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IVANPAH SOLAR ELECTRIC GENERATING SYSTEM
AVIAN & BAT MONITORING PLAN

2016 – 2017 WINTER REPORT

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Executive Summary

Avian and bat monitoring surveys were conducted from 21 October 2016 to 20 March 2017 (the winter season) at the Ivanpah Solar Electric Generating System facility (referred to in this report as "Ivanpah" or "Project") in accordance with the Project's Avian & Bat Monitoring and Management Plan (Plan) as revised November 2015.

Per the revised Plan, potential flux effects are investigated by surveying 100 percent of the tower area in all three units, and collisions with facility structures (towers and heliostats) are evaluated by systematic sampling of 100% of the tower areas (154 acres) in each of the three units, and 20% of Unit 2 heliostat field (240 acres) as representative of the facility. The "tower area" consists of the power block and inner high-density (HD) heliostats surrounding each power block on approximately 154 acres; and the "heliostat area" consists of the inner and outer heliostat segments outside of the inner HD heliostats on approximately 2,991 acres. Searches were conducted within the winter season at intervals of approximately 21 days.

All bird and bat fatalities and injuries, referred to as "detections" in this report, including those found incidentally and during standardized facility searches, were documented and categorized as singed, collision, other project causes or unknown based on examination with a binocular microscope and evidence collected from the location of the detection. During the period 21 October 2016 – 20 March 2017, a total of 2 bat detections, and 65 avian detections (including 1 injured bird), were found.

Per the specifications of the revised Plan, the number of avian detections was categorized by facility structure and cause. These avian fatality search results, along with searcher efficiency and carcass removal rates from trials conducted onsite, were input into a fatality estimator model (Huso 2010) to provide an estimate of the fatalities for the facility.

Using the fatality estimator model, during the period 21 October 2016 – 20 March 2017, there were an estimated 70 fatalities (8.9%) from known causes and 715 fatalities (91.1%) from unknown causes. Of the known causes, all 70 fatalities (100%) were estimated for the 154-acre tower area. No known cause detections were found in the heliostat area.

Of the unknown causes, 237 fatalities (33.1%) were estimated for the tower area, 478 fatalities (66.9%) were estimated for the heliostat area. Driving this estimate was a large number of feather spots (37) comprising the majority (64.9%) of the unknown-cause detections in the tower area. Overall, based on the monitoring results and estimates for known causes for the winter season, the effect of the Project on birds does not rise above the "low" category.

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Section 1.0 Introduction

1.1 Project Background

The Ivanpah Solar Electric Generating System (referred to in this report as "Ivanpah" or "Project") consists of three solar power electrical generating facilities (Units 1, 2, and 3) with a combined net capacity of 377 megawatts. Each unit includes a central power tower with an air cooled condenser (ACC) and associated electrical generating equipment, surrounded by a heliostat array that reflects sunlight to a boiler at the top of the power tower. Ivanpah is located on approximately 1,457 hectares (3,600 acres) of Bureau of Land Management (BLM) land west of Interstate 15 near the town of Nipton in San Bernardino County, California (Figure 1). Construction was initiated in 2010 and completed in late 2013.

1.2 Monitoring Plan Overview and Goals

An Avian & Bat Monitoring and Management Plan (Plan) was prepared by the Project proponent in collaboration with the U.S. Fish and Wildlife Service (USFWS), California Department of Fish and Wildlife (CDFW), California Energy Commission (CEC), and Bureau of Land Management (BLM) to guide comprehensive monitoring of impacts to birds and bats associated with the operation of the Project. Revision 12 of the Plan (2013) was accepted by the agencies in November 2013 and required two years of monitoring, which were completed at the end of October 20, 2015. As part of the Plan, a Technical Advisory Committee (TAC) with representative from the agencies and the project was formed to guide implementation of the Plan. The TAC determined that the goals of the Plan (2013) were met, and in November 2015, the TAC-approved Revision 13 to the Plan (2015) to require a third year of monitoring to provide collision and flux mortality estimates. Revision 13 of the Plan (2015) reflects reduced monitoring requirements as informed by the first two years of intensive monitoring. Specifically, the Plan (2015) details the onsite and offsite surveys to be conducted and the data analysis and reporting processes that will be implemented by Ivanpah in collaboration with the USFWS, CDFW, CEC, and BLM and provides the following goals and objectives as excerpted from the Plan (2015):

Plan Goals

1. Provide Collision Mortality Estimates: Estimates of avian mortality from collision will be calculated from data obtained by monitoring and identifying avian mortality and injury associated with facility structure collisions.
2. Provide Solar Flux Mortality Estimates: Estimates of avian mortality from flux effects will be calculated from data obtained by monitoring and identifying avian mortality and injury associated with solar flux generated by the facility.
3. Provide a Framework for Management and Response to Risks**:** The designation and description of the functioning of the TAC provides a management and decision framework for the identification and implementation of potential adaptive management measures.

