opportunities to strengthen VIA methods used to analyze and disclose visual impacts.

The methods used for this study could also be incorporated into a visual resource monitoring protocol for future solar energy projects.

The intended users of this document and the study results it contains include:

1. Professionals conducting VIAs for solar energy facilities and specifying visual impact mitigation measures;

2. Agency staff who regulate or approve VIAs and associated mitigation measures;

3. Solar industry professionals who must implement mitigation measures; and

4. Other stakeholders who may be affected by the visual impacts of solar facilities.

1.4 DOCUMENT ORGANIZATION

This report is organized into eight main sections:

1. Introduction

2. CDSEF Description and Study Methodology. A description of the CDSEF and the methods used for conducting observations.

3. Results of Field Observations. Descriptions of the field observations of CDSEF and the visual contrasts and contrast sources associated with solar facilities.

4. Comparison of Field Observations with Draft EIS Simulations and Contrast Ratings. Comparisons of visibility ratings and photographs of CDSEF made in the field with the contrast assessments and simulations contained in the Draft EIS.

5. Assessment of Efficacy of Visual Impact Mitigation Measures. A description and assessment of selected visual impact mitigation measures and their effectiveness for avoiding or reducing visual contrast from the CDSEF.

6. Conclusions and Recommendations. A discussion of study results and recommendations for further studies.

7. References. References cited in this report.

8. Appendices. A description of Study Observations, SOPs, and Sample Data Collection Forms.

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2 CDSEF DESCRIPTION AND STUDY METHODOLOGY

2.1 CDSEF DESCRIPTION

The CDSEF is a 1,600 acre (650 ha), 110 MW solar power tower facility currently in operation on land administered by the U.S. Department of the Interior Bureau of Land Management. The facility is located approximately 14 mi (23 km) northwest of the city of Tonopah in Nye County in south central Nevada (NREL 2016) and is within the southern portion of the Big Smoky Valley, north of US Highway 95/6 along Poleline Road (State Highway 89). The eastern edge of the CDSEF heliostat array is approximately 0.75 mi (1.2 km) west of the westernmost portion of the Crescent Dunes sand dune field. The Big Smoky Valley is ringed by mountain ranges in most directions, at distances between approximately 5 to 17 mi (8 to 27 km), and these mountain ranges effectively restrict long distances views of the CDSEF from lower elevations, except to the north, southwest, and southeast. The facility site ranges in elevation from approximately 4,890 to 5,010 ft (1,490 to 1,530 m) above mean sea level. Figure 2.1-1 is a map of the region in which the CDSEF is located, showing all 21 of the SOPs from which the CDSEF was observed. Figure 2.1-2 is a more detailed map of the CDSEF vicinity within the Big Smoky Valley, showing the 19 closest SOPs (the two farthest SOPs in California are omitted for scale reasons).

The basic operation of the CDSEF can be summarized as follows: the CDSEF is a concentrating solar power tower facility, using heliostats (mirrors) to reflect and concentrate sunlight onto a receiver atop the receiver tower (NREL 2016). A heat transfer fluid is heated as it passes through the receiver, and is then circulated through a series of heat exchangers to generate high-pressure steam. The steam is used to power a conventional Rankine cycle steam turbine, which produces electricity. The exhaust steam from the turbine is condensed and returned via feedwater pumps to heat exchangers where steam is regenerated. Hybrid cooling, combining wet and dry cooling processes, minimizes water use while continuing to maintain efficient power generation.

The facility uses 10,347 heliostats in one heliostat array to reflect and concentrate sunlight onto a receiver atop the receiver tower (NREL 2016). The receiver tower is slightly south of the center of the circular heliostat array, as shown in Figure 2.2-2. The heliostat array is approximately 9,240 ft (2,816 m) in diameter.

Each heliostat consists of 35 mirror facets, each measuring 6 ft × 6 ft (1.8 m × 1.8 m), in a rectangular array, with a usable reflective surface area of 1,245 ft^2 (115.7 m^2). Each heliostat is mounted on a pylon inserted directly into the ground. The heliostats are arranged in concentric circles around the tower and are programmed by computers to track the daily apparent motion of the sun across the sky, while reflecting sunlight onto the receiver.

The receiver tower is 640 ft (195 m) tall. Because the tower exceeds 200 ft (60 m) in height, aerial hazard navigation lighting is required for the tower, and includes several white flashing strobe lights during the day and at twilight, and slowly flashing red lights at night. The tower is made of reinforced concrete, is round in cross section, and is approximately 53 ft (16 m)

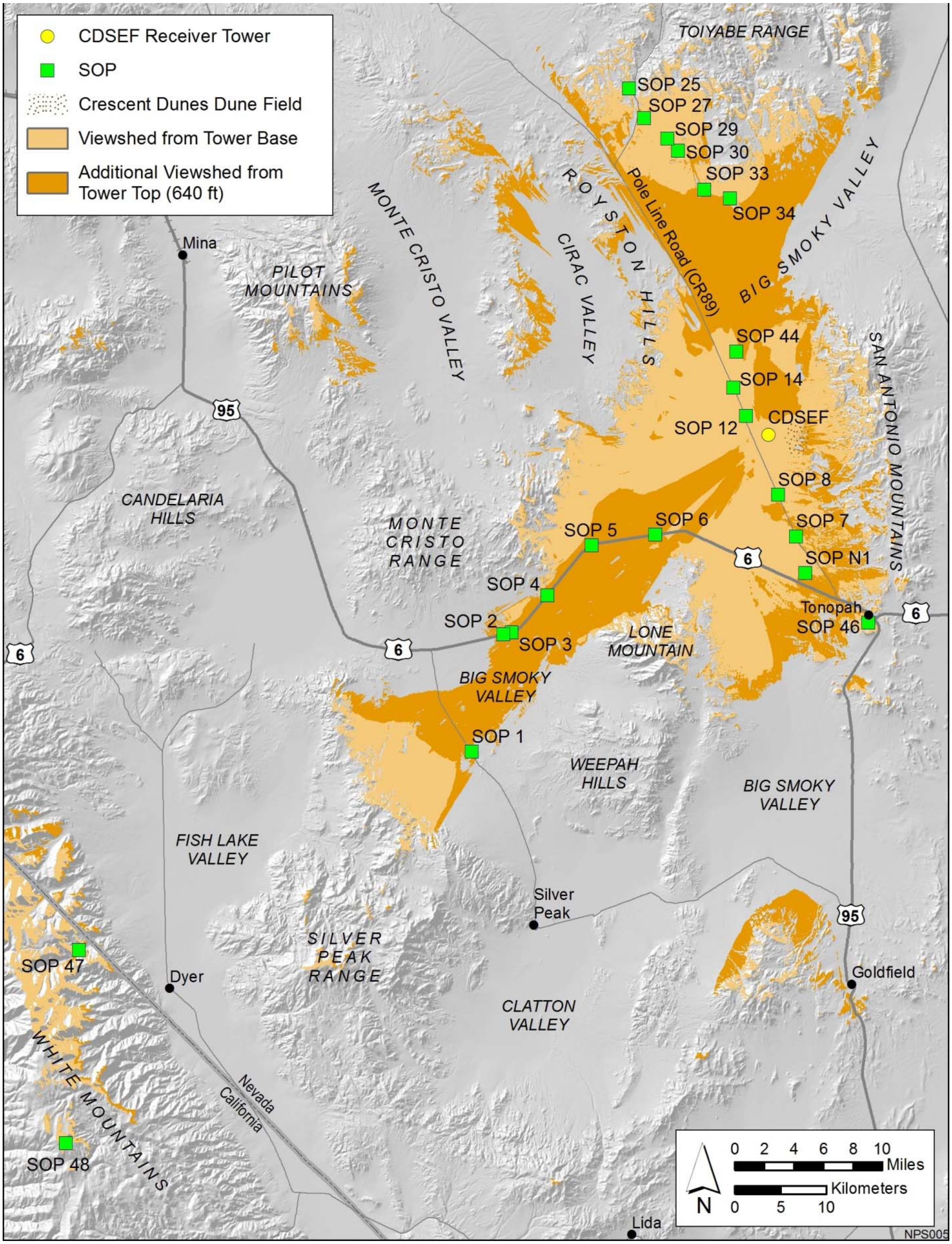

FIGURE 2.1-1 Overview of CDSEF Vicinity and SOPs with CDSEF Viewshed

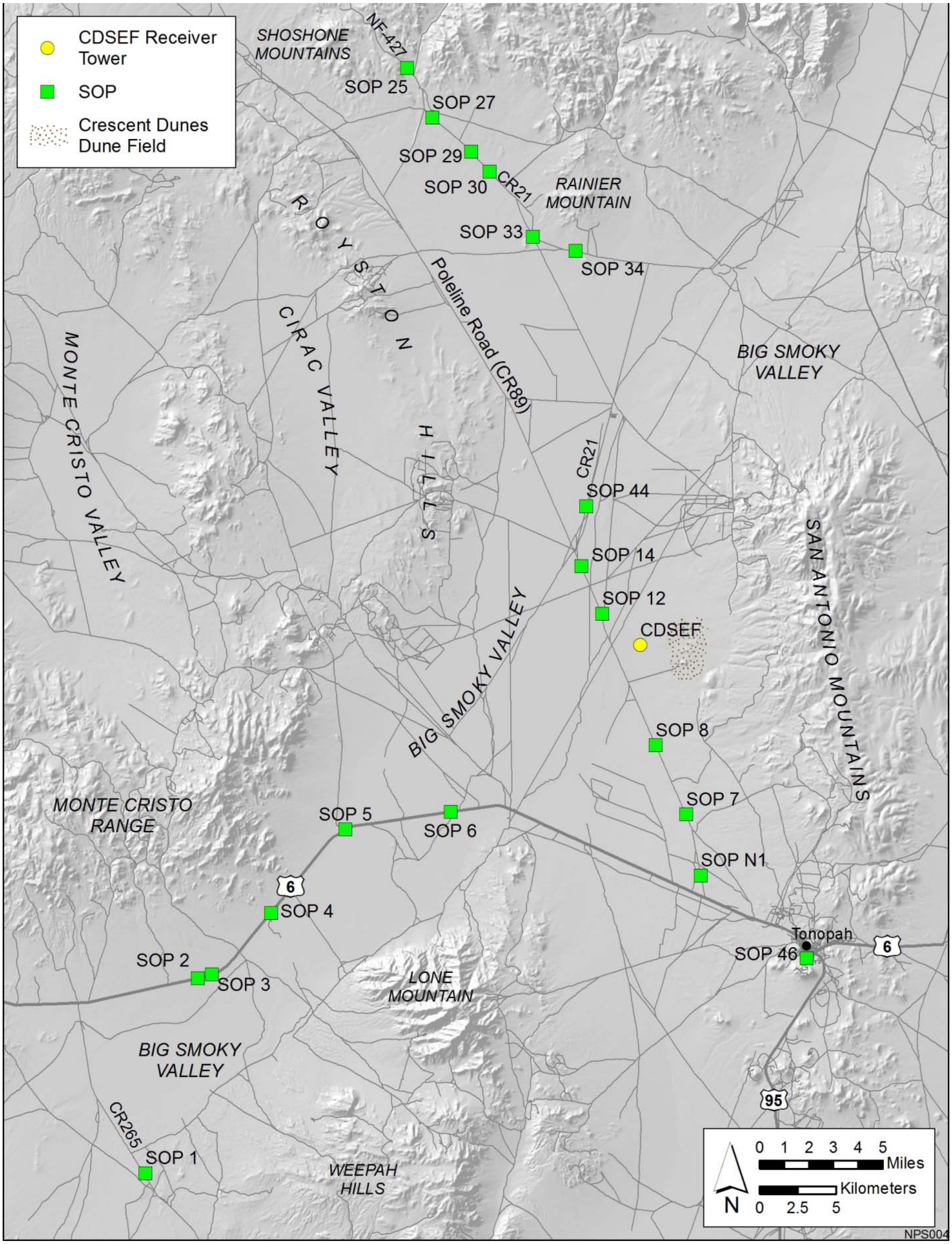

FIGURE 2.1-2 Detail of CDSEF Vicinity

wide, measured at the base of the tower. The top portion of the receiver tower (approximately 100 ft [30 m] in height) is the receiver itself. When the plant is not operating, the surface of the receiver is deep black in color. When the plant is operating, the heliostat array concentrates reflected sunlight on the receiver, thereby illuminating it, and causing it to reflect light to the surrounding area, and at these times, the receiver appears brilliant white in color.

In addition to the receiver tower and heliostat array, other facility components of CDSEF include hot and cold salt tanks, the air cooled condenser, the steam turbine/generator and steam generation system, and the control and operation building. These components are collectively referred to as the “power block” in this report. Figure 2.2-1 is an annotated photograph of the CDSEF showing the major facility components. Figure 2.2-2 is a plan view of the CDSEF showing the major facility components. Figure 2.2-3 is a ground-level photograph of the facility, showing some of the major facility components and the general appearance of the CDSEF when operating.

2.2 STUDY METHODOLOGY

This section describes the procedures used to identify SOPs for the study and the procedures and forms used to collect study data. Additional information about methods and sample forms are provided in the appendices.

2.2.1 SOP Identification and Data Collection Schedule

Prior to conducting fieldwork, geographic information system (GIS) viewshed analyses were conducted to identify those lands within 75 mi (121 km) of the CDSEF from which the facility would be visible. Within these lands, 21 SOPs were selected for the current study. Most of the selected SOPs were points on or near roadways, and had generally clear views of the CDSEF at 1-mi (1.6 km) intervals away from the facility in various directions, to the limit of the viewshed within 30 mi (48 km) of the CDSEF. These SOPs were selected in order to make an observation of the CDSEF from particular desired distances. Beyond this distance, significant gaps in visibility occurred, at least for easily accessible points. In order to test the limits of visibility, two additional SOPs were selected within the White Mountains of California at distances of 58.4 and 67.5 mi (94.0 and 108.6 km) from the CDSEF. SOP locations in or near the Big Smoky Valley are shown in Figure 2.1-2. All SOP locations are shown in Figure 2.1-1.

In all but one case, the SOPs were located on or very near roads; however, one SOP was located at an elevated location on a mountainside well away from any road. Observation elevations ranged from 4,781 ft to 11,645 ft (1,457 m to 3,549 m) above mean sea level. Many SOPs were located either slightly below or above the elevation of the facility, but some SOPs north of the facility were more than 1,000 feet higher in elevation than the CDSEF, and the two farthest SOPs (58.4 and 67.5 mi [94.0 and 108.6 km] respectively) were located in distant mountains several thousand feet higher in elevation than the CDSEF.

FIGURE 2.2-1 Major CDSEF Components (Source: Solar Reserve, LLC.)

After identifying the SOPs, the locations were exported to a GIS software package, GIS Pro (Version 3.18; Garafa, LLC, 2015), available on an Apple iPad mobile device. GIS Pro was used for navigation, distance determination, and data recording in the field.

All observations were made by a two-person team, both of whom are Argonne visual resource analysts trained in data collection for visual resource analysis studies using the various data collection forms employed in this study, which are discussed below. Observations were conducted daily from the morning of August 8, 2016, through the afternoon of August 11, 2016. Daylight observations were made as early as 8:15 a.m. and as late as 5:45 p.m., and nighttime

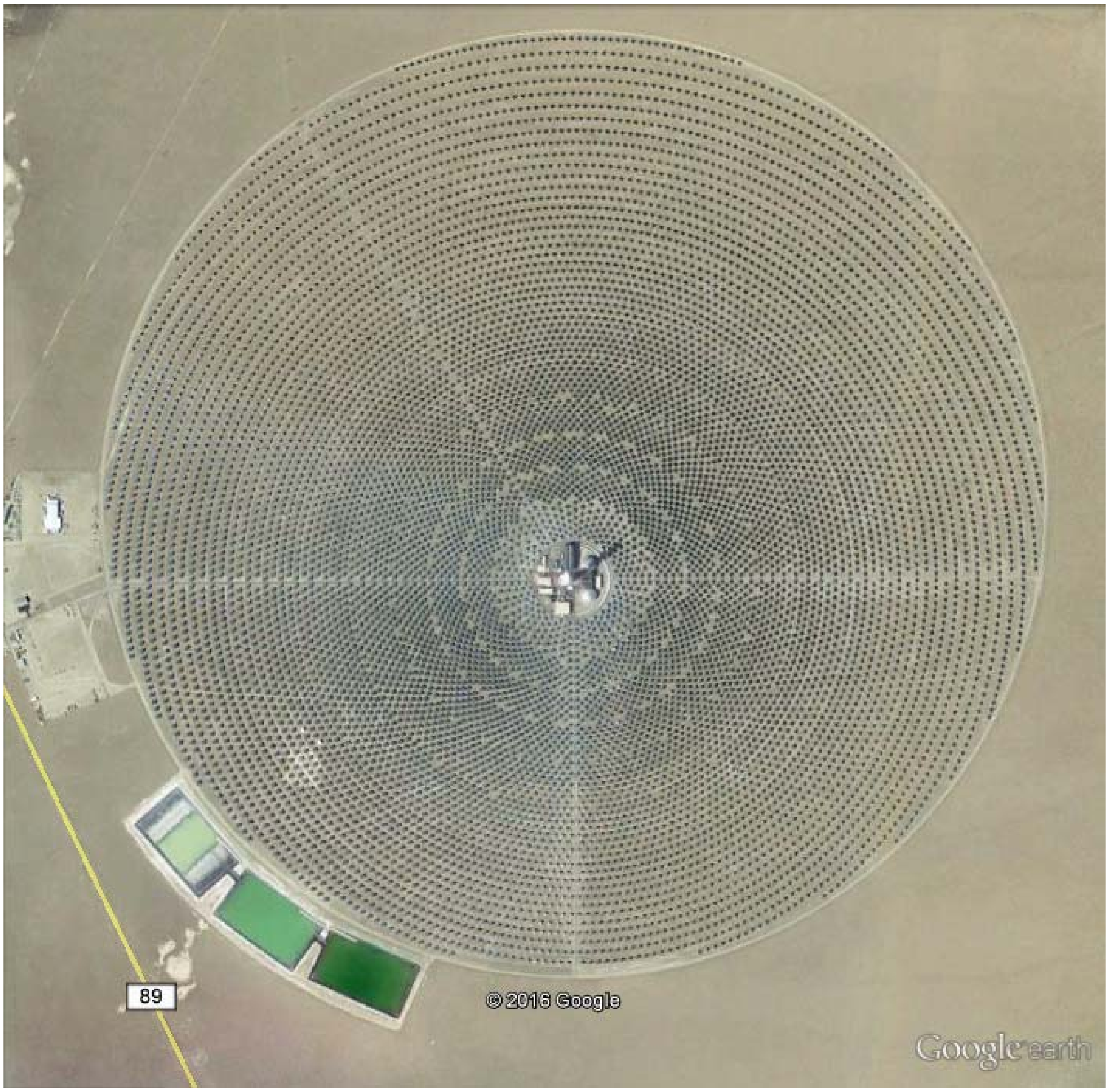

FIGURE 2.2-2 CDSEF Plan View showing Power Block and Receiver within Heliostat Array

observations were made on August 8 at 9:00 p.m. and August 9 between 7:40 p.m. and 9:35 p.m. A total of 28 observations were made from the 21 SOPs. Brief descriptions of the SOPs are provided in Appendix A.

2.2.2 Field Data Collection Procedures and Forms

After driving or hiking to each SOP using its pre-determined coordinates for navigation, the analysts determined the actual coordinates used for the observation using the iPad's GPS positioning capability. Depending on the type of SOP and the circumstances, two to four data collection forms were used to record study data. For all daytime observations, except the two farthest observations in the White Mountains in California, data regarding the CDSEF's general

FIGURE 2.2-3 Ground-Level View of CDSEF Facility, showing Major Facility Components

visual characteristics were recorded on the "Solar Facility Visual Characteristics Study Data Collection Form," and visibility ratings were recorded on the "Visibility Rating Form." If a significant glare event was observed, data concerning the event were recorded on the "Solar Facility Transitory Visual Effects Data Collection Form." Examples of these forms are provided in Appendix B.

Solar Facility Visual Characteristics Study Data Collection Form

Data recorded on the "Solar Facility Visual Characteristics Study Data Collection Form" included weather conditions, general locational information, the visible components of the facility, facility backdrop color and contrast, viewing angle between the observation point and facility, lighting quality and angle, and collector orientation and color. Any visible contrasts such as glare, light patterns, plumes, or transitory effects were also recorded. A space was also provided to record additional observations not called out on the form. In addition to the GIS Pro software discussed above, the iPhone/iPad application Theodolite Pro (Version 5.0; Hunter Research and Technology LLC, 2015) was used to determine approximate bearings of views toward the CDSEF facility, and SunSeeker (Version 5.2.1; OzPDA 2016) was used to determine solar azimuth and elevation for all observations.

Solar Facility Transitory Visual Effects Data Collection Form

The "Solar Facility Transitory Visual Effects Data Collection Form" was used to record information about transitory visual effects. Transitory visual effects are of brief duration and often fluctuate in visual character, for example, glare, rather than being of a continuous and generally less variable nature, or, reflected light from the receivers. Data collection items included a description of the observed phenomenon, and for glare events, the apparent glare source, type, color and location; duration of glare; and the visual discomfort level caused by the glare, if any. The back of the form included a plan-view image of the facility used to mark the location of observed transitory visual effects.

Visibility Rating Form

To record data on the "Visibility Rating Form," each of the observers numerically rated the visibility of the CDSEF using a methodology developed for the Visual Impact Threshold Distance Study developed for the BLM (Sullivan et al. 2012b). This approach assessed the effects of distance and atmospheric variables on the visibility and visual contrast levels of wind facilities, and in this case, the forms were adapted for use with solar facilities. The same form and procedures were used for the ISEGS study (Sullivan and Abplanalp 2015). The visibility assessments consist of numeric ratings on a scale of 1 to 6, scored according to the visibility of a solar facility within its landscape setting and the weather and lighting conditions at the time of the observation.

Within the visibility scale, a visibility score of "1" implies a facility that is just barely visible to the unaided eye, while a score of "6" indicates a facility that dominates the view because of its size and strong color contrasts, with intermediate scores indicating intermediate contrast magnitudes. The visibility rating is a judgment of the observers, made by comparing the solar facility in view with language given on the Visibility Rating Form that describes the visual characteristics of the solar facility appropriate to each rating level. Photographs were not used for visibility ratings; the ratings were conducted through naked-eye observations of the facility in the field.

Visibility and contrast threshold distance assessments are useful for two primary purposes:

1. They are useful for determining the appropriate area of analysis for VIAs. Visibility and contrast threshold distance assessments identify the maximum distance at which a facility is likely to be seen, the approximate distances at which it is easily seen, and the distance at which it is likely to become a major focus of visual attention, and this information can be used to identify the distance from the facility for which impacts should be analyzed. For example, the minimum distance for which impacts should be analyzed in a VIA likely corresponds to the distance at which viewers are likely to see the facility at a casual glance.

2. The visibility and contrast threshold distance assessment methodology also requires that the observers record the contrast sources associated with the facility that they see, and identify the facility components or contrasts that contribute most to the project's overall visibility. This approach is useful for identifying important contrast sources, which is key to determining BLM Visual Resource Management (VRM) Class conformance, and also to identifying mitigation opportunities.

In addition to recording data on the various study forms, each observation included photography of the facility and its surroundings. At each daytime observation point, a series of panoramic photos were taken using an iPhone, and the panoramic photos were stitched into a single panoramic image "on the fly" using Autostitch (Version 2.3; Cloudburst Research, Inc. 2015), a photography app available for the iPhone. In addition, a series of single-frame high-resolution photos were taken of the facility using a Nikon D7000 digital single lens reflex camera with an 18–300 mm zoom lens. For the single nighttime observation, the Nikon D7000 was used to take long-exposure photos; no panoramic photos were taken. These photos were the source of most of the figures in this report; the complete set is available from the lead author on request.

Night-time observations also included estimation of the brightness of observed lighting at CDSEF by directly comparing the apparent brightness of the observed lighting to stars visible at the time of the observation. The names of the comparison stars and their apparent stellar magnitudes were recorded at the time of the observation. This information was obtained through the iPhone/iPad application GoSkyWatch (Version 8.1; GoSoftWorks, 2015).

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3 RESULTS OF FIELD OBSERVATIONS

This section summarizes the key results of the field observations of the CDSEF.

3.1 VISUAL CHARACTERISTICS OF THE CDSEF FACILITY

Section 3.1 describes the general appearance and visual characteristics of the CDSEF both in operating and non-operating modes. Section 3.1.1 describes the general appearance of the facility as a whole. Because they are the major sources of visual contrast, the receiver tower and heliostat array are described in Sections 3.1.2 and 3.1.3, respectively. The visual characteristics of other facility components that contributed to observed visual contrasts are described in Section 3.1.4. Section 3.1.5 contains a description of the CDSEF facility lighting visible at night.

3.1.1 General Visual Characteristics of the CDSEF

The overall appearance of the CDSEF is highly dependent on the observer's distance from the facility. In all views, absent "heliostat flares" (see Section 3.2.2 below) or non-operating tower, the brilliant reflected light of the operating receiver was by far the dominant visual element. When the CDSEF was online, the receiver was seen as a brilliant white rectangular or cylindrical source of light atop the straight vertical line (or band, for closer views) of the tower. The visual properties of the receiver are described in more detail in Section 3.1.2. A general view of the operating CDSEF is shown in Figure 3.1-1.

At the base of the receiver tower, the very broad, flat heliostat array was almost always visible, regardless of distance, unless it was screened by topography. The portion of the array closest to the observer (consisting of the mostly shaded backs of the heliostats) was generally almost black or a dull dark gray in color, while the portion opposite (and farthest from the observer, consisting of the reflective faces of heliostats facing the observer) was silvery-white in color. The middle portion of the array was generally a dull gray or blue-gray, but sometimes silvery-white, depending on the observer position, i.e., whether the observer was at the same elevation as the facility or slightly elevated and looking downward at the heliostat array. The visual properties of the heliostat array are described in more detail in Section 3.1.3.

Similar to the ISEGS facility (Sullivan and Abplanalp 2015), the overall visual effect of the CDSEF is of an object that is relatively flat and wide (because the heliostat array is approximately 14 times wider than the tower is tall), with a very small but extremely bright object atop a short vertical line or band at its center. Depending on distance and observer orientation to the array, the CDSEF may appear to occupy much of the field of view. At a distance of 4 mi (6.4 km), the CDSEF occupies a horizontal angle of view of approximately 24°, or 19% of the normal field of view of 124° (NZILA Education Foundation 2010), as shown in Figure 3.1-1. At approximately 67.5 mi (56 km), as seen from the White Mountains of California, the CDSEF occupies approximately 1.5°, or 1.2% of the normal field of view, and so appears very small at that distance, but was sufficiently bright to be easily visible, as shown in Figure 3.1-2.

FIGURE 3.1-1 View of CDSEF. Photo location: SOP 8. The CDSEF occupies 24°, 19% of the Normal Horizontal Field of View. Distance to Tower is 4.1 mi (6.6 km).

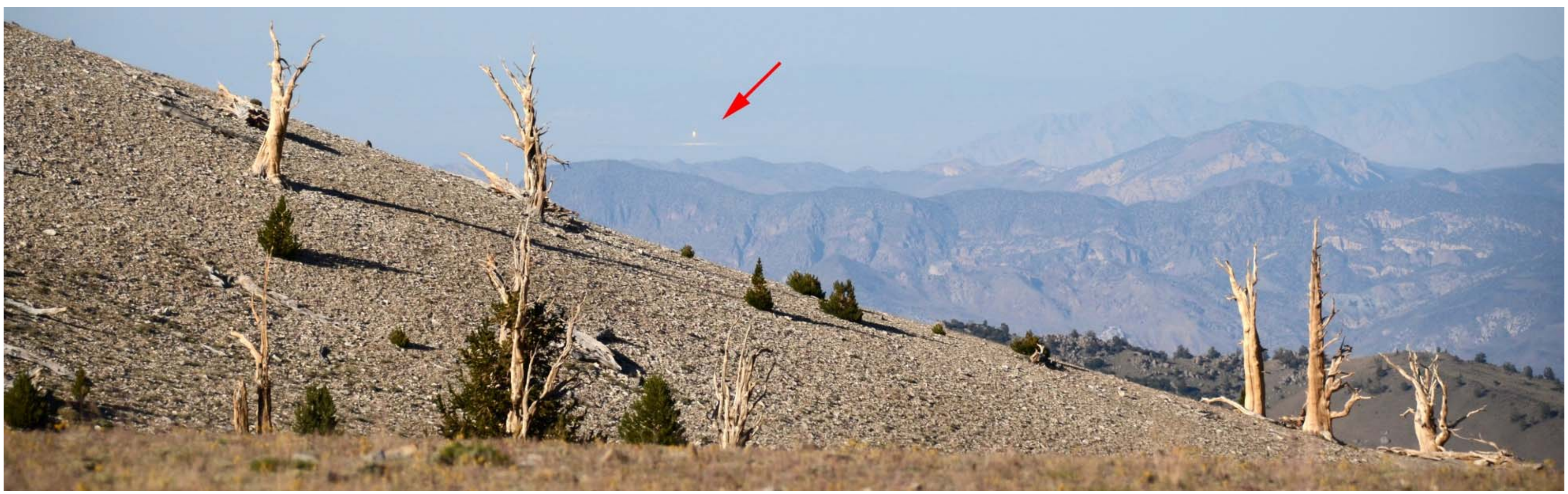

FIGURE 3.1-2 View of CDSEF (Indicated by Arrow). The CDSEF occupies 1.5°, 1.2% of the Normal Horizontal Field of View. Photo location: SOP 48. Distance to Tower is 67.5 mi (108.6 km).

Similar to the ISEGS facility, the appearance of the operating CDSEF was generally consistent throughout the course of the day, and less subject to change relative to utility-scale photovoltaic (PV) and parabolic trough facilities, whose appearance changes dramatically as the sun altitude and azimuth change, or as the observer changes position (Sullivan and Abplanalp 2013, 2015). As for many power tower facility designs, the CDSEF heliostats are arrayed in concentric circles around the tower, and the receiver tower looks very similar from all sides. As a result, neither time of day nor view bearing affected the appearance of the receiver and heliostat array substantially, though the heliostat array color may vary somewhat depending on the sun angle relative to the view direction. The power block components vary in size and shape, and are asymmetrically placed around the tower; thus, their appearance varies depending on sun angle and view bearing, but the differences are difficult to notice except at relatively short viewing distances.

Two phenomena did strongly affect the CDSEF's appearance: going offline (see Section 3.1.2), and heliostat flares (see Section 3.1.3). The CDSEF suddenly went offline in the course of an observation on August 8, and within a few seconds, the receiver changed from a brilliant white to a deep black color, and the overall visibility of the CDSEF dropped substantially. Heliostat flares involved the sudden appearance of extremely bright spots of reflected light from individual heliostats in the heliostat array, but were observed to be less bright than similar flares at ISEGS (Sullivan and Abplanalp 2015), and to occur much less frequently.

Other frequently observed visual phenomena included relatively faint reflected light from atmospheric dust, referred to by Ho et al. (2014) as "dust halos" (see Section 3.1.2), flashing strobe lights on the receiver tower (see Section 3.1.2). Other facility components, such as buildings and transmission lines were visible in some views (see Section 3.1.4). At night, flashing red lights were visible on the receiver towers, and lighting illuminated the power block (see Section 3.1.5).

3.1.2 Receiver

When the CDSEF was online, the brilliant reflected sunlight from the receivers was its dominant visual element, and the primary (but not sole) reason that the CDSEF was easily visible. The reflected light from the receiver appeared to be pure and brilliant white, but unlike the ISEGS receivers, did not cause substantial visual discomfort even when viewed from within the facility itself, although one observer reported discomfort after a few seconds of viewing at 2.0 mi (3.2 km). It did cause afterimages after extended viewing at a distance of 16.1 mi (25.9 km), and after brief viewing at distances between 2.0 and 6.0 mi (3.2 and 9.6 km).

The receiver appeared overall as a cylinder greater in height than in width and depth; with sections of differing width and various projections; and with coloring of either a deep black with white horizontal bands at top and bottom (when the tower was not operating), or a brilliant white (when the tower was operating). The receiver sits atop a smooth grey concrete tower. Close-up views of the receiver and illuminated and un-illuminated receiver and power block are shown in Figures 3.1-3 and 3.1-4, respectively.

FIGURE 3.1-3 CDSEF Operating Receiver, Power Block, and Inner Portion of Heliostat Array

FIGURE 3.1-4 CDSEF Offline. Receiver and Inner Portion of Heliostat Array with Heliostats in Stow Position.