Plan Objectives

The first two years of monitoring documented that the mortality associated with the perimeter fences, transmission lines, and offsite transects was less than 5 detections a season. Additionally, the patterns

associated with avian use have been consistent over the seasons and documented in the annual reports. Therefore, as revised, the Plan has the following objectives:

1. Estimate collision-related avian mortality and injury with the following facility structures (Figure 1), using empirical data to calculate facility-wide mortality and injury rates:

   a. Power towers
   b. Heliostats

2. Estimate flux-related avian mortality and injury using empirical data to calculate facility-wide mortality and injury rates.
3. Document patterns of collision or flux-related mortality and injury associated with species, age/sex, season, weather, and visibility.
4. Document spatial patterns associated with collision- or flux-related mortality and injury.
5. Provide quantitative information for developing and implementing adaptive management responses commensurate with identified impacts.

As provided in the Plan (2015), the revised Plan continues to: 1) satisfy the BLM Right-of-Way (ROW) Permit requirement that the proponent develop an avian plan as well as a Migratory Bird Treaty Act (MBTA) Conservation Agreement; 2) satisfy the requirements for the Avian & Bat Monitoring and Management Plan approved by the CEC for Ivanpah per CEC Condition of Certification BIO-21; and 3) achieve the avian and bat protection objectives of the USFWS in relation to the MBTA, Bald and Golden Eagle Protection Act (Eagle Act), and Federal Endangered Species Act (FESA), including preparing written records of the actions that have been taken to avoid, minimize, and compensate for potential adverse impacts to avian and bat species. By developing a proactive management plan in close consultation with the USFWS and other relevant state and federal agencies, Project proponents can effectively comply with the intent of the federal MBTA, Eagle Act, FESA, and relevant state regulations (USFWS 2012).

1.3 Purpose of This Report

This report represents the first "quarterly" (i.e., seasonal) report for the fourth year of monitoring (or, the ninth quarterly report) summarizing monitoring methods and results for avian and bat fatalities and injuries based on the procedures and requirements specified in the Plan and as required by CEC Condition of Certification BIO-21. This report covers the winter 2016 – 2017 season, which includes the period from 21 October, 2016 through 20 March, 2017.