The receiver surface appeared to be a flat, deep black when the tower was not illuminated, and the details of the receiver form, colors, and surface textures were relatively easy to discern. Generally, as shown in Figure 2.2-3 and 3.1-1, when the power tower was operating, the glare made the details of its form difficult to see, except from very short viewing distances. Under normal operating conditions, the receiver light was steady, in that it did not noticeably fluctuate; however, as described below, it was extinguished quickly when the CDSEF went offline.

The ISEGS receiver towers have the shape of rectangular prisms and consist largely of complex steel open latticework, through which the background (generally the sky) is visible, so they are very different in appearance than the CDSEF receiver tower, which is a smooth and solid light gray concrete cylinder. The CDSEF receiver tower presents a much simpler visual appearance than the ISEGS towers, but is almost 200 ft (60 m) taller.

As noted in the ISEGS study, the Solar Programmatic Environmental Impact Statement (PEIS) (BLM and DOE 2010) predicted that at long distances, power tower receivers would appear as bright star-like points of light. However, in the CDSEF visibility study observations, the receiver light appeared as a tiny but slightly vertically elongated light source even at the longest observation distance of 67.5 mi (108.6 km). The tower structure below the receiver was faintly visible at 29.3 mi (47.2 km), but could not be seen clearly at 67.5 mi (108.6 km).

The ISEGS study noted that faint streams of light (dust halos), appearing to originate from the receivers, shining outwards and downwards, and generally forming a conical or fan shape, were sometimes observed at distances of approximately 9 mi (14 km) or less. The streamers are caused by the reflection of light from dust particles suspended in the atmosphere around the receiver tower (Ho et al. 2014). The streams from individual heliostats at the CDSEF are plainly visible in Figure 3.1-3. At greater distances, the individual streams coalesce into a dust halo. At CDSEF, dust halos were observed at much greater distances than at ISEGS, and were especially prominent when the CDSEF was offline. Dust halos were observed to be visible at 22.5 mi (36.2 km) with the CDSEF offline, and appeared much larger and more complex visually than those observed at ISEGS (See Figure 3.1-5), and more similar in appearance to those observed at the Gemasolar facility located in Fuentes de Andalucia in Seville, Spain (Sullivan et al 2012a). There simply may have been more dust present during the CDSEF observations, but it is also possible that different approaches to positioning of heliostats between the CDSEF and the ISEGS facility in standby mode may have caused some of the differences in the intensity and structure of the dust halos. At both facilities, dust halos were often observed when the tower was illuminated, but were usually less noticeable (perhaps because of a masking effect caused by glare from the receiver itself), and generally appeared as a conical or fan shape with the apex of the cone at the receiver and the wider base below, as shown in Figure 3.1-6.

During four days of observations, the tower was offline for almost two days (August 89) due to an unplanned shutdown. When the tower was observed to go offline, the brilliant light of the receiver faded very rapidly (over several seconds), to be replaced by the deep black surface of the unilluminated receiver, bounded on the top and bottom by a horizontal band of white that contrasted strongly with the black receiver surface. The sudden loss of the receiver light was quite noticeable. As the tower came back online on the morning of August 10, the receiver

FIGURE 3.1-5 CDSEF Dust Halo with Facility Offline

FIGURE 3.1-6 CDSEF Dust Halo with Facility Online

slowly and gradually brightened, with a spot or spots of bright light visible on the receiver surface rather than the entire receiver surface being illuminated evenly. The size and shape of the spot(s) were observed to change noticeably in the course of seconds or minutes. The ISEGS facility was observed to display a generally similar process of darkening and brightening when going off- and online (Sullivan and Abplanalp 2015).

Similar to the ISEGS facility (Sullivan and Abplanalp 2015) flashing white strobe lights affixed to the receiver tower were visible in many views, but were observed at much greater distances. The strobe lights were particularly noticeable when the towers were not operating. When the tower was not illuminated, the strobe lights were very faintly and only intermittently visible at 22.0 mi [35.5 km], but easily and more consistently seen as the distance to the tower decreased. When the towers were illuminated, the strobe lights were often visible, but much less noticeable because of the visual dominance of the brilliant receiver light.

At ISEGS, small plumes of steam or water vapor were observed at the top of the receivers during a number of observations (Sullivan and Abplanalp 2015). At the CDSEF, no plumes were seen associated with the receiver itself, but a very small and faint plume is visible in Figure 3.1-7, which shows the partially illuminated receiver coming online early on the morning of August 10. It is possible that plumes might have been more frequently observed and more prominent under different atmospheric conditions.

3.1.3 Heliostat Array

As for the ISEGS facility, aside from the receiver, the heliostat arrays were rated by the observers as being the largest sources of visual contrast from the CDSEF. As noted in Section 3.1.1, the portion of the array closest to the observer was generally almost black or a dull dark gray in color, while the portion opposite (and farthest from the observer) was silvery-white in color. The middle portion of the array was generally a dull gray or blue-gray, but sometimes silvery-white. Usually, when the entire array was visible, a smaller portion at the top center of the array was silvery white, while the remainder (the lower portion) was gray or almost black. The silvery white color was prominent in all views, and was visible even at the longest-distance observation in the study—67.5 mi (108.6 km), as shown in Figure 3.1-2.

A discernable texture was sometimes seen in the heliostat array at relatively long distances (up to 20 mi [32 km]). The texture was caused by the alternating light and dark of individual heliostats reflecting sunlight and the open spaces (sometimes shadowed by the heliostats) in between them. The heliostats at the CDSEF are much larger than those at the ISEGS facility, and this may at least partially account for the texture being visible at longer distances than was observed in the ISEGS study (Sullivan and Abplanalp 2015). A close-up of the CDSEF heliostats, with a vehicle to show scale), is shown in Figure 3.1-8.

Close inspection showed that the silvery white color appeared to be caused by sunlight reflected more or less directly toward the observer (even though the heliostats reflect light primarily toward the receivers), while the darker colors in the middle of the array appeared to result primarily from the heliostats reflecting the blue color of the sky. This effect is shown in

FIGURE 3.1-7 Partially Illuminated Receiver, with Water Vapor Plume Immediately Left of Tower

FIGURE 3.1-8 CDSEF Heliostats

Figure 3.1-9, and is also visible in Figure 3.1-6. The dull gray and almost black colors observed in the area of the heliostats nearest the observer, was caused by looking directly at the shadowed backs of heliostats and the shadowed spaces of ground between heliostats. The colors showed less variety than observed at ISEGS, where the varied color of the ground surface included browns of bare soil and the dull browns, greens, and grays of the low vegetation found under the heliostats. At CDSEF, the ground beneath the heliostats appeared to have been more completely cleared of shrub vegetation, but some short and uniformly-colored vegetation was observed, and this may have limited the variety of colors visible when looking at the heliostat array. An alternative explanation is that the vertical angle of view for most observations at CDSEF was lower than that at the ISEGS facility, which is located on sloping ground, and this may have reduced visibility of the ground surface, especially given that the heliostats at CDSEF are much higher off the ground than at ISEGS.

Other CDSEF components and activities observed included the power block (i.e., the steam turbine generator building, hot and cold salt tanks, the cooling system, and related structures), various buildings, transmission lines, fences, and the movement of vehicles and workers. A view of the CDSEF power block is shown in Figure 3.1-10, and details of the power block are also plainly visible in Figures 2.2-1 and 3.1-3. Several close-up views of power block structures from within the power block itself are located in Section 5.3 of this report. These facility components were not visible at all in the longest-distance views at 58.3 and 67.5 mi (98.3 and 108.6 km); however, the power blocks were faintly visible at 25.1 mi (40.4 km). These other facility components were visible in most observations, but generally showed low contrast with the background, except during some glare events (see Section 3.2). A generally conspicuous group of buildings was visible west of the central tower beyond the heliostat array. These buildings are visible in many of the longer-distance photos shown in the figures, and are also a source of lighting impacts at night; however these are temporary structures “left over” from the construction phase and will be completely removed within the next few years.

FIGURE 3.1-9 Variation in Apparent Color of CDSEF Heliostat Array

FIGURE 3.1-10 Power Block Components. Air Cooled Condenser at Left, Top of Cold Salt Tank at Right. Steam Turbine/Generator behind Tower.

3.1.4 Nighttime Facility Lighting

Three nighttime observations of the CDSEF were made to assess the extent and visibility of lighting at the facility. Nighttime observations were made on August 8 at 9:00 p.m. (one observation at a distance of 29.4 mi [47.3 km]) and August 9 between 7:40 and 9:35 PM (two observations at distances of 18.6 mi [29.9 km] and 9.6 mi [15.4 km] respectively). Both nights were moonless at the time of the observations.

Study Observation Point 1.

The observations showed that at 29.4 mi (47.3 km), the lighting at the CDSEF was plainly visible to moderately dark adapted eyes (5-10 minutes of dark adaptation). Three types of lights were visible:

1. What appeared to be two slowly flashing red lights, with the lower light seeming to be wider than tall;

2. A yellowish white, roughly lens-shaped area of light underneath the red flashing lights; and

3. Fainter points of white light to the left (west) of the red flashing and yellowish white lens-shaped lights.

Figure 3.1-11 shows these lights as they appeared at the distance of 29.4 mi, a photograph taken with exposure and white balance set to approximate the actual appearance of the facility reasonably well. In this figure, the red lights are aerial hazard navigation lights (as required by the Federal Aviation Administration [FAA]) on the CDSEF receiver tower, and the lens-shaped light is the reflected light of the illuminated power block buildings, while the points of light to the left of the red flashing and white lens-shaped light are unshielded lights on the temporary buildings. The red aerial hazard navigation lights on the tower flashed on and off continuously, in a cycle of approximately 1 second on and 2 seconds off.

The red flashing aerial hazard navigation lights were judged to be as bright as Alpha Aquilae (Altair), magnitude 0.77. The yellowish lighting around the power blocks were judged to be as bright as the star Alpha Cassiopeiae (Schedar), magnitude 2.24, which was visible at the time.[1] The isolated white lighting at the temporary buildings was judged to be considerably fainter. Because the immediate area around the CDSEF is almost completely dark, the CDSEF lighting was prominent, though not the brightest ground-based light visible at the time.

Study Observation Point 4.

The observation at 18.6 mi (29.9 km) showed that the lighting at the CDSEF was plainly visible to slightly dark adapted eyes (2-3 minutes of dark adaptation). Three types of lights were visible:

1. The two slowly flashing red lights;
2. The lens-shaped area of yellowish white light underneath the red flashing aerial hazard navigation lights; and
3. Additional fainter white points of light to the left (west) of the aerial hazard navigation and lens-shaped lights.

At this distance, the red flashing aerial hazard navigation lights were judged to be as bright as Alpha Lyrae (Vega), magnitude 0.03, and the brightest star visible at the time. The yellowish lighting around the power blocks were judged to be as bright as Alpha Scorpii (Antares), magnitude 1.03. Additional lights at the temporary buildings were visible from this distance. The CDSEF lighting was judged to be sufficiently bright to attract visual attention, and the flashing red lights to be a major focus of visual attention, and a distraction from the rest of the night scene, though bright moving lights of vehicles on Highway 6 were also visible. The appearance of the facility at this distance is shown in Figure 3.1-12.

Study Observation Point N1.

At 9.6 mi (15.4 km) many more lights were visible. At this distance, the wider lower red light was clearly resolved into two separate red lights that flashed on and off in unison. In addition to these three bright red flashing lights, several other red lights were observed on the tower, in pairs at regular intervals up the sides of the tower. Two paired white lights were also visible part way up the tower, and several point-like light sources were also visible on both sides of the tower, but mostly on the left (west) side; some of these may have been more distant lights not associated with the CDSEF. More than 15 yellowish lights were visible in and around the power block, and the light from the luminaires reflected off the surfaces of the various structures with enough brightness to illuminate the lower portions of the receiver tower. Both the red and

[1] A method for approximating the apparent brightness of a light at night is to compare it with a visible star of a known apparent magnitude, as described in Section 2.2.2.

white lights were judged to be brighter than the star Vega, and the CDSEF lighting was judged to be sufficiently bright to be a major focus of visual attention, and a distraction from the rest of the night scene. The appearance of the facility at 9.6 mi (15.4 km) is shown in Figure 3.1-13.

FIGURE 3.1-11 Nighttime View of CDSEF, showing Facility Lighting. Photo Location: SOP 1. Distance to Tower is 29.4 mi (47.3 km)

FIGURE 3.1-12 Nighttime View of CDSEF, showing Facility Lighting. Photo Location: SOP 4. Distance to Tower is 18.6 mi (29.9 km)

FIGURE 3.1-13 Nighttime View of CDSEF, showing Facility Lighting. Photo Location: SOP N1. Distance to Tower is 9.6 mi (15.4 km)

3.2 GLARE INCIDENTS

Three types of glare incidents were observed in the course of the CDSEF visibility study: glare from sunlight reflected from the surface of the receiver; glare from sunlight reflected off individual heliostats; and glare from the surface of structures in the power block. The three types of glare events had different characteristics, as described below.

3.2.1 Receiver Glare

One observer recorded glare from the receiver during a single observation, from a location 16.1 mi (25.9 km) from the CDSEF receiver. The observation was made at 3:38 p.m. local time. The observer found the receiver to be bright enough to cause an afterimage after looking directly at the receiver for an extended period; however, extended viewing was possible, and neither observers experienced discomfort. A photograph from that observation is shown in Figure 3.2-1. It should be noted, however, that similar to the observations made during the ISEGS study, the receiver (and other intense reflections from the facility components) viewed in person was much brighter than it appeared to be in the photograph. Other study observations made from shorter distances than this observation caused neither afterimages nor discomfort, and this was true even standing almost directly under the receiver during the facility visit on August 11.

3.2.2 Heliostat Glare

Glare apparently from an individual heliostat (referred to as a “heliostat flare” in this and the ISEGS study report) was observed twice during the course of the study. Heliostat flares occur when sunlight is reflected from one or more heliostats directly toward the observer, appearing as a bright (sometimes exceedingly bright) spot of light within the heliostat array.

The heliostat flares are shown in Figure 3.2-2 and Figure 3.2-3. The heliostat flare shown in Figure 3.2-2 was observed at 4:00 p.m. on August 8, from a point 14.3 mi (23.0 km) south-southeast of the facility, at which time the solar azimuth was 246° and the solar elevation was 41°. The facility was offline at the time the flare occurred. The heliostat flare shown in Figure 3.2-3 was observed at 6:27 a.m. (shortly after sunrise) on August 10, from a point 9.5 mi (15.2 km) south-southeast of the facility, at which time the solar azimuth was 74° and the solar elevation was 5°. At the time of this observation, the facility was in the process of coming online, that is, heliostats were being gradually pointed to illuminate the receiver. When the facility is offline, in the process of going offline, or coming online, the reflected light from all of the heliostats is not directed at the receiver, and this may increase the chances for heliostat flares.

As was the case with most incidents of glare in the ISEGS study, the two CDSEF heliostat flares lasted approximately one minute or less, and consisted of a very rapid and large increase in brightness of a point in the heliostat array. At their peak brightness, both heliostat flares rivaled the operating receiver itself (as observed at other times) in brightness. The flares shone steadily and then rapidly faded back to their previous brightness. In their general

FIGURE 3.2-1 Glare from CDSEF Receiver, as seen from 16.1 mi (25.9 km) from Receiver Tower. Photo location: SOP 34.

FIGURE 3.2-2 CDSEF Heliostat Flare, as seen from 14.3 mi (23.0 km) from Receiver Tower. Photo location: SOP 46.

FIGURE 3.2-3 CDSEF Heliostat Flare, as seen from 9.5 mi (15.2 km) from Receiver Tower. Photo location: Poleline Road.

appearance, these glare events were very similar to those observed at ISEGS, as shown by Figure 3.2-4, which shows heliostat flares at the ISEGS facility.

In the course of the ISEGS study, heliostat flares were recorded during 15 of the 19 observations, and often several flares were observed multiple times in the course of one observation (Sullivan and Abplanalp 2015). During the CDSEF visibility study, glare from any source was observed during only eight of 25 daytime observations, plus one other time outside of an observation, and only two of these glare incidents appear to have been heliostat flares. The other instances involved glare that appeared to originate very close to the base of the receiver tower, and are more likely to have been associated with facility components within the power block or possibly vehicles (see Section 3.2.3). If it can be assumed that the incidence of heliostat flares that was observed during the periods of study at both facilities occurred at typical rates, because heliostat flares at ISEGS were often as bright or brighter than the light from the receivers, they were a major source of visual contrast at ISEGS, but appear to be only a minor source of visual contrast at the CDSEF.