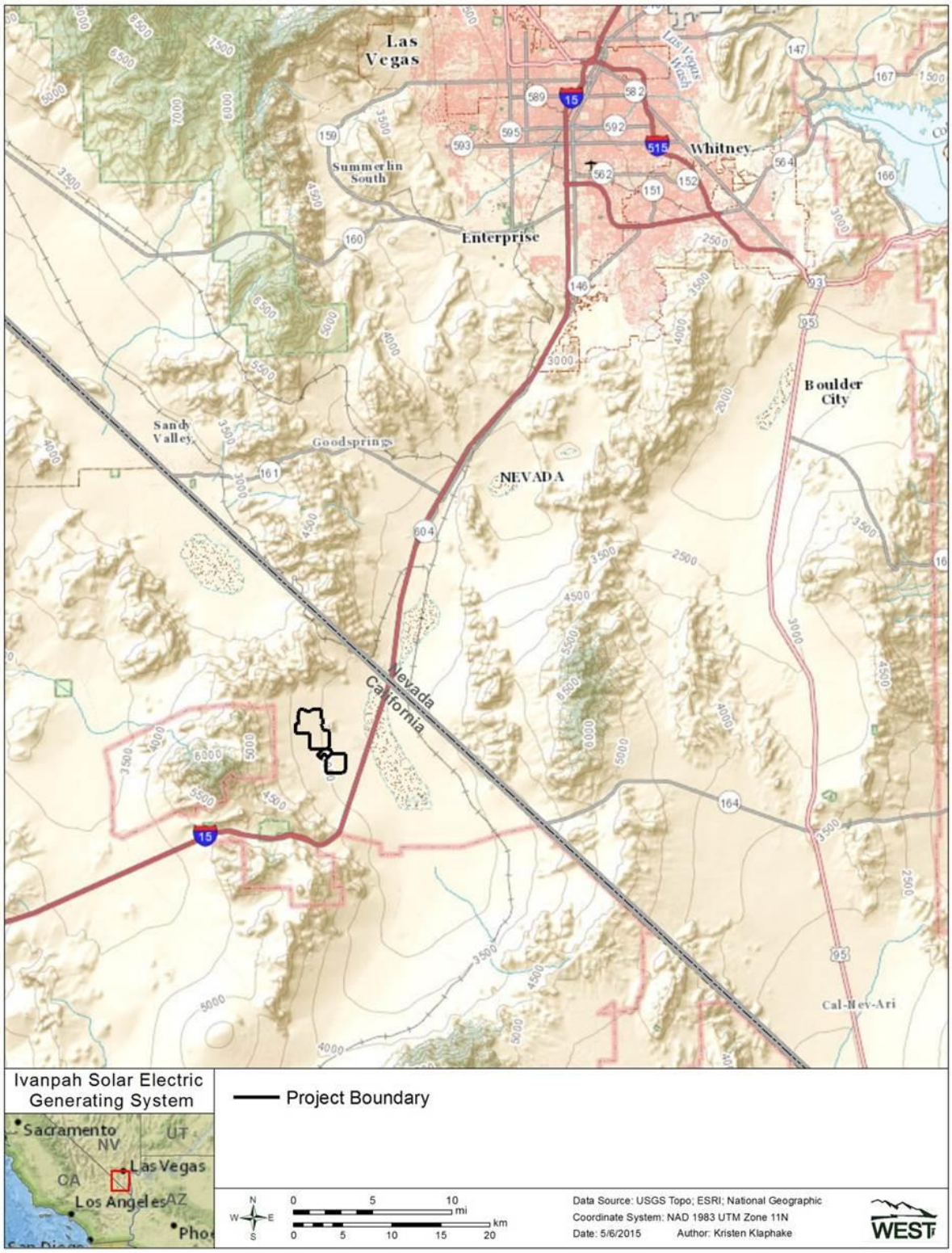

Figure 1. Ivanpah Vicinity Map.

Section 2.0 Methods

The Plan (2015) describes the methods by which monitoring and certain analyses, including compilation of the overall fatality estimate, will occur. Below is an abridged description .

2.1 Facility Monitoring

This section describes areas surveyed, the timing and frequency of the searches, and the methods by which standardized searches were conducted to identify dead/injured birds and bats (hereafter detections) at the Project. This section also describes the methods for conducting carcass removal and searcher efficiency trials; how data were reported and analyzed for incidental detections; and the methods for producing fatality estimates for the Project.

2.1.1 Standardized Searches

2.1.1.1 Areas Surveyed

Per the Plan (2015), monitoring was conducted in the "tower area" and a sample of the "heliostat area". The tower area is defined as the power block (the area consisting of the tower, the ACC unit, the associated control building, and immediately adjacent areas defined by the ring road and berm/slopes surrounding these facilities) and inner high-density (HD) heliostats surrounding each power block. The heliostat area is defined as the inner and outer heliostat segments outside of the inner HD heliostats. For year 3, 100% of the tower area at each unit was surveyed and approximately 24% of the Unit 2 heliostat area (8% of the total heliostat area) was surveyed. Table 1a provides the acreage searched within each of the survey areas, as well as the percent of the facility comprised by these search areas. Overall, approximately 12.9% of the Project was searched (Figure 2).

To ensure a balanced distribution of heliostat field survey plots, Unit 2 was divided into inner and outer heliostat fields, and approximately 20% of each sub-area was randomly selected for monitoring. The actual percentage of Unit 2 heliostat area being surveyed was 24%. Arc plots used for monitoring in Unit 2 were the same as previous years. This stratified random sampling design ensures that survey plots will not be clustered or biased in any distance or direction from the tower.

Table 1a. Monitoring Areas, 2015-2016 Winter Season.

Area	Facility Locations Included	Acreage Searched	Percent of Facility
Tower Area	ACC, Power Block, Inner HD	154	4.80%
Heliostat Area	Unit 2 Inner and Outer Heliostat Segments	240	8.09%
Total		394	12.89%

*NA = Not applicable as offsite survey areas are located outside of the facility

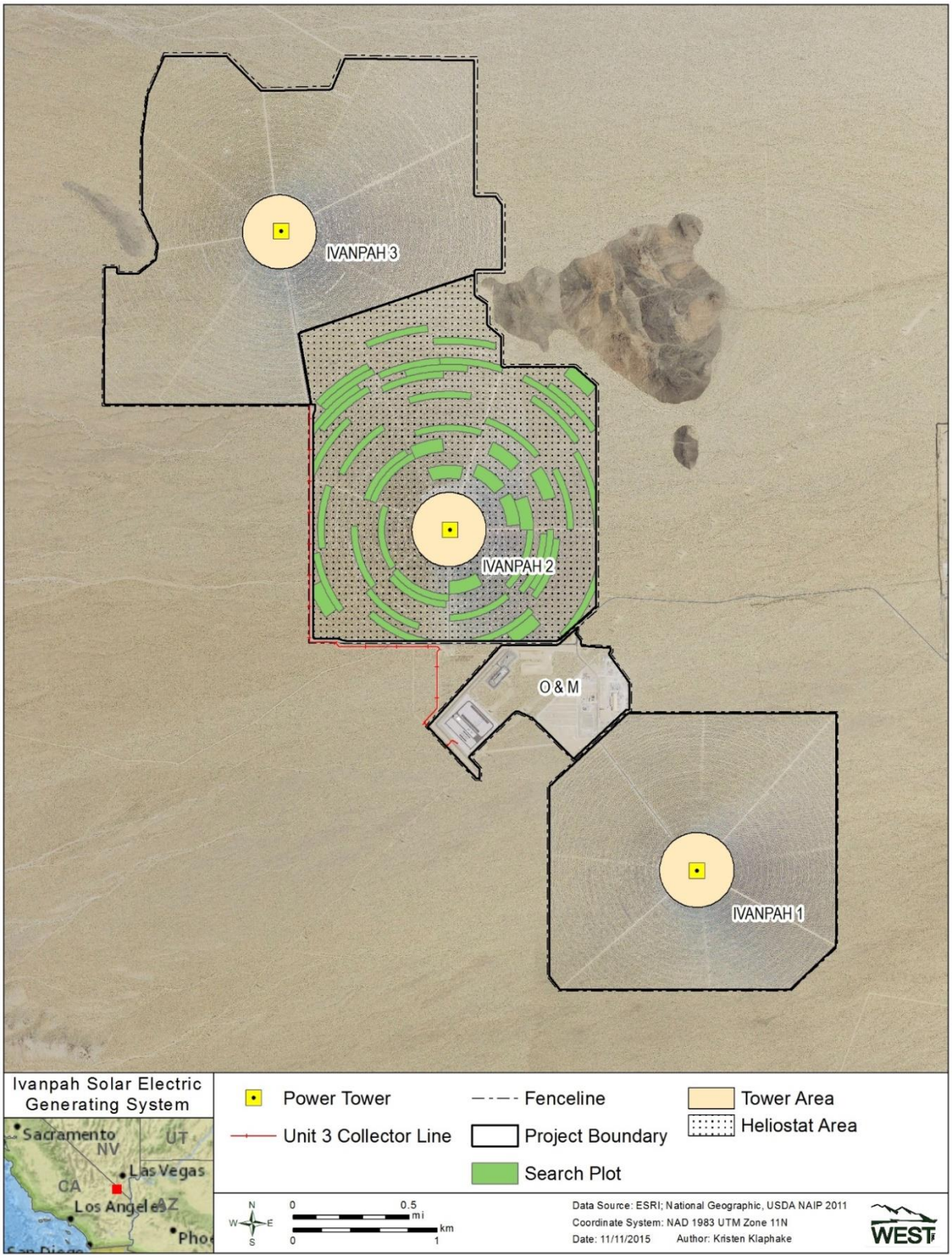

Figure 2. Ivanpah Search Areas.

2.1.1.2 Search Frequency and Timing

Consistent with the first two years of monitoring, standardized searches occurred at each unit on a nominal 21-day interval through the 2016 – 2017 winter season. Variation in search interval and number of visits to each unit was anticipated to occur due to the transition between 21-day search and 7-day search interval between seasons of differing length, as well as the transition to Revision 13 of the Plan (2015), after November 15, 2015. The tower area of Units 1, 2 and 3 were visited a total of seven times, and the inner and outer heliostat segments of Unit 2 was visited seven times.