While the cause of the apparent difference in the rate of heliostat flares at the two facilities cannot be determined conclusively, it may be that during the time of the observations, a greater number of heliostats were pointed away from the receivers at the ISEGS facility than were pointed away from the receiver at the CDSEF.

3.2.3 Glare from Other CDSEF Components

In seven of the ten observations of glare at the CDSEF, glare appeared to originate very close to the base of the receiver tower. Because the heliostat array does not approach closer than approximately 370 ft (113 m) to the receiver tower, glare very close to the base of the receiver is likely to be associated with components of the power block or within the power block area, such as the hot and cold salt tanks; the steam generation system;. or, possibly, vehicles parked within this area. These causes of glare are confirmed for at least some cases. In the course of the observation, inspection of the facility with binoculars showed that glare appeared to come from these sources, though in most cases, the glare itself and/or the long distance from the SOP to the facility made the identification of an exact glare source impossible. Figure 3.2-5 shows an example of a glare event that may have originated from a structure within the power block rather than a heliostat. The glare was observed at 3:38 p.m. on August 10, from a point 10.2 mi (16.4 km) southwest of the facility, at which time the solar azimuth was 248° and the solar elevation was 48°. While heliostats cannot be ruled out as the source of this event (they were recorded as being the source at the time, probably in error), this CDSEF glare event was less bright and distinctly different in appearance than similar events observed at the ISEGS facility. The CDSEF event, as pictured in Figure 3.2-5, shows a vertically elongated glare “spot” with two lobes appearing less “point-like” in shape. The glare was visible when the observers arrived at the SOP, throughout the observation, and was still visible when the observers left the SOP, at least 20 minutes first observing the glare spot.

In this particular case, examination of the viewing geometry suggests that the source of glare may have been a white tank (the raw water tank) visible in the lower left quadrant of the power block area shown in Figure 2.2-1. (After completion of this study, the tank was painted Covert Green, a color from BLM Standard Environmental Colors Chart [Seley 2017], a list of nine standard color choices for use in selecting the most appropriate color(s) for facilities located on lands managed by the BLM). Alternatively, the glare could have been caused by reflections from power block components near the tank (such as the steam turbine/generator or the control and operation building), or a vehicle parked near the tank.

The six other glare events were substantially fainter than the glare event just described, and all appeared to emanate from locations very close to the tower. They were reported as likely coming from either pipes (possibly from the steam turbine/generator or the air cooled condenser) or the roof of a structure at the base of the receiver; however, definite identification was not possible.

FIGURE 3.2-4 ISEGS Heliostat Flares, as seen from 35 mi (56 km) from the ISEGS Facility. Flares are visible near right-most tower (one in front and to the left, and one to the immediate right of the tower)

FIGURE 3.2-5 Glare Likely from CDSEF Power Block Component, as seen from 10.2 mi (16.4 km) from Receiver Tower

3.3 CDSEF VISIBILITY RATINGS

As discussed in Section 2.2.2, most study observations included a facility visibility assessment that required each of the two observers to quantitatively assess the visibility of the CDSEF on a scale of 1 to 6, where a visibility score of "1" implies a facility that is just barely visible to the unaided eye, and a score of "6" indicates a facility that dominates the view because of its size and strong color contrasts. See Appendix B, Visibility Rating Form, page 2, for definitions of visibility ratings. For each observation, the visibility scores are averaged between the observers to obtain the *average visibility rating* (AVR). A graph of the visibility ratings for the study is presented in Figure 3.3-1. Visibility ratings for the operating facility (online) are graphed separately from the visibility ratings for the non-operating facility (offline).

The graph shows the AVR for the 22 observations for which visibility assessments were conducted. Of these 22 observations, 16 observations were conducted with the facility online, (with the receiver illuminated), and six observations were conducted with the facility offline (with the receiver not illuminated).

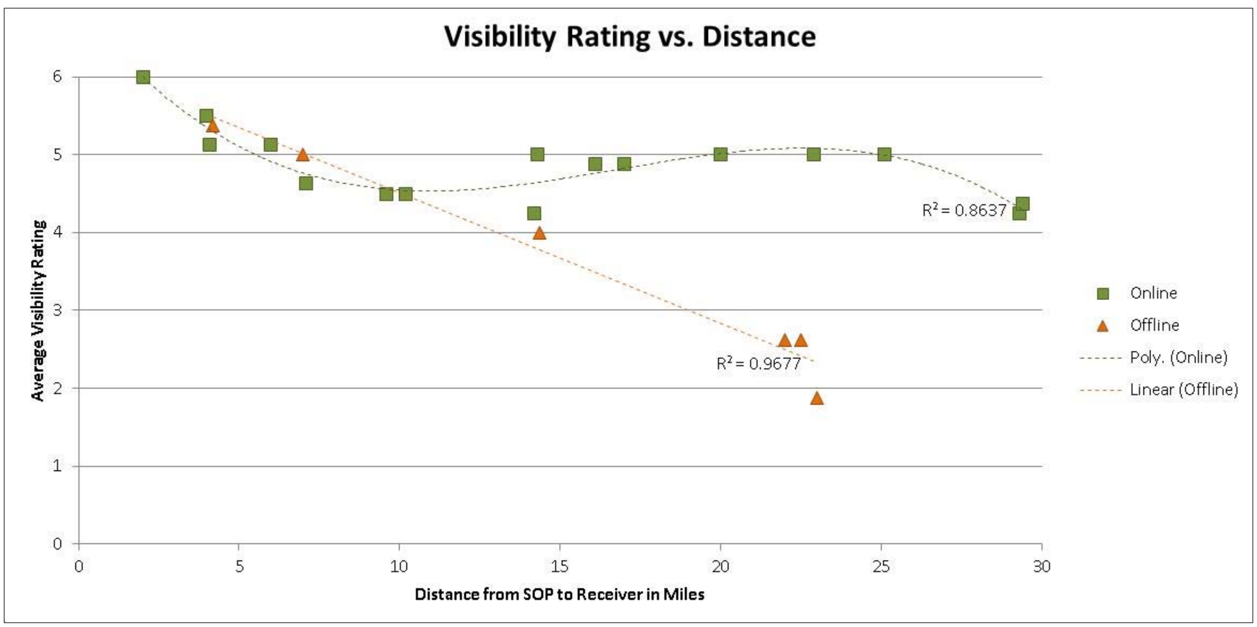

FIGURE 3.3-1 Average Online and Offline Visibility Rating Versus Distance to CDSEF Receiver

Figure 3.3-1 shows that when online, the CDSEF is a significant source of visual contrast for a relatively long distance. When online, the CDSEF AVR was at or near “5” to a distance of 25 mi (40 km). The rating language for a Visibility Rating of “5” is as follows:

> Strongly attracts visual attention for views in general direction of study subject. Attention may be drawn by strong contrast in form, line, color, or texture, by luminance, or by motion.
>
> *Describes an object/phenomenon that is not of large size, but that contrasts with the surrounding landscape elements so strongly that it is a major focus of visual attention, drawing viewer attention immediately, and tending to hold viewer attention. In addition to strong contrasts in form, line, color, and texture, bright light sources (such as lighting and reflections) and moving objects associated with the study subject may contribute substantially to drawing viewer attention. The visual prominence of the study subject interferes noticeably with views of nearby landscape elements.*

Thus the CDSEF is a major source of visual contrasts that strongly attracts and holds visual attention at a distance of 25 mi (40 km), and is a moderate source of visual contrast beyond that distance. While the farthest observation in the Bristlecone Pine Forest in the White Mountains of California at a distance 67.5 mi (108.6 km) did not include a formal visibility rating, both observers judged the CDSEF would not likely be missed by a casual observer, which corresponds to an AVR of “3.” The rating language for a Visibility Rating of “3” is as follows:

> Visible after brief glance in general direction of study subject and unlikely to be missed by casual observer.
>
> *Describes an object/phenomenon that can be easily detected after a brief look and which would be visible to most casual observers, but lacks sufficient size or contrast to compete with major landscape elements.*

In fact, at a nearby location (the Patriarch Grove, approximately 0.5 mi (0.8 km) east of the Bristlecone Pine Forest SOP), the observers encountered two tourists discussing the CDSEF (without knowing it was a solar facility), attempting to determine what it actually was, and stating that “it was obviously man-made.” This supports the findings of the judgement of the observers regarding the noticeability of the CDSEF to a casual observer, and suggests that while small in apparent size at very long distances, the CDSEF remains plainly visible. It should be noted that in this observation, not only was the illuminated receiver visible, the heliostat array was also easily seen, as shown in Figure 3.3-2.

FIGURE 3.3-2 Photograph of CDSEF from SOP 48, at a Distance of 67.5 mi (108.6 km)

At a distance of approximately 2.0 mi (3.2 km), the facility was large enough in terms of occupying so much of the observer's horizontal field of view to receive and AVR of "6." The rating language for a Visibility Rating of "6" is as follows:

> Dominates view because study subject fills most of visual field for views in its general direction. Strong contrasts in form, line, color, texture, luminance, or motion may contribute to view dominance.
>
> *Describes an object/phenomenon with strong visual contrasts that is of such large size that it occupies most of the visual field, and views of it cannot be avoided except by turning the head more than 45 degrees from a direct view of the object. The object/phenomenon is the major focus of visual attention, and its large apparent size is a major factor in its view dominance. In addition to size, contrasts in form, line, color, and texture, bright light sources, and moving objects associated with the study subject may contribute substantially to drawing viewer attention. The visual prominence of the study subject detracts noticeably from views of other landscape elements.*

Although the sample size is small, the results suggest the CDSEF major source of visual contrasts that strongly attracts and holds visual attention (AVR=5) as far as 25 mi (40 km) away, with the apparent size of the facility contributing substantially to view dominance at distances of approximately 2 mi (2 km) (AVR=6). The data suggest that beyond 25 mi (40 km), the noticeability of the CDSEF drops very slowly as the observation distance increases, with the CDSEF very small in apparent size but still easily seen (primarily because of the brightness of the reflected light from the receiver) at 67.5 mi (108.6 km) and potentially substantially beyond that distance.

The graph shows that the AVRs for the observations with the plant offline appeared to decrease in a linear fashion with distance, though caution must be exercised in interpretation, because of the small sample size. The data indicate that despite the receiver not being illuminated, the CDSEF received an AVR of “5,” indicating that it was a major focus of visual attention at a distance of 7.0 mi (11.3 km). The CDSEF AVR did not fall below the threshold of noticeability to a casual observer (AVR=3) until approximately 19 mi (31 km), and was still visible after extended close viewing of the landscape (AVR=2) at a distance of 22.5 mi (36.2 km). Figures 3.3-3 through 3.3-6 show the change in visibility of the CDSEF as distance increases.

Comparing the CDSEF visibility results with ISEGS observations shows, in general, a similar trend, but the CDSEF is rated as slightly less noticeable than ISEGS overall. Topographic screening blocked visibility of the ISEGS facility between approximately 20 mi (32 km) and 35 mi (56 km); however, in the ISEGS study, all but one observation at less than 20 mi (32 km) received an AVR of “5” or greater. The ISEGS observations at 35 mi (56 km) received an AVR of “4,” indicating a facility that is “plainly visible, could not be missed by [a] casual observer, but does not strongly attract visual attention, or dominate view because of apparent size.” (Sullivan and Abplanalp 2015, 51). All online CDSEF observations at less than 20 mi (32 km) received AVRs of “4” or greater, and if the CDSEF trend line was extended, it would indicate an AVR of “4” at approximately 31 mi (50 km). A likely reason for the CDSEF receiving somewhat lower AVRs than the ISEGS facility is that the ISEGS facility has three receivers and the CDSEF only one.

FIGURE 3.3-3 CDSEF at 4 mi to Receiver Tower. The CDSEF Occupies 24°, 19% of the normal horizontal field of view.

FIGURE 3.3-4 CDSEF at 10 mi to Receiver Tower. The CDSEF occupies 10°, 12% of the normal horizontal field of view.

FIGURE 3.3-5 CDSEF at 15 mi to Receiver Tower. The CDSEF occupies 7°, 6% of the normal horizontal field of view.

FIGURE 3.3-6 CDSEF at 29.3 mi to Receiver Tower, with High Level of Atmospheric Haze and Heliostat Field Partially Screened. The CDSEF occupies 3.4°, 3% of the normal horizontal field of view.

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4 SIMULATIONS AND CONTRAST RATINGS COMPARISONS: FIELD OBSERVATIONS AND DRAFT ENVIRONMENTAL IMPACT STATEMENT

Another objective of the CDSEF visibility study was to compare the "as-built" visual characteristics and contrasts of the operating facility with the characteristics and contrast levels portrayed in the visual simulations and visual impact analysis contained in the CDSEF Draft EIS (BLM 2010c; hereafter abbreviated "Draft EIS") and supporting documents prepared prior to construction of the facility. Sullivan and Abplanalp carried out a similar analysis for the ISEGS facility (2015). Those analysis results can be summarized as follows:

- The simulations of the ISEGS facility in the ISEGS EIS and supporting documents exhibited low spatial accuracy and realism in some instances.

- The simulations of the ISEGS facility in the EIS and supporting documents substantially under-represented the actual visual contrast from the project, as observed in the field in the course of the ISEGS study.

- Some of the contrast ratings in the ISEGS EIS predicted substantially lower levels of visual contrast than were actually observed for the operating facility.

- The ISEGS facility is substantially brighter and is seen more clearly in the field than in photographs of the facility or in simulations based on photographs.

The Draft EIS VIA identified six KOPs for evaluation of visual impacts of the preferred action and two alternatives, resulting in preparation of 18 simulations. The two alternatives involved slightly different locations for the CDSEF; however, the contrast and impact analysis for all alternatives were identical. In the CDSEF Record of Decision (BLM 2010d; hereafter abbreviated "ROD"), Alternative 2 was selected, and the simulations for that alternative are reproduced here and used in this analysis. The KOP and project viewshed are shown in Figure 4-1, reproduced from the original visual impact analysis report, "Tonopah Solar Energy, LLC, Crescent Dunes Solar Energy Project Final Visual Report," (BLM 2010b; hereafter abbreviated "FVR").

The Draft EIS contains pre-construction visual simulations and contrast/impact analysis for three of the six KOPs. Additional simulations (without discussion) are presented in the FVR, and are reproduced here.

The contrast and impact analysis for KOPs 1, 3, and 4 are essentially identical in both the FVR and the Draft EIS, and reach the same conclusions about visual contrast and impacts of the CDSEF (BLM 2010b; BLM 2010c). For the remainder of this report, the analyses are referred to together as "FVR/Draft EIS."

The FVR/Draft EIS did not provide information about the simulations beyond short descriptions of the simulation locations, general statements about field of view, and what the simulations showed; nor did the studies include precise locations for the simulations, dates and time of day for the base photographs, or precise field of view (BLM 2010b, 2010c). These and numerous other data are currently called for in BLM and other guidance documents (BLM 2013; Sullivan and Meyer 2014). These data greatly facilitate accurate evaluation of visual simulations for proposed facilities.

For the current study, photographs were taken at approximately the same distance as the KOPs in the FVR/Draft EIS to serve as a basis of comparison for the CDSEF visual simulations and contrast analysis in the FVR/Draft EIS VIAs.

The simulations from the FVR/Draft EIS as well as the corresponding photographs for the CDSEF visibility study for these six KOPs are presented in Sections 4.1-4.6. For each KOP:

- The simulation from the FVR/Draft EIS is compared with the CDSEF visibility study photograph that most closely matches the scene included in the simulation, and

- The visual contrast discussion in the FVR/Draft EIS is compared with the average visibility ratings (AVR) and supporting data obtained for the CDSEF visibility study.

It should be noted that the simulations in the FVR/Draft EIS were prepared before the exact design of the CDSEF was known, and some details of the facility design apparently changed after the simulations were prepared. For example, the FVR/Draft EIS states the approximate width of the CDSEF heliostat array as 4,300 ft, and further states that the heliostat array would contain 17,500 heliostats (BLM 2010b, 2010c). In fact, the heliostat array in the as-built facility is approximately 9,240 ft in diameter and includes 10,347 heliostats, a substantial difference. There are also discrepancies in details of the receiver, receiver tower, and the power block components. Thus, the analysts were using simulations that were not spatially accurate with respect to part of the facility, which potentially may have affected the accuracy of the contrast assessments in the FVR/Draft EIS. This situation is not uncommon for EIAs of energy facilities, but can have a major effect on the accuracy of simulations used in VIAs (Sullivan and Meyer 2014).