2.1.1.3 Search Methods

Biologists performed surveys in the tower area, and plots in the heliostat area. Standardized walking surveys for fatalities were performed by biologists approved by CEC and BLM, in accordance with the methods outlined in the Plan (2015). In the heliostat area, a pair of biologists walked a total of four transects oriented longitudinally along the complete length of each arc-plot, with the ring roads serving as the outer boundaries of each arc plot (Figure 3). While walking each transect, biologists walked a narrow search section approximately 10 meters (m) wide. Within the power block, biologists walked through and around the power tower and ACC unit looking for dead and injured birds and bats, and walked transects through the gravel surrounding the structures to achieve 100% coverage within physically accessible areas. Within the inner HD heliostats surrounding each power block, biologists walked transects to ensure 100% coverage. Thus, the tower area, comprising the area within 260 m of each tower, was completely covered during each survey, excepting any areas that were physically inaccessible or unsafe to survey. Inaccessible areas were, to the extent possible, scanned using binoculars.

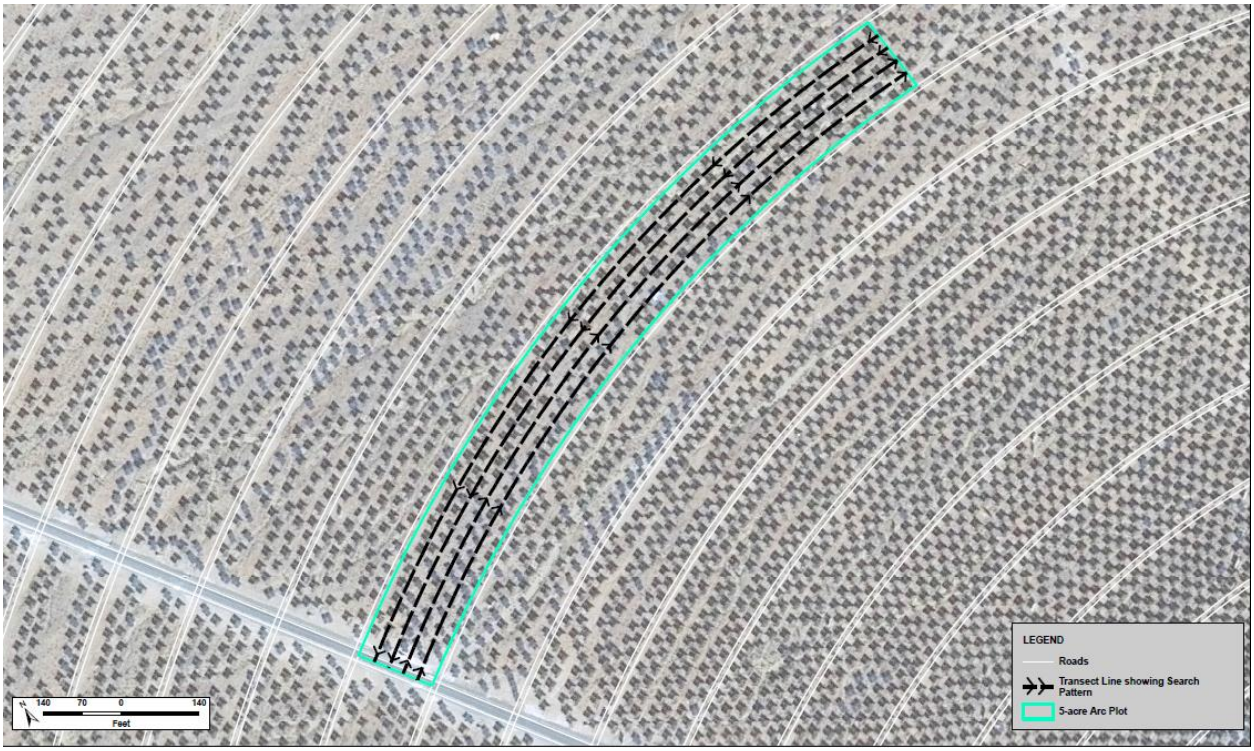

Figure 3. Monitoring Search Pattern for Arc Plots.

Carcass and Feather Spot Examination. Every carcass and feather spot was examined visually by a biologist approved by the CEC and BLM for evidence of singeing or collision. Singeing to feathers can occur when a bird enters the flux around the power tower. When no obvious evidence of singeing or collision were evident to the naked eye, the carcass or feather spot was then examined using an AmScope SE306R-AZ-E2 20X-40X-80X Digital Binocular Stereo Microscope. When singed detections involving carcasses (as opposed to only feather spots) were found, the singeing was assigned a grade based on Kagan et al. (2014), as follows.

- Grade 1 – curling of less than 50% of the flight feathers
- Grade 2 – curling of 50% or more of the flight feathers
- Grade 3 – curling and visible charring of contour feathers

Kagan et al. (2014) originally found no singeing of contour feathers in the absence of curling of 50% or more of the flight feathers. In contrast, we have found singeing of contour feathers with curling of less than 50% of flight feathers, and in the absence of curling or singeing of any flight feathers. We therefore assigned grade 3 independent of grades 1 and 2.