The six KOPs were selected within 10 mi (16 km) of the proposed CDSEF site. The FVR/Draft EIS states the following:

> The viewshed has an approximate radius of 10 miles in any direction from the project site. The proposed project would not be a dominant visual feature beyond 5 miles, and views beyond 10 miles of the project would be very difficult to discern. (BLM 2010b, 2010c)

The results of the CDSEF visibility study indicate that this statement is in error. In fact, as discussed in Section 3.1.1, the CDSEF was small in apparent size but still plainly visible and noticeable to a casual observer at a distance of 67.5 mi (108.6 km), and was found to be a major source of visual contrast as far out as 25 mi (40 km). This suggests that the area of visual impact analysis for the CDSEF visual impact analysis should have been far greater than 10 mi (16 km). Similar results were found for the ISEGS facility (Sullivan and Abplanalp 2015).

While the FVR/Draft EIS prepared simulations for all six KOPs, contrast assessments were conducted only for KOPs within 3 mi (4.8 km) of the facility (KOPs 1, 3, and 4). These KOPs were selected because the FVR/Draft EIS erroneously assumed there would be minimal visibility of the facility at distances beyond a few miles. The discussions in Sections 4.1-4.6 will compare simulations for all six KOPs, but because no contrast assessments were performed in the FVR/Draft EIS for the three more distant KOPs, those discussion are limited to the apparent levels of contrast shown in photographs obtained in this study.

When considering images of solar facilities that include glare or very bright reflections, it is important to note that photographs and computer monitors (a common medium for display of simulations) cannot depict the brightness of intense light sources accurately, because of the limits of the display medium. There are limits to the maximum brightness and contrast that these output media can display, as demonstrated by the fact that, as observed in the field, glare can be painfully bright enough to cause involuntary closing of the eyes or diverting of one's gaze, but photographs and computer screens cannot cause this level of visual discomfort. Similarly, display media generally lack the dynamic contrast range and sharpness that are observed in the field. When comparing photographs taken of the CDSEF during this study with the actual view in the field of the facility from the same location, it was clear that the photographs showed lower brightness, contrast, and sharpness than was actually observed. This same phenomenon was observed in the course of the ISEGS study (Sullivan and Abplanalp 2015). The ultimate effect is that the photographs (and simulations based on photographs) underrepresent the true brightness and contrast of the existing or proposed facility, and this must be kept in mind when considering all photographs and simulations contained in this report.

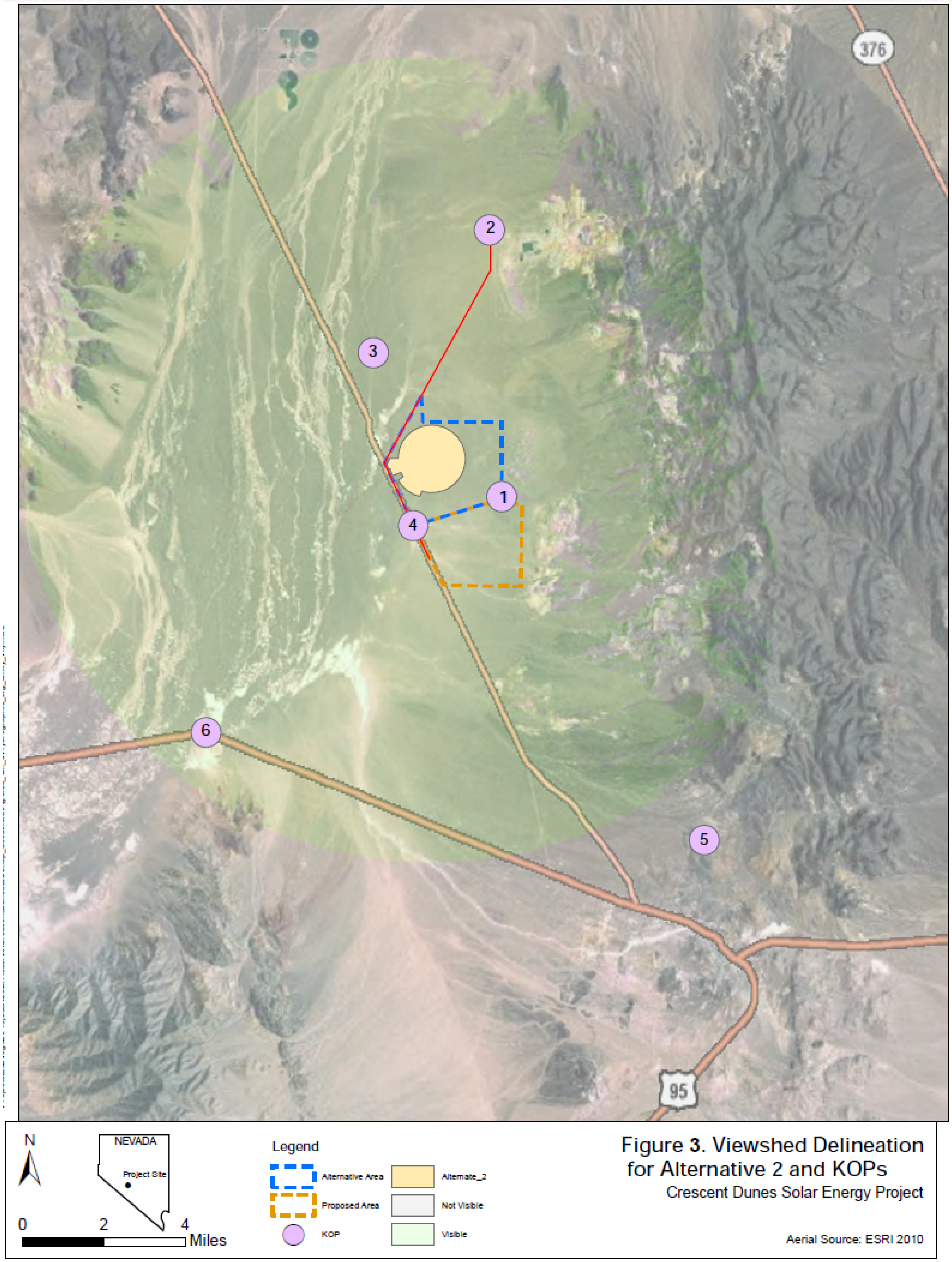

FIGURE 4-1 KOP Locations and Project Viewshed (Figure reproduced from FVR)

4.1 FVR/DRAFT EIS KOP 1 AND CDSEF VISIBILITY STUDY SOP 12

The FVR/Draft EIS KOP 1 is within the Crescent Dunes Special Recreation Management Area, approximately 2 mi (3.2 km) southeast of the CDSEF receiver tower. The view faces southwest toward Miller's Rest Stop (BLM 2010b, 2010c). The CDSEF visibility study SOP 12 is located 2 mi (3.2 km) northwest of the CDSEF tower, and is used here for comparison purposes, despite the difference in viewing direction. Figure 4.1-1 shows the existing and simulated view of the CDSEF from the FVR/Draft EIS (BLM 2010b, 2010c), and Figure 4.1-2 shows a CDSEF visibility study photograph taken from SOP 12 at approximately 12:08 p.m. local time on August 10.

Examination of the two figures shows that the illuminated receiver in Figure 4.1-2 is many times brighter than it appears in the FVR/Draft EIS simulation, Figure 4.1-1. In the simulation, the top of the receiver is a dull white, while in the photograph, it is a brilliant yellow-white, and was even more brilliantly white as observed in the field. The receiver in the photograph is also larger in size than the simulated receiver, appearing as a roughly rectangular element about three times taller than it is wide Also, the shape of the receiver tower in the simulation is inaccurate, as is the depiction of the power block. The simulated power block structures differ in size and shape from the as-built facility. And although it is not evident in the photograph because of deep shadowing of the power block area, the simulation shows the color of the power block elements inaccurately as well. The simulated heliostat array is more gray and substantially brighter than it appears in the as-built photograph; however, without knowing the

Existing Condition

Proposed

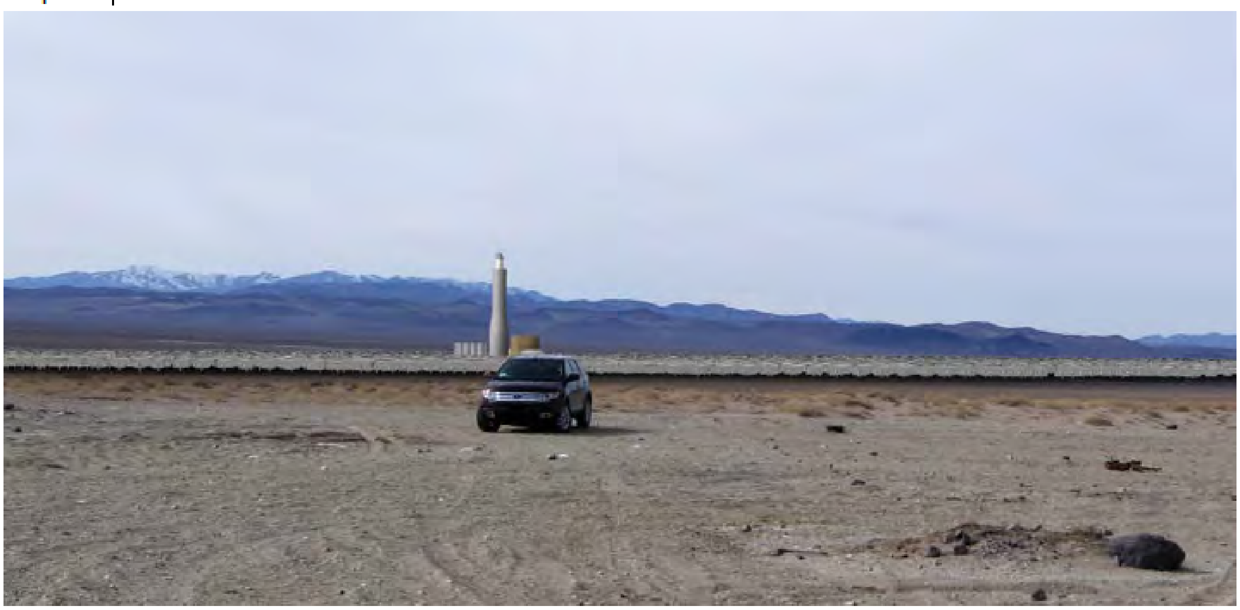

FIGURE 4.1-1 Visual Simulation of the CDSEF as it would be seen from the FVR/Draft EIS KOP 1, within Crescent Dunes SRMA

FIGURE 4.1-2 Photograph of the CDSEF as seen from CDSEF Visibility Study SOP 12

date and time the simulation base photograph was taken, there is no way to judge the accuracy of the lighting depiction (BLM 2010b, 2010c).

Discrepancies in the depiction of facility components in the simulation are those of spatial accuracy—they show the facility or its components at the wrong location, size, or positioning, or with missing or extra components (BLM 2013, Sullivan and Meyer 2014). It should be noted that the simulation may show the proposed facility design correctly, according to the proposed design at the time, and if so, this cannot be considered an error, only an inaccuracy that could not be avoided. The failure to show the receiver as bright as it would be in reality constitutes an error in realism, that is, not showing the facility as it would really appear, namely, colored and shaded realistically with cast shadows depicted accurately and realistically.

The FVR/Draft EIS describes the visual contrasts for this view as follows:

> In relation to the surrounding landforms, the Proposed Action would result in a moderate contrast in form, line, color, and texture. The tower would be a new structure in the surrounding flat landscape, introducing a strong vertical line…At this distance, the tower and surrounding heliostat field would be clearly visible from the dunes. Additionally, the Proposed Action would result in a moderate contrast of texture because the solar panels would create a repetitive texture on the landscape that would be moderately different from the texture of the surrounding landforms. Additionally, at this distance, the tower may appear white, and the reflective properties of the heliostats may appear to have a water-like effect on the surrounding landscape. (BLM 2010c, 4-93)

As observed in the CDSEF visibility study, the contrast caused by the extreme brightness of the receiver and the large apparent size of the facility resulted in an AVR of "6," described in the rating system as:

Dominates view because study subject fills most of visual field for views in its general direction. Strong contrasts in form, line, color, texture, luminance, or motion may contribute to view dominance. *Describes an object/phenomenon with strong visual contrasts that is of such large size that it occupies most of the visual field, and views of it cannot be avoided except by turning the head more than 45 degrees from a direct view of the object. The object/phenomenon is the major focus of visual attention, and its large apparent size is a major factor in its view dominance. In addition to size, contrasts in form, line, color, and texture, bright light sources, and moving objects associated with the study subject may contribute substantially to drawing viewer attention. The visual prominence of the study subject detracts noticeably from views of other landscape elements.*

By finding that the CDSEF would cause moderate contrasts, the FVR/Draft EIS analysis underrepresents the observed visual contrast of the facility, likely because of the substantial underrepresentation of the receiver brightness in the simulation. It should be noted that some other elements of the contrast analysis description correspond well with the appearance of the facility in the photograph such as the strong vertical line contrast of the receiver tower, its white color, and the texture of the heliostat field (BLM 2010b, 2010c).

4.2 FVR/DRAFT EIS KOP 2 AND CDSEF VISIBILITY STUDY SOP 17

The FVR/Draft EIS KOP 2 is located at the western edge of the Anaconda-Moly Substation, approximately 6 mi (9.7 km) north-northeast of the CDSEF receiver tower. The CDSEF visibility study SOP 17 is located 6 mi (9.7 km) north-northwest of the CDSEF tower off Peavine Road, and is used here for comparison. Figure 4.2-1 shows the existing and simulated views of the CDSEF from the FVR/Draft EIS (BLM 2010b, 2010c), and Figure 4.2-2 shows a CDSEF visibility study photograph taken from SOP 17 at approximately 11:07 a.m. local time on August 10.

Similar to the KOP1 simulation, examination of Figures 4.2-1 and 4.2-2 shows that the illuminated receiver in the CDSEF visibility study photograph is much brighter than it appears in the FVR/Draft EIS KOP 2 simulation. In the simulation, the receiver tower is relatively difficult to notice, and the receiver itself is a tiny medium gray dot, while in the photograph, it is a bright yellow-white, easily seen and clearly rectangular in shape. In the simulation, no details of the power block or array are visible, but details are faintly visible in the photograph, and were more clearly seen in the field (BLM 2010b, 2010c).

Existing Condition

Proposed

FIGURE 4.2-1 Visual Simulation of the CDSEF as it would be seen from the FVR/Draft EIS KOP 2, Anaconda Substation

FIGURE 4.2-2 Photograph of the CDSEF as seen from SOP 17, Off Peavine Road

No description or narrative for the simulation for KOP 2 is provided in the FVR/Draft EIS (BLM 2010b, 2010c). As observed in the CDSEF visibility study, the contrast caused by the extreme brightness of the receiver and the large apparent size of the facility merited an AVR of "5.125." An AVR of "5" is described in the facility visibility rating system as:

> Strongly attracts visual attention for views in general direction of study subject. Attention may be drawn by strong contrast in form, line, color, or texture, by luminance, or by motion.
>
> *Describes an object/phenomenon that is not of large size, but that contrasts with the surrounding landscape elements so strongly that it is a major focus of visual attention, drawing viewer attention immediately, and tending to hold viewer attention. In addition to strong contrasts in form, line, color, and texture, bright light sources (such as lighting and reflections) and moving objects associated with the study subject may contribute substantially to drawing viewer attention. The visual prominence of the study subject interferes noticeably with views of nearby landscape elements.*

Analysis of the KOP 2 simulation from the FVR/Draft EIS clearly shows that it does not describe an AVR of “5,” because the simulated facility does not draw visual attention, nor does it interfere noticeably with views or nearby landscape elements. The contrast shown in the simulation is substantially lower than an AVR of “5” (BLM 2010b, 2010c).

4.3 FVR/DRAFT EIS KOP 3 AND CDSEF VISIBILITY STUDY SOP 14

The FVR/Draft EIS KOP 3 is located at the junction of Pole Line Road and the Anaconda-Moly substation access road, approximately 2.9 mi (4.7 km) from the CDSEF receiver tower. The CDSEF visibility study SOP 14 is located 4 mi (6.4 km) northwest of the CDSEF tower, and is used here for comparison purposes, despite the 1 mi (16 km) difference in distance from the CDSEF tower. Figure 4.3-1 shows the existing and simulated views of the CDSEF from the FVR/Draft EIS, and Figure 4.3-2 shows a CDSEF visibility study photograph taken from SOP 14 at approximately 11:41 a.m. local time on August 10 (BLM 2010b, 2010c).

As with KOP 1 and 2 simulations, examination of Figures 4.3-1 and 4.3-2 shows the illuminated receiver in the photograph is substantially brighter than it appears in the FVR/Draft EIS simulation. The simulation shows the top of the receiver as a dull white, while in the photograph, it is a brilliant yellow-white. The simulation shows some of the power block elements as substantially taller than they appear in the as-built photograph . The heliostat array in the simulation is white, while in the photograph it is mostly dark, and has more visible texturing. The dark appearance of the heliostat array in the photograph is due to shadowing of the ground and lower portions of the heliostats by the heliostats themselves. The shadowing is not shown in the simulation.

The FVR/Draft EIS describes the visual contrasts for the Proposed Action as follows:

> The Proposed Action would introduce a weak visual contrast for form, line, color, and texture into the viewshed because the central receiver tower and surrounding heliostats would barely be discernable from this distance. (BLM 2010c, 4-95)

The Proposed Action was not the alternative selected, and the simulation for the Proposed Action shows the facility to be smaller than shown in Figure 4.3-1; however, the FVR/Draft EIS says, for the alternative selected (Alternative 2) “the viewer contrast rating, viewer sensitivity analysis, and overall visual impact analysis would be similar to those associated with the Proposed Action.” Presumably, the descriptive text for the Proposed Action should at least approximate that for the selected alternative.

As observed in the CDSEF visibility study, the contrast caused by the extreme brightness of the receiver and the large apparent size of the facility resulted in an AVR of “5.5,” which, as discussed in Section 4.2, indicates a strong visual contrast that would attract and hold visual attention and interfere noticeably with views of other landscape elements. Analysis of the KOP 3 simulation shows that while the simulated facility does draw visual attention, it arguably does not interfere noticeably with views of nearby landscape elements. The contrast shown in the simulation is somewhat lower than an AVR of “5.”

Existing Condition

Proposed

FIGURE 4.3-1 Visual Simulation of the CDSEF as it would be seen from the FVR/Draft EIS KOP 3, at the Intersection of Pole Line Road and the Anaconda-Moly Access Road

FIGURE 4.3-2 Photograph of the CDSEF as seen from CDSEF Visibility Study SOP 14

4.4 FVR/DRAFT EIS KOP 4 AND CDSEF VISIBILITY STUDY SOP 12

The FVR/Draft EIS KOP 4 is located at the junction of Pole Line Road and the Crescent Dunes access road, approximately 1.6 mi (2.6 km) from the CDSEF receiver tower. The CDSEF visibility study has no SOP closer than 2 mi (3.2 km), so SOP 12, at 2 mi (3.2 km), northwest of the CDSEF tower is used here for comparison purposes. SOP 12 was also used for comparison in Section 4.1, and the reader is referred to that section and Figure 4.1-2 for discussion of the view from SOP 12. Figure 4.4-1 shows the existing and simulated views of the CDSEF from the FVR/Draft EIS (BLM 2010b, 2010c), and Figure 4.2-2 shows a CDSEF visibility study photograph taken from SOP 12 at approximately 12:08 p.m. local time on August 10.

As with the other simulations, examination of Figures 4.4-1 and 4.1-2 shows the illuminated receiver in the photograph is much brighter than it appears in the FVR/Draft EIS simulation. In the simulation, the top of the receiver is white, while in the photograph, it is a much more brilliant yellow-white and larger in size. Some of the power block elements in the simulation are substantially taller than they appear in the as-built photograph; however, the heliostat array is roughly similar in appearance in the simulated and as-built facilities.

Existing Condition

Proposed

FIGURE 4.4-1 Visual Simulation of the CDSEF as it would be seen from the FVR/Draft EIS KOP 4, at the Intersection of Pole Line Road and the Crescent Dunes Access Road

The FVR/Draft EIS describes the visual contrasts for the Proposed Action as follows:

> "The Proposed Action would introduce a moderate visual contrast for form, line, color, and texture because the facilities would be dominant in the foreground."
> (BLM 2010c, 4-96).

As noted above, the Proposed Action was not the alternative selected, but the simulation for the Proposed Action shows the facility to be approximately the same size as shown in Figure 4.4-1. The FVR/Draft EIS says that for the alternative selected (Alternative 2) "the viewer contrast rating, viewer sensitivity analysis, and overall visual impact analysis would be similar to those associated with the Proposed Action." Presumably, the descriptive text for the Proposed Action should approximate that for the selected alternative.

As noted in Section 4.1 and as observed in the CDSEF visibility study, the contrast caused by the extreme brightness of the receiver and the large apparent size of the facility resulted in an AVR of “6,” indicating a very strong visual contrast rather than a moderate contrast as described in the FVR/Draft EIS (BLM 2010b, 2010c).

4.5 FVR/DRAFT EIS KOP 5 AND CDSEF VISIBILITY STUDY SOP 46

The FVR/Draft EIS KOP 5 is located on Penstemon Court, in a residential area on the outskirts of Tonopah, approximately 11 mi (18 km) from the CDSEF receiver tower. The CDSEF visibility study SOP 46 is located 14.3 mi (23.0 km) SE of the CDSEF in a residential area within the city of Tonopah, near the intersection of Air Force Road and Victoria Road, just northwest of Butler Mountain. SOP 46 is considerably farther from the CDSEF than KOP 5, but in nearly the same direction as the KOP 5 simulation, so it is used here for comparison purposes. Figure 4.5-1 shows the existing and simulated views of the CDSEF from the FVR/Draft EIS, and Figure 4.5-2 shows a CDSEF visibility study photograph taken from SOP 46 at approximately 4:23 p.m. local time on August 10 (BLM 2010b, 2010c).

Examination of Figure 4.5-1 shows no discernable difference between the existing conditions photograph and the simulation of the proposed project. In other words, the simulation suggests that the CDSEF would not be visible at all. Figure 4.5-2 shows that the CDSEF is easily visible and a major focus of visual attention as seen from a location significantly father away (14.3 mi [23.0 km] vs. 11 mi [18 km]). The receiver light is very prominent, and the heliostat array is plainly visible across a substantial portion of the horizontal field of view. The facility would likely be substantially more noticeable at 11 mi (18 km), the distance for the KOP 5 simulation (BLM 2010b, 2010c).

No description or narrative for the simulation for KOP 5 is provided in the FVR/Draft EIS. As observed in the CDSEF visibility study, the contrast caused by the extreme brightness of the receiver and the large apparent size of the facility merited an AVR of “5.” Thus, the KOP 5 simulation from the FVR/Draft EIS greatly under-represents the visibility of the CDSEF from Tonopah (BLM 2010b, 2010c).

Existing Condition

Proposed

FIGURE 4.5-1 Visual Simulation of the CDSEF as it would be seen from the FVR/Draft EIS KOP 5, at Penstemon Court

FIGURE 4.5-2 Photograph of the CDSEF as seen from CDSEF Visibility Study SOP 46

4.6 FVR/DRAFT EIS KOP 6 AND CDSEF VISIBILITY STUDY SOP 6

The FVR/Draft EIS KOP 6 is located near Miller's Rest Stop, off US-6, approximately 8.4 mi (13.5 km) SW of the CDSEF receiver tower. In the CDSEF visibility study, SOP 6 is located 10.2 mi (16.4 km) SW of the CDSEF, also off US-6. SOP 6 is farther from the CDSEF than KOP 6, but in nearly the same direction as the KOP 6 simulation, so it is used here for comparison purposes. Figure 4.6-1 shows the existing and simulated views of the CDSEF for KOP 6 from the FVR/Draft EIS and Figure 4.6-2 shows a CDSEF visibility study photograph taken from SOP 6 at approximately 3:38 p.m. local time on August 10 (BLM 2010b, 2010c).

Examination of Figure 4.6-1 shows that the CDSEF is easily missed unless looking closely at the simulation, where the receiver itself is a tiny medium gray dot. In the CDSEF visibility study photograph, the receiver is a bright yellow-white, substantially larger, more easily seen, and clearly rectangular in shape. The receiver light is very prominent, and the heliostat array is plainly visible. The facility would likely be somewhat more noticeable at 8.4 mi (13.5 km), the distance for the KOP 6 simulation (BLM 2010b, 2010c)

No description or narrative for the simulation for KOP 6 is provided in the FVR/Draft EIS. As observed in the CDSEF visibility study, the contrast caused by the extreme brightness of

Existing Condition

Proposed

FIGURE 4.6-1 Visual Simulation of the CDSEF as it would be seen from the FVR/Draft EIS KOP 6, near Miller's Rest Stop

FIGURE 4.6-2 Photograph of the CDSEF as seen from CDSEF Visibility Study SOP 6

the receiver and the large apparent size of the facility merited an AVR of "4.5." An AVR of "4" is described in the CDSEF visibility rating system as:

> Plainly visible, could not be missed by casual observer, but—for views in general direction of study subject—does not strongly attract visual attention or dominate view because of apparent size.
>
> *Describes an object/phenomenon that is obvious and with sufficient size or contrast to compete with other landscape elements, but with insufficient visual contrast to strongly attract visual attention and insufficient size to occupy most of the observer's visual field.*

In the KOP 6 simulation from the FVR/Draft EIS, the CDSEF could be missed by a casual observer and is not obvious (BLM 2010b, 2010c). The simulation substantially under-represents the visibility of the CDSEF from Miller's Rest Stop.

4.7 SUMMARY OF COMPARISONS BETWEEN PROJECTED AND ACTUAL CONTRAST LEVELS

Six simulations were presented in the FVR/Draft EIS for which corresponding visual contrast ratings and photographs were taken as part of the CDSEF visibility study. The simulations depicted the anticipated appearance of the CDSEF as it would be seen from particular KOPs, while the photographs taken during the CDSEF visibility study depicted the actual appearance of the facility in operation.

Comparisons of the simulations and with the photographs showed that all of the simulations exhibited minor discrepancies in spatial accuracy and major discrepancies in realism. The simulations did not present all facility components accurately, probably because of design changes after the simulations were prepared. Some project elements visible in the photographs, such as receiver tower, the power block elements, and tower structure details, differed substantially from their depiction in the simulations. More importantly, the simulations greatly under-represented the brightness of the illuminated receiver, primarily because the simulated reflected light from the receiver was far more dim than it actually appears in the field. As a result, the simulations substantially under-represented the visual contrasts of the facility.

A comparison of the visual contrast ratings presented in the FVR/Draft EIS and those made during the CDSEF visibility study is presented in Table 4.7-1. The FVR/Draft EIS projected *weak* or *moderate* visual contrasts from the project as it would be seen from three of the six KOPs discussed in this report. The contrast ratings and visibility assessments for the operating facility indicated that the actual visual contrasts observed during the field assessments were *very strong* or *strong to very strong*, despite the fact that in two of the three observations, the comparison SOPs were considerably further from the CDSEF than the KOPs used for the simulations. While the photographs taken during the contrast assessments do not show the receivers to be as bright as they were to the naked eye, they do show the receivers to be substantially brighter than shown in the simulations.

For the remaining three KOPs, the FVR/Draft EIS did not provide contrast assessments based on a finding that there would be little or no contrast at the distances involved (BLM 2010b, 2010c), while the CDSEF visibility study indicated *strong* or *moderate to strong* visual contrasts. In general, the visual contrast levels predicted in the FVR/Draft EIS were much lower than those actually observed for the as-built facility as determined by the CDSEF visibility study.

TABLE 1 Comparison of FVR/Draft EIS Visual Contrast Ratings to CDSEF Visibility Study Contrast Ratings

FVR/ Draft EIS KOP	Visibility Study SOP	FVR/Draft EIS KOP Location	FVR/Draft EIS Contrast Rating	CDSEF Visibility Study Contrast Rating	Distances and Notes
1	12	Crescent Dunes SRMA	Moderate	Very Strong: AVR=6	KOP Distance=2 mi SOP Distance=2 mi
2	17	Anaconda Substation	N/A	Strong: AVR=5.125	KOP Distance=6 mi SOP Distance=6 mi
3	14	Pole Line Road/ Anaconda-Moly Road	Weak	Strong to Very Strong: AVR=5.5	KOP Distance=2.9 mi SOP Distance=4.0 mi FVR/Draft EIS says “central receiver tower and surrounding heliostats would barely be discernable”
4	12	Pole Line Road/ Crescent Dunes Road	Moderate	Very Strong: AVR=6	KOP Distance=1.6 mi SOP Distance=2.0 mi
5	46	Penstemon Court	N/A	Strong: AVR=5	KOP Distance=11 mi SOP Distance=14.3 mi Project not visible in simulation.
6	6	Miller’s Rest Stop	N/A	Moderate to Strong: AVR=4.5	KOP Distance=8.4 mi SOP Distance=10.2 mi

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5 EFFICACY OF VISUAL IMPACT MITIGATION MEASURES

5.1 INTRODUCTION

Another CDSEF visibility study task was to assess the efficacy of visual impact mitigation measures employed at the CDSEF to avoid, minimize, or reduce over time the visual contrasts created by its construction and operation. This task involved the following steps:

- Identify visual impact mitigation measures specified in the ROD (BLM 2010d);
- Determine which of the mitigation measures specified in the ROD were implemented;
- Assess the efficacy of implemented mitigation for which field verification is possible; and
- Identify potential opportunities for improvements and additions to mitigation measures.

The BLM's publication, *Best Management Practices for Reducing Visual Impacts of Renewable Energy Facilities on BLM-Administered Lands* (BLM 2013), provides detailed recommendations for mitigation of visual impacts for renewable energy facilities on BLM-administered lands in the western United States, and was used as the reference standard for this study.

Some important caveats apply in the assessment of the efficacy of visual impact mitigation measures at the CDSEF. First, when the facility is operating, the primary source of visual contrast is the reflected sunlight from the receiver. While the tower, heliostat array, and other structures may be plainly visible (particularly at shorter viewing distances), they contribute less to the overall visual contrast from the CDSEF than the operating receiver. Visual impact mitigation for these facility elements will reduce visual contrast, but will have a relatively minor effect on the overall visual contrast from the operating CDSEF. However, when viewed from shorter distances (up to several miles), or when the facility is not operating because it is offline or during cloudy conditions, mitigation for these elements is more noticeable. As a result, under these conditions, the other structures contribute may contribute substantially to the overall contrast from the facility.

Second, the *Best Management Practices* publication notes that for various reasons, often technical, legal, practical, and/or safety related, a desired mitigation measure or practice cannot be implemented (BLM 2013). For example, for safety reasons, the FAA requires flashing red lights on structures more than 200 ft tall, which includes the CDSEF receiver tower. The flashing red lights greatly increase the nighttime visual contrast from the CDSEF (that is, of course, the intended purpose of the FAA-required lighting), undesirable from a visual contrast perspective, but unavoidable. Similarly, for technical reasons, some structures at the CDSEF that are subject to very high temperatures (e.g., the hot and cold salt tanks; see Figure 2.2-1) cannot be painted (Painter 2016). Additionally, in some cases commercially purchased components may only be available in particular colors or surface treatments that may be undesirable from a visual contrast perspective.

5.2 CDSEF MITIGATION REQUIREMENTS

The VRM Class for the project area is VRM Class IV. The objective and allowed level of change for VRM Class IV are as follows:

> 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.

The ROD Appendix A Right-of-Way (ROW) Lease/Grant (BLM 2010e) specified the following visual impact mitigation measures:

1. Measures to reduce night lighting in all natural areas to avoid unnecessary visual disturbance to wildlife. Methods to be implemented include, but are not limited to, shielding methods, and/or reduced human intensity. Effective lighting should have screens that do not allow the bulb to shine up or out. All lighting to be located to avoid light pollution onto any adjacent lands as viewed from a distance. Lighting fixtures shall be hooded and shielded face downward, located within soffits and directed on or to pertinent site only, and away from adjacent areas.

2. Outdoor lighting to be low-pressure sodium lighting and photocell controlled through contacts that control the outdoor lighting. Sensor lights and directional lighting to be used in cases where safety and security would not be compromised.

3. Lighting will not be provided for in the solar field, but is expected to be provided for in the following areas: building interior equipment, office, control, maintenance, and warehouse; tower, exterior building entrances, outdoor equipment within the power block and tank areas; power transformers; power block roadway, parking areas within the power block area; tank area, entrance gate; water treatment and air cooled condenser areas.