When a carcass was detected, biologists looked for evidence of collision, including obvious physical trauma or detection adjacent to a heliostat with a bird-strike imprint, smudge mark, and/or feathers on or near the surface of the mirror. If there was no evidence of collision or singeing (e.g., charring, curling, or melting of feathers), as confirmed through microscopic examination, the cause of injury or fatality was listed as "unknown".

For the purpose of these surveys, feather spots were considered detections when they met the following definition:

> At least two or more primary flight feathers, 5 or more tail feathers, or 10 or more feathers of any type concentrated together in an area 1-m^2 or smaller (Smallwood 2007), without any bone, beak, or significant amounts of flesh or skin.

In some cases, an individual detection was broken up into aggregations of feathers that would meet the criteria for a feather spot, but with pieces of the carcass that contained bone or significant amounts of flesh or skin also present. In these cases, the detection was categorized as a partial carcass (rather than a feather spot), per the "feather spot" definition above.

2.1.2 Carcass Persistence Trials

Carcass persistence trials were performed throughout the 2016 – 2017 winter monitoring season. A total of 20 small bird carcass trials were conducted. The TAC approved discontinuing large bird carcass trials at the conclusion of the 2015 summer season due to the consistency of large bird persistence times collected over the previous seasons. In response to the previous TAC request of increased sample size, the number of small bird trials was increased relative to the 2013 – 2014 winter monitoring season.

The facility contains vegetated and unvegetated areas that could affect the ability to detect a carcass or the amount of time a carcass persists until it is scavenged. The tower area (power block and inner high density (HD) heliostat area, where most singed detections occur, is unvegetated; all other areas are considered vegetated. In order to examine carcass persistence times for vegetated and unvegetated areas, carcasses were also distributed through the facility, with 10 carcasses placed in the unvegetated tower area, and 10 carcasses placed in the vegetated heliostat arrays. Non-native house sparrows (*Passer domesticus*) were used for small carcass trials conducted during the 2016 – 2017 winter monitoring season. A camera was placed at each carcass to record the time of scavenging and the scavenging species.

2.1.3 Searcher Efficiency Trials

A total of 74 searcher efficiency trials (22 small birds, 29 large birds, and 23 feather spots) were conducted during the 2016 – 2017 winter monitoring season. Carcasses and feather spots were placed in various vegetation heights and in areas that had different soil and vegetation colors and values to represent the range of conditions under which searches occur. Trials were placed in the tower areas of all three units and in the heliostat area of Unit 2; however, no trials were placed in the ACC building since detection probability is assumed to be 100% in this area of the power block. Each trial carcass was placed by a Designated Biologist (a biologist responsible for implementing the conditions of certification) prior to a scheduled search without knowledge of the searchers. For trial carcasses that were not detected by searchers, the Designated Biologist returned to the trial location to see if the trial carcass was still available to be found. If the trial carcass was absent, it was assumed to have been removed prior to the search, and thus not available to be detected.

Overall, 36 trial carcasses/feather spots were placed in the tower area and 38 trial carcasses were placed in vegetated areas in the inner/outer segments of the heliostat area. Of the 74 trial carcasses placed, 60 (22 small carcasses, 29 large carcasses, and 23 feather spots) were available to be found; 14 carcasses (2 small carcasses, 9 large carcass, and 3 feather spots) were removed (scavenged) from the trial location before searchers had an opportunity to find them.

2.1.4 Incidental Reporting

Some detections were made outside standardized search areas, or were within search areas but not during standardized searches. Detections at locations not searched under the Plan (2015) such as the fenceline and heliostat areas of Unit 1 and Unit 3, are considered incidental detections for this report. These detections were reported in accordance with the facility's Wildlife Incident Reporting System (described in Section 3.4 of the Plan) and were considered "incidental" detections. Data on these incidental detections were reported in the SPUT permit database. As described in Section 2.1.5, incidental data could be included in the fatality estimates when they were found in areas covered during standardized surveys (e.g., tower area). Incidental detections from outside the survey areas were not included in the fatality estimates as discussed in Section 2.1.5; however, all detections regardless of the method or source of detection are reported in the SPUT permit database.

2.1.5 Fatality Estimator

Fatality rate estimation is a complex task due to several variables inherent to every fatality monitoring study. Carcasses may persist for variable amounts of time due to local scavenger activity or environmental conditions leading to carcass degradation over time. Carcasses and feather spots are also

detected with varying levels of success based on carcass characteristics and ground cover (e.g., vegetated areas underneath heliostats versus cleared areas around towers). For these reasons, it is generally inappropriate to draw conclusions based on the raw number of fatalities alone. The desire to estimate fatalities given these variables has driven the development of several statistical methods for estimating fatalities (e.g., Smallwood 2007, Huso 2010, Korner-Nievergelt 2011). All of these fatality estimation methods share a similar underlying model. Generally, the fatality estimation for a given site may be written as:

$$F=C/rp,$$

where F is the total number of fatalities, C is the number fatalities detected and included in fatality estimation, r is the probability a carcass is unscavenged and available to be found at the end of the search interval, and p is the probability of detecting a carcass (Huso 2010).

The bias correction factors r and p are estimated by covariates that may influence the detectability and persistence of each carcass, such as carcass size, presence of vegetation, and stage of decay or scavenging (i.e., feather spot versus carcass). For this study, the Huso estimator was used to correct for detection and scavenging bias; the estimator was demonstrated to perform well under a variety of conditions (Huso 2010). The Huso model was developed in the context of estimating fatalities for post-construction fatality studies at wind energy facilities; however, the Huso estimator is suitable for other sources of anthropogenic avian mortality, including power lines and utility scale solar facilities (Huso 2010).

All fatality estimates were calculated using the Huso estimator, as well as 90% confidence using bootstrapping (Manly 1997). Bootstrapping is a computer simulation technique that is useful for calculating point estimates, variances, and confidence intervals for complicated test statistics. A total of 1,000 bootstrap replicates were used. The lower 5th and upper 95th percentiles of the 1,000 bootstrap estimates provide estimates of the lower limit and upper limit of an approximate 90% confidence interval on all estimates.

Estimating Carcass Persistence Times. Measurement of carcass persistence time is often subject to censoring. In this context, censoring refers to the fact that a value (e.g., days a carcass is present before being removed) may not be known exactly, but within a finite range. For example, suppose a carcass was checked on day 7 and was present, and was checked again on day 10, but was found to be missing. The exact time until removal is unknown; however, it is known that the carcass was available to be found for between 7 and 10 days. This carcass would be considered "interval censored". Similarly, if a carcass lasts the entire six-week trial period, that carcass is "right censored"—we know the carcass lasted at least six weeks, but it could have persisted longer. Due to the fact that camera traps (e.g., cameras that automatically document activity at the trial carcass) were used for carcass removal trials, the majority of scavenging times can be known precisely, and data are not censored. However, when cameras fail to record the moment of scavenging, trials are treated as interval censored between the last time the carcass was visible on the camera, and the earliest time at which it was known to be removed.

Survival regressions models are well-suited to accommodate censored carcass persistence data and are typically used to generate the average probability of persistence for fatality estimation (Huso et. al 2012). There are four commonly used distributions implemented in the survival models used to estimate the

value of r : exponential, Weibull, loglogistic, and lognormal. These four distributions exhibit varying degrees of flexibility in order to model a wide variety of removal time distributions. Akaike's Information Criterion adjusted for sample size (AICc; Akaike 1973) was used to rank the fit of each survival model fit to carcass removal data. The exact time of death for detected fatalities is usually unknown, so the probability of persistence cannot be calculated exactly for each carcass; however, it can be estimated from the selected survival model and bootstrapped to obtain a range of estimates of r for each carcass.

Estimating Searcher Efficiency. Searcher efficiency, or the proportion of carcasses detected, p, is represented most simply by the following equation:

$$p = \frac{Number\ of\ Carcass\ Observed}{Number\ of\ Carcasses\ Available}$$

Model Selection for Searcher Efficiency Trials. The Plan states that searcher efficiency trials will be conducted during each season in which vegetation differs from the prior season, because changes in vegetative cover may affect carcass detectability. *A priori* decisions were not made regarding whether vegetative cover would differ between seasons, but rather, searcher efficiency trials were conducted in all seasons. Following the completion of year 1 fall searcher efficiency trials, there was sufficient cumulative data for the year to assess whether searcher efficiency differed significantly by Project area (e.g., unvegetated tower area versus vegetated heliostat fields), season, and/or carcass size. The nearly complete lack of vegetation cover in the tower area suggested that searcher efficiency may be higher in the tower area than in other Project areas. If this hypothesis were true, accounting for this difference in searcher efficiency across Project areas would be important for producing accurate fatality estimates.