4. A lighting plan shall be submitted with the site plan review and/or architectural drawings indicating the types of lighting and fixtures, the

locations of fixtures, lumens of lighting, and the areas illuminated by the lighting plan.

5. Any required FAA lighting is exempt from this condition.

6. The holder shall ensure that all structures installed as part of the project will be color treated to reduce contrast with the surrounding environment. Structures to be color treated include the cooling tower siding and fan shroud, the air cooled condenser siding, building siding and roofing, water tanks, any walls surrounding switchyard/substation facilities, and any other walls or enclosed structures installed as part of the project. The holder will work with the Authorized Officer to select the appropriate color from the BLM approved color palette. All color treatments shall be approved by the Authorized Officer prior to any application.

These mitigation measures can be summarized as five artificial lighting impact mitigation measures and one color treatment mitigation measure to reduce daytime visual impacts. Mitigation measures 1-3 and 6 in the list above were judged to be at least partly verifiable through field observation, and are addressed in the following discussion.

5.3 MITIGATION APPLICATION AND EFFICACY ASSESSMENT

1. **Placement and shielding of light fixtures.**

   The site managers and BLM provided a tour of the CDSEF facility for the study authors on August 10. In the course of the tour, the authors were able to verify, with the exception of lighting on temporary buildings/structures scheduled to be removed from the site upon completion of the project, observed lighting was full-cutoff and pointed downward, as shown in Figures 5.3-1, 5.3-2, and 5.3-3. This practice is consistent with the artificial lighting mitigation measures called for in the BLM *Best Management Practices* publication (BLM 2013). The lighting was not shielded; however, the lamps were flush or recessed within the fixture head and thus would not allow light to shine upward or at 90°. There may have been additional lighting on site that was not observed, particularly within the steam turbine generator and steam generation system areas, which were not approached closely during the tour.

   While the downward-pointing full-cutoff lighting likely reduced the contrasts from the facility, as shown in Figure 5.3-4, many lights are still visible at the CDSEF facility at night (aside from the FAA-required lighting on the receiver tower), and the non-tower lighting is strong enough to be plainly visible at long distances, as shown in Figure 5.3-5, taken from SOP 1 at a distance of 29.4 mi (47.3 km). It could not be verified in the field whether the lights were shining directly toward the viewer or were reflected light from surfaces illuminated by downward-facing shielded lighting. Looking closely at

Figure 5.3-5, some of the light appears to be reflected from a large tank at the left (west), but the bulk of the lighting appears to be associated with the steam turbine generator and the steam generation system. If this lighting is not full-cutoff and/or shielded, it could be the source of much of the non-FAA lighting visible at night. If this is the case, reducing the number or intensity of lights/lighting or improving the design of the lights (if it could be done in a manner consistent with safety requirements) could reduce artificial lighting impacts.

Lighting that appeared to be associated with the temporary buildings was plainly visible west of the receiver tower, as shown in Figures 3.1-12 and 3.1-13. While it cannot be stated with certainty, the point-like nature of the visible light suggests that the lighting was unshielded and the lamps were not flush or recessed within the fixture head, and/or the light was not pointed downward. This would allow the light itself to be directly visible, increasing visual contrast.

2. **Lighting color.**

While the exact color spectrum of the lighting in use at CDSEF could not be determined through field observation, the soft yellow color of the “white” lighting visible in Figures 5.3-4 and 5.3-5 suggests that it may be low-pressure sodium lighting, a mitigation measure called for in the *Best Management Practices* publication (BLM 2013). If this is the case, using low-pressure sodium lights or reducing use of non-low-pressure sodium lights could reduce artificial lighting impacts. Lighting controls could not be verified in the field.

The unshielded lighting that appeared to be associated with temporary buildings (shown in Figures 3.1-12 and 3.1-13) is more white in color, suggesting that it is not low-pressure sodium lighting, and thus inconsistent with the recommendations in the *Best Management Practices* publication (BLM 2013).

FIGURE 5.3-1 Full-Cutoff Lighting

FIGURE 5.3-2 Full-Cutoff Lighting on Buildings

FIGURE 5.3-3 Full-Cutoff Lighting

FIGURE 5.3-4 CDSEF Lighting Close-up View

FIGURE 5.3-5 CDSEF Lighting Distant View at 29.4 mi (47.3 km)

3. **Lighting placement.**

While the exact placement of lighting could not be verified in the field, during the field observations, no lighting was visible within the heliostat array. All lighting not associated with temporary buildings or the receiver tower appeared to be associated with the power block and nearby structures, as shown in Figures 5.3-5 and 5.3-6. This practice is consistent with the *Best Management Practices* publication recommendation to minimize the number of light sources (BOM 2013).

4. **Surface treatment.**

Figures 5.3-7 and 5.3-8 show that some buildings and structures at CDSEF have been color-treated to blend with the existing surroundings. For example, the building at left in Figure 5.3-7 was painted a "desert sand" light beige color. However, as shown in both Figures 5.3-7 and 5.3-8, not all structures have been color treated, and those that appear to have been color treated, in some cases, use different colors, which is undesirable from a mitigation perspective. It is likely, in at least some instances, technical considerations (e.g., the structure subject to high temperatures), may have precluded color treating. At least some of the temporary buildings were not color treated, and overall contrast from the CDSEF is higher as a result.

The *Best Management Practices* publication recommends that surfaces be color treated using colors from the "BLM Standard Environmental Color Chart CC-001" (BLM 2008). The chart recommends avoiding lighter colors, and suggests that selected colors should be slightly darker than the surrounding background to compensate for shadows that darken most textured natural surfaces. The light color used for color treating some CDSEF structures shown in Figures 5.3-2, 5.3-6, and some structures visible in Figure 5.3-7, appears to be lighter than any color on BLM's Standard Environmental Color Chart (2008) , and also appears to be lighter than the vegetated ground surface around the facility. Using a darker color likely would have improved the effectiveness of the mitigation.

The *Best Management Practices* publication recommends that "grouped structures should be color treated using the same color to reduce visual complexity and color contrast" (BLM 2013, 197). As is evident in Figure 5.3-7, the colors of structures at the CDSEF are varied, which adds to the visual complexity of the power block and increases its visual contrast.

FIGURE 5.3-6 Color Treatment of Power Block Structures

FIGURE 5.3-7 Color Treatment of Power Block Structures

FIGURE 5.3-8 Backs of Heliostats and Heliostat Support Structures Surrounded by Cleared Area

The *Best Management Practices* publication also recommends that

> 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. . . . 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. (BLM 2013, 191)

As shown in Figure 5.3-1, 5.3-3, 5.3-6, and other figures in the report, some structures at the CDSEF do appear to have non-reflective or low-reflectivity surface treatments, but some do not, such as the hot and cold salt tanks.

As noted in Section 3.2.3, most of the glare at the CDSEF appears to originate very close to the base of the receiver tower. While the exact sources of glare could not be determined, it is likely they involved highly reflective surfaces that potentially could have benefitted from non-reflective or low-reflectivity surface treatments if it were feasible to use them.

Mitigation measures called for in the *Best Management Practices* publication that do not appear to have been implemented at the CDSEF include color-treating the backs of the heliostats and their support structures, and leaving existing vegetation within the heliostat array (BLM 2013). Figure 5.3-8 shows the backs of the heliostats in a portion of the heliostat array. The tops of several of the visible heliostats are brightly illuminated by reflected sunlight from the heliostats immediately behind them. The illuminated backs of the heliostats are sometimes visible for several miles, as shown in Figure 5.3-9. Color treating the backs of the heliostats likely would have reduced or possibly eliminated this source of contrast.

In Figures 5.3-1 and 5.3-8, while some weedy vegetation appears to have grown on the site, it is evident that the ground surface within the heliostat array had been cleared and leveled. If retention of some of the existing vegetation had been possible, some contrast between bare soils and vegetation and structures likely would have been achieved; however, given that most views of the CDSEF are not elevated, the ground surface is not easily seen in any event.

FIGURE 5.3-9 Sunlight Reflected from Untreated Heliostat Backs Visible Across Heliostat Array

5.4 SUMMARY AND CONCLUSIONS

The ROD Appendix A ROW Grant (BLM 2010e) required visual impact mitigation measures for avoiding and reducing artificial lighting impacts from the CDSEF and the color treatment of CDSEF facility components to avoid and reduce daytime visual impacts. The required mitigation measures were partially implemented, though it must be noted that technical and safety requirements precluded full implementation for all of the mitigation measures.

As far as could be determined, the lighting mitigation measures were partially implemented in accordance with the recommended practices described in BLM's *Best Management Practices* (BLM 2013). While the implemented measures likely reduced the nighttime visual contrasts from the CDSEF relative to what might have been observed without the mitigation, the facility lighting was still plainly visible at a distance of 29.4 mi (47.3 km), and likely at further distances. Unshielded lighting and lighting apparently of less desirable color on temporary buildings contributed to lighting contrasts.

A number of structures within the CDSEF power block were painted or coated to match their surroundings which successfully reduced the visual contrasts from the facility; however, results likely would have been improved if more structures had been color treated (including all temporary structures), if a consistent color was used in color treatment, and, for several structures, if a darker color had been used in the color treatment. In at least one instance, a lack of color treatment appears to have resulted in a discernable increase in visual contrast from the CDSEF.

While non-reflective or low-reflectivity surface treatment was not specified in the ROD (BLM 2010d), some CDSEF structures appeared to have this type of mitigation applied, but others did not. While it cannot be stated conclusively, it appears that glare incidents at the CDSEF may have resulted from highly reflective surfaces within the power block.

Preserving existing vegetation within the heliostat array also was not required by the ROD (BLM 2010d), and does not appear to have been implemented at the CDSEF. While doing so might reduce visual contrasts, the lack of visibility of the ground surface of the CDSEF heliostat array would likely have minimized any apparent reduction in contrast that might have been gained from this mitigation.

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6 CONCLUSIONS AND RECOMMENDATIONS

This study characterized the visual properties and visual contrasts associated with the operating CDSEF facility; compared the predicted contrast levels and visual simulations from the CDSEF Final EIS (BLM 2010) with the actual contrast levels and photographs of the as-built CDSEF in operation; and assessed the efficacy of visual impact mitigation measures implemented to avoid and reduce visual contrast from the CDSEF.

Significant study findings include the following:

- Similar to ISEGS, reflected sunlight from the receiver was the primary source of visual contrast from the operating CDSEF under sunny conditions, regardless of viewing distance or viewing geometry.
- Unlike ISEGS, reflected sunlight from the receiver rarely caused discomfort for observers, regardless of distance.
- In unobstructed views, the CDSEF was found to be a major source of visual contrast for most observations up to 25 mi (40 km).
- The CDSEF facility, including the heliostat field, was plainly visible at 67.5 mi (108.6 km), and may be visible for a substantially greater distance.
- Unlike ISEGS, glare from individual heliostats was rarely visible; however, glare was often observed associated with power block components. Both types of glare were significantly less bright than the glare from heliostats at ISEGS.
- “Dust halos,” relatively faint patches of light reflected from atmospheric dust, were frequently visible around the operating receiver tower, and were visible at distances as great as 29 mi (47 km). Dust halos were much more prominent when the facility was offline.
- At night, lighting at CDSEF was plainly visible at a distance of 29 mi (47 km), and may be visible for a substantially greater distance.
- The CDSEF is substantially brighter and is seen more clearly in the field than in photographs of the facility or in simulations based on photographs.
- The simulations of the CDSEF in the Draft EIS and supporting documents had relatively minor problems with spatial accuracy but significant problems with realism, primarily because they showed the reflected light from the receiver to be much less bright than it appears in reality (BLM 2010b, 2010c).
- The contrast ratings in the Draft EIS predicted substantially lower levels of visual contrast than were actually observed for the operating facility (BLM 2010c).

- Visual impact mitigation measures used for CDSEF include painting/coating structures to blend with the existing landscape and using shielded lighting. These mitigation measures were judged to be effective at reducing visual contrasts; however, the CDSEF still creates large visual contrasts at long distances both day and night. Some visual impact mitigation measures were inconsistently applied and some additional visual impact mitigation measures likely could have reduced observed visual contrasts.

- The study findings have important implications for conducting VIAs for proposed solar power tower facilities in terms of the distance away from the facility used for the assessment of impact analysis, the importance of accurate and realistic simulation of visual impacts, and the need for effective mitigation of artificial lighting impacts associated with the facilities.

The Solar Programmatic EIS (DOE and BLM 2010) used 25 mi (40 km) as the maximum potentially affected viewshed (PAV) distance, the maximum distance at which visual impacts were assessed, for the VIA. The CDSEF EIS used 10 mi (16 km) as the maximum PAV (BLM 2010c). The CDSEF visibility study showed that the CDSEF was a minor source of visual contrast at 67.5 mi (108.6 km), suggesting that future VIAs should have PAV distances of at least 75 mi (120 km), if not greater.

The study showed that the CDSEF was a major source of visual contrast at distances up to 25 mi (40 km), suggesting that both solar facility siting or viewing platform designs (i.e., siting of scenic or recreation trails and sites and scenic viewpoints) should avoid creating situations where observers will be required to look at the facility for extended periods of time.

The study showed that, similar to the ISEGS facility, heliostat flares were a source of visual contrast from the CDSEF facility, although they were observed much less frequently than during the ISEGS study. This type of visual contrast may occur at many or all power tower facilities, which suggests that the potential occurrence of heliostat flares should be addressed in the VIAs for power tower facilities, and furthermore that potential mitigation methods for heliostat flares should be developed.

The study also demonstrated that the simulations prepared as part of the CDSEF VIA were not realistic depictions of the as-built facility, and they substantially under-represented the degree of visual contrast caused by the CDSEF. Similar results were observed in comparing the as-built ISEGS facility to the simulations prepared for the ISEGS VIA (CEC 2010). It is extremely important that the visual characteristics of solar power tower facilities be as accurately and realistically depicted as possible in simulations used as the basis for assessment of visual impacts. The results of the CDSEF visibility study suggest that more rigorous evaluation of simulations used in VIAs is warranted. Further research is needed to determine if impact assessments based on simulations systematically underestimate the visual contrasts caused by operating power tower facilities because they cannot accurately depict the extreme brightness of reflected light from the receiver and other glare sources at the facilities.

As a “follow-on” study to the ISEGS visibility and visual characteristics study, the CDSEF visibility study showed, while there are many similarities in the visual characteristics of the two facilities and associated visual contrasts, one major observed difference between the two is that, in the CDSEF observations, glare from heliostats was observed much less frequently than in the ISEGS study. and when it was observed, it was much less bright. The reason for this difference is not known, which suggests further study is warranted, because glare potentially is a major visual impact from power tower facilities.

The CDSEF visibility study findings also suggest further work to develop better visual impact mitigation for both daytime and nighttime impacts of solar power towers. These mitigation efforts should address visual contrasts from heliostat glare, glare from other sources, and the light of the receiver, if such mitigation can be devised, as well as better mitigation for lighting impacts.

The CDSEF is only the second utility-scale solar power tower facility to be built in the United States, while numerous power tower facilities are operating, under construction, or planned for development in other countries. Although the ISEGS and CDSEF studies have advanced understanding of the visual characteristics of operating power tower facilities, further work is needed to develop more effective mitigation strategies to minimize the potentially large visual impacts of this type of solar energy facility, and to ensure that VIAs for proposed power tower projects accurately predict and describe these impacts.

Based on the conclusions of the study, the following actions are recommended:

- For VIAs conducted for power tower facilities on BLM-administered lands, require a PAV distance of at least 75 mi (120 km), if not greater.

- For VIAs conducted for power tower facilities on BLM-administered lands, require analysis of potential glare impacts, including the likely occurrence and magnitude of heliostat flares.

- For VIAs conducted for power tower facilities on BLM-administered lands, require analysis of potential lighting impacts.

- Conduct further research on the nature, magnitude, frequency, and causes of heliostat flares and other glare from solar facilities, as well as development of appropriate glare measurement, analysis, and mitigation methods.

- Conduct further research on the nature, magnitude, frequency, and causes of non-glare visual impacts from solar facilities, as well as development of appropriate mitigation methods.