To evaluate various hypotheses regarding differences in carcass detectability among Project areas, seasons, and/or carcass size, logistic regression models were fit to searcher efficiency data and corrected Akaike's Information Criteria (AICc) was used to compare models. The Project area was defined using two categories to reflect the suspected differences in searcher efficiency due to differences in vegetation cover: the tower area, which consists of the power block and the inner HD heliostats, and other areas, which consists of all other Project areas not included in the tower area. Models were constructed for all combinations of year, season, carcass size, Project area, and compared to the null model (Table 8). The data for this analysis included all human searcher efficiency trials of carcasses from the beginning of trials in the winter 2013 – 2014 season through the 2016 – 2017 winter season.

Fatality Estimates. Estimates for the number of detections in the tower area components (i.e., the power block and inner HD heliostats) are reported combined, because 100% of these areas were searched. A separate estimate was produced for the heliostat area of all three Units (the inner and outer heliostat segments combined), in which 8% of the total area was searched. Fatality estimates reported in the inner/outer heliostat areas were adjusted to account for the unsearched area in the inner/outer heliostat areas (i.e., divided by 0.08).

The ACC buildings are only marginally accessible to scavengers from the outside; therefore, they act primarily as a closed system with a scavenging rate that approaches zero. Furthermore, carcasses are, generally, visible against the industrial backgrounds. Thus, the fatalities found in the ACC were not adjusted using the Huso estimator; rather, raw counts of ACC detections were added to fatality estimates

for the power block. All detections within the ACC buildings are considered facility related, whether or not they showed evidence of singeing or collision.

Within the power block, during the 2016 – 2017 winter season, incidental detections accounted for 29.0% of the detections recorded. Thus, as previously modeled, incidentals found within the power block were included in estimates, but treated differently from other fatalities. To reflect the high human activity in the power block—and frequent observation of the areas within the power block—the search interval for these detections was set to one day based on concurrence from the TAC on March 6, 2015 (H.T. Harvey & Associates 2015; Table 1b).

In previous seasons, incidental detections found outside of the power block but within standardized search areas were partially processed in the field and left in place to give searchers the opportunity to discover the carcass on the next scheduled search. As approved by the TAC, this method was discontinued in the 2015 fall season to prevent the scenario where an incidental detection is recorded, left in place, but scavenged before the next standard search and no carcass is associated with the data. In the 2015 fall season, incidental detections found outside of the power block, but within standardized search areas, were removed from field and included in fatality estimates under the conservative assumption that the search interval was the time between the last search of the area and the time of incidental discovery (Table 1b).

Table 1b. Treatment of Incidental Detections by Location

Location	Search Interval	Included in Analysis?
Power Block	1 Day	Yes, if carcass age is less than 24 hours
All Other Standardized Search Areas	Calculated days between date of detection and date of previous standard search in that location	Yes, if carcass age is less than calculated search interval

All fatality estimators have limitations, particularly when fatality counts are low. In particular, when detections are fewer than five, regardless of survey effort, estimates and confidence intervals can be unstable and must be interpreted with caution (Korner-Nievergelt et. al 2011). Rather than report estimates with little inferential value, no estimates were provided for combinations of covariates (e.g. size, location, cause) resulting in five or fewer detections.

The fatality estimator accounts for imperfect detection probability by using bias trials to estimate searcher efficiency. The Huso estimator is constructed under the assumption that searchers have a single opportunity to discover a carcass. Therefore, if a carcass is missed on the first search it was available and then found on the next search, it will effectively be over-counted. The method typically used to overcome multiple-detection-bias is to exclude any detection determined to be significantly older than the search interval. Each detection made during the 2016 – 2017 winter season was evaluated for exclusion from the estimator based on the observed time since death (i.e., the length of time between an animal's death and when the detection was discovered), and the search interval associated with that detection. For example, if a detection determined to have been on the ground for > 1 month was made in the inner HD of Unit 2, which had been searched seven days earlier, that carcass would be excluded from analysis.

Determining the age of a carcass was based on detailed qualitative analysis of every detection (carcasses and feather spots) recovered onsite. Qualitative analysis began with in situ aging analysis in the field by biologists approved by the CEC and BLM, followed by a more detailed analysis in the lab. In the field, biologists noted the presence of rigor mortis, condition of eyes and feathers, and condition of blood or viscera (if present). In the lab, each carcass was further examined and compared to photographs of decomposed test carcasses. The test carcasses were used to document decomposition over time at Ivanpah