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APPENDIX A: STUDY OBSERVATION AND STUDY OBSERVATION POINT DESCRIPTIONS

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APPENDIX A: STUDY OBSERVATION AND STUDY OBSERVATION POINT DESCRIPTIONS

This appendix includes brief descriptions of the study observations (SOs) and study observation points (SOPs) used in the CDSEF visibility study. Each SO refers to a unique observation at a particular location, referred to as a SOP. In some cases, more than one observation was conducted at a particular SOP. The latitude and longitude for each SOP are provided in parentheses after the SOP name. The distance listed is from the SOP to the CDSEF receiver tower.

SO 1 and SO 4: SOP 1, off County Road 265 (37.9209, -117.72086)

SOP 1 is located approximately 29.3 mi (47.2 km) SW of the CDSEF on a small rise just north of County Road 265. It is the farthest easily accessible point within the 30 mi (48 km) viewshed of CDSEF. One daytime observation with the CDSEF online was made from this SOP on the morning of August 8, 2016, and one nighttime observation was made from this SOP, also on August 8.

SO 2 and SO 5: SOP 2, off U.S. Highway 6 (38.03567, -117.68697)

SOP 2 is located approximately 22.5 mi (36.2 km) SW of the CDSEF on a small rise adjacent to U.S. Highway 6. One daytime observation with the CDSEF online was begun from this SOP on the morning of August 8, 2016, but the facility went offline during the observation. Another daytime observation with the CDSEF offline was made from this SOP on the morning of August 9.

SO 3 and SO 26: SOP 46, Tonopah, near intersection of Air Force Road and Victoria Road (38.06004, -117.22907)

SOP 46 is located 14.3 mi (23.0 km) SE of the CDSEF in a residential area within the city of Tonopah, near the intersection of Air Force Road and Victoria Road, just northwest of Butler Mountain. Two daytime observations were made from this SOP, one with the CDSEF offline on the afternoon of August 8, and one with the CDSEF online on the afternoon of August 10.

SO 6: SOP 3, off U.S. Highway 6 (38.038, -117.67674)

SOP 3 is located approximately 22 mi (35.4 km) SW of the CDSEF adjacent to U.S. Highway 6. One daytime observation with the CDSEF offline was conducted from this SOP on the morning of August 9, 2016.

SO 7, SO 21: SOP7, off County Road 89 (Pole Line Road) (38.14194, -117.3247)

SOP 7 is located 7.0 mi (11.3 km) SSE of the CDSEF on County Road 89 (Pole Line Road). Pole Line Road is the primary access road for the CDSEF. A daytime observation with the CDSEF offline was made from this SOP on the morning of August 9. A daytime observation with the CDSEF online was made from this SOP on the afternoon of August 10.

SO 8, SO 20: SOP 8, Off County Road 89 (Pole Line Road) (38.17891, -117.34751)

SOP 8 is located 4.1 mi (6.6 km) NNW of the CDSEF on County Road 89 (Pole Line Road). A daytime observation with the CDSEF offline was made from this SOP on the morning of August 9. A daytime observation with the CDSEF online was made from this SOP on the afternoon of August 10.

SO 9, SO 23: SOP 4, off U.S. Highway 6 (38.075051, -117.63385)

SOP 4 is located 18.6 mi (29.9 km) SW of the CDSEF on U.S. Highway 6. A nighttime observation with the CDSEF offline was made from this SOP on the morning of August 9. A daytime observation with the CDSEF online was made from this SOP on the afternoon of August 10.

SO 10, SO 22: SOP N1, off County Road 89 (Pole Line Road) (38.10612, -117.3116)

SOP N1 is located 9.6 mi (15.4 km) SSE of the CDSEF on County Road 89 (Pole Line Road). A nighttime observation of the CDSEF offline was made from this SOP on August 9.

SO 11: SOP 25, off Road NF-427 (38.56974, -117.55534)

SOP 25 is located 25.1 mi (40.4 km) NNW of the CDSEF on Road NF-427. A daytime observation with the CDSEF online was made from this SOP on the morning of August 10.

SO 12: SOP 27, off County Road 21 (38.5414, -117.53499)

SOP 27 is located 22.9 mi (36.9 km) NNW of CDSEF on County Road 21. A daytime observation with the CDSEF online was made from this SOP on the morning of August 10.

SO 13: SOP 29, off County Road 21 (38.5225, -117.50456)

SOP 29 is located 21.0 mi (33.8 km) NNW of the CDSEF on County Road 21. A daytime observation with the CDSEF online was made from this SOP on the morning of August 10.

SO 14: SOP 30, off County Road 21 (38.51142, -117.49006)

SOP 30 is located 20.0 mi (32.2 km) NNW of the CDSEF on County Road 21. A daytime observation with the CDSEF online was made from this SOP on the morning of August 10.

SO 15: SOP 33, off County Road 21 (38.47428, -117.45566)

SOP 33 is located 17.0 mi (27.4 km) NNW of the CDSEF on County Road 21. A daytime observation with the CDSEF online was made from this SOP on the morning of August 10.

SO 16: SOP 34, off County Road 21 (38.46697, -117.42265)

SOP 34 is located 16.1 mi (25.9 km) NNW of the CDSEF on County Road 21. A daytime observation with the CDSEF online was made from this SOP on the morning of August 10.

SO 17: SOP 44, off Pea Vine Road (38.31858, -117.40775)

SOP 44 is located 6.0 mi (9.7 km) NNW of the CDSEF on County Road 21. A daytime observation with the CDSEF online was made from this SOP on the morning of August 10.

SO 18: SOP 14, off County Road 89 (Pole Line Road) (38.2836, -117.410)

SOP 14 is located 4.0 mi (6.4 km) NNW of the CDSEF on County Road 89 (Pole Line Road). A daytime observation with the CDSEF online was made from this SOP on the morning of August 10.

SO 19: SOP 12, off County Road 89 (Pole Line Road) (38.25637, -117.39295)

SOP 12 is located 2.0 mi (3.2 km) NNW of the CDSEF on County Road 89 (Pole Line Road). A daytime observation with the CDSEF online was made from this SOP on the afternoon of August 10.

SO 24: SOP 5, off U.S. Highway 6 (38.12534, -117.58035)

SOP 5 is located 14.2 mi (22.9 km) SW of the CDSEF on U.S. Highway 6. A daytime observation with the CDSEF online was made from this SOP on the afternoon of August 10.

SO 25: SOP 6, off U.S. Highway 6 (38.13802, -117.5015)

SOP 6 is located 10.2 mi (16.4 km) SW of the CDSEF on U.S. Highway 6. A daytime observation with the CDSEF online was made from this SOP on the afternoon of August 10.

SO 27: SOP 47, Near Lytle Creek in White Mountains, CA (37.712578, -118.200803)

SOP 47 is located 58.4 mi (94.0 km) SW of the CDSEF near Lytle Creek off Lytle Creek Road in the White Mountains in California, approximately 8.0 mi NW of the town of Dyer, CA. A daytime observation with the CDSEF online was made from this SOP on the afternoon of August 11.

SO 28: SOP 48, Bristlecone Pine Forest in White Mountains, CA (37.524754, -118.206858)

SOP 48 is located 67.5 mi (108.6 km) SW of the CDSEF within the Ancient Bristlecone Pine Forest off White Mountain Road in the White Mountains in California. A daytime observation with the CDSEF online was made from this SOP on the afternoon of August 11.

APPENDIX B: SAMPLE DATA COLLECTION FORMS

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APPENDIX B: SAMPLE DATA COLLECTION FORMS

Solar Facility Visual Characteristics Study Data Collection Form

SITE DESCRIPTION

Observation #:	Observers:			Date:	Time:	
Facility:			Secondary Facility:			
Location:						
Weather: Clear Mostly Clear Partly Clear Partly Cloudy Mostly Cloudy Cloudy Cirrus Rain Fog Snow						
Visibility:	Good	Fair	Poor			
GPS Coordinates:				Bearing:		
VAV Descriptor:	Superior	Normal	Inferior			
General Description of Viewed Facility:						
Facility Backdrop:	Sky	Sky/Ground	Ground			
Facility Backdrop Lightness:	Dark	Medium	Light			
Facility Backdrop Contrast:	High	Medium	Low			
Facility Backdrop Color:						
Lighting Quality:	Even Sun	Part Sun/Part Shade	Even Shade			
Solar Azimuth:			Elevation:			
Lighting Angle:	Frontlit	Sidelit Left	Sidelit Right	Backlit	Shade	Not Apparent
Collector Field Orientation:	Forward	Forward Oblique	Side	Rear Oblique	Rear	
Collector Array Color(s):						
Glare Visible?	Yes	No				
Light Patterns Visible?	Yes	No	Plumes Visible?	Yes	No	
Other Transitory Effects?	Yes	No				
Other Infrastructure Prominent?	Yes	No				
Other Observations:						

PHOTOGRAPHS

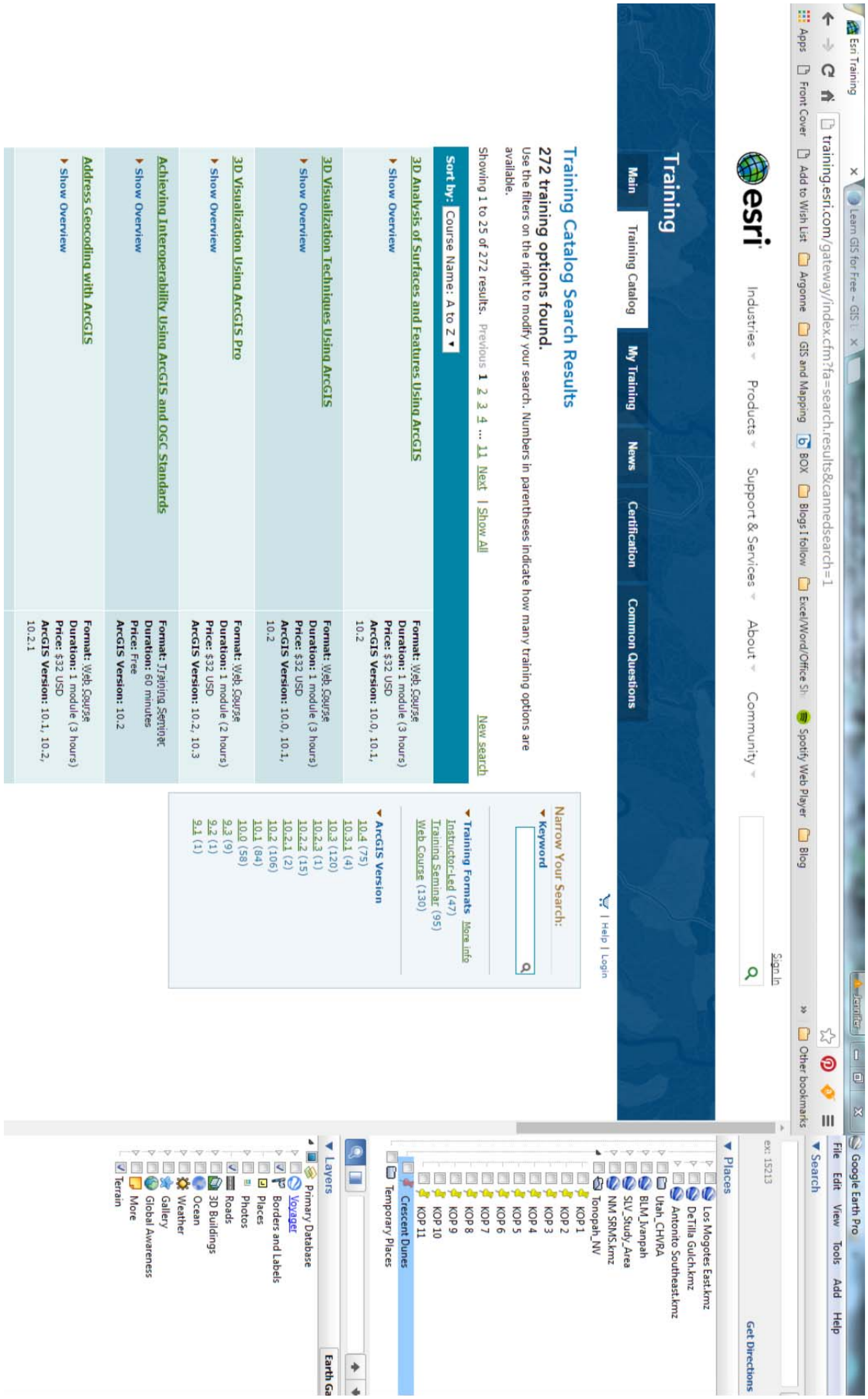
Photographer	
Camera	
Lens	

Photo Number	**FL**	**Bearing**	**Subject**

Solar Facility Transitory Visual Effects Data Collection Form

Obs. #:	Observers:	Date:	Time:
Facility:		Secondary Facility:	
Location:			
Glare Type: Point Beads and approx. # Line Other (specify)			
Glare Location: Array Front Sides Top Other Infrastructure (describe)			
Apparent Glare Source:			
Glare Discomfort: Minimal After extended view After brief view Instant			
Glare Duration: Persists with short movement Changes with short movement			
Collector Array Color(s):			
Light Pattern Orientation and Description:			
Plume Height (Relative to Building) and Description:			
Other Prominent Infrastructure Description:			
Other Observations:			

Solar Facility Transitory Visual Effects Data Collection Form (cont.)



Solar Facility Visibility Study: Visibility Rating Form

Observation #:		Date:	Time:
Facility:	Location:		
Rater:	Other observers:		

VISIBILITY RATING

VISIBILITY RATING	NOTES

QUESTIONS

Would the facility be likely to attract the attention of a casual viewer? Yes No
Is the facility a major focus of visual attention? Yes No Explain.
Which facility elements contribute most to visibility? Facility Size Component Size Geometry Color Glare/Glinting Other Explain.
Does the facility repeat basic elements of form/line/color/texture found in predominant natural features?
Does the facility repeat basic elements of form/line/color/texture found in predominant man-made features?
Notes

Solar Facility Visibility Study: Visibility Rating Form (Cont.)

Note: “View in general direction of study subject” defined as field of view visible when observer is looking toward study subject without turning head more than 45 degrees in either direction.

VISIBILITY LEVEL 1: Visible only after extended, close viewing; otherwise invisible.
Describes an object/phenomenon that is near the extreme limit of visibility and which could not immediately be seen by a person who was unaware of its location in advance, and looking for it. Even under those circumstances, the object can only be seen after looking at it closely for an extended period of time.

VISIBILITY LEVEL 2: Visible when scanning in general direction of study subject; otherwise likely to be missed by casual observer.
Describes an object/phenomenon that is very small and/or faint, but which—when the observer is scanning the horizon or looking more closely at an area—can be detected without extended viewing. It could sometimes be noticed by a casual observer; however, most people would not notice it without some active looking.

VISIBILITY LEVEL 3: Visible after brief glance in general direction of study subject and unlikely to be missed by casual observer.
Describes an object/phenomenon that can be easily detected after a brief look and which would be visible to most casual observers, but lacks sufficient size or contrast to compete with major landscape elements.

VISIBILITY LEVEL 4: Plainly visible, could not be missed by casual observer, but—for views in general direction of study subject—does not strongly attract visual attention or dominate view because of apparent size.
Describes an object/phenomenon that is obvious and with sufficient size or contrast to compete with other landscape elements, but with insufficient visual contrast to strongly attract visual attention and insufficient size to occupy most of the observer’s visual field.

VISIBILITY LEVEL 5: Strongly attracts visual attention for views in general direction of study subject. Attention may be drawn by strong contrast in form, line, color, or texture, by luminance, or by motion.
Describes an object/phenomenon that is not of large size, but that contrasts with the surrounding landscape elements so strongly that it is a major focus of visual attention, drawing viewer attention immediately, and tending to hold viewer attention. In addition to strong contrasts in form, line, color, and texture, bright light sources (such as lighting and reflections) and moving objects associated with the study subject may contribute substantially to drawing viewer attention. The visual prominence of the study subject interferes noticeably with views of nearby landscape elements.

VISIBILITY LEVEL 6: Dominates view because study subject fills most of visual field for views in its general direction. Strong contrasts in form, line, color, texture, luminance, or motion may contribute to view dominance.
Describes an object/phenomenon with strong visual contrasts that is of such large size that it occupies most of the visual field, and views of it cannot be avoided except by turning the head more than 45 degrees from a direct view of the object. The object/phenomenon is the major focus of visual attention, and its large apparent size is a major factor in its view dominance. In addition to size, contrasts in form, line, color, and texture, bright light sources, and moving objects associated with the study subject may contribute substantially to drawing viewer attention. The visual prominence of the study subject detracts noticeably from views of other landscape elements.

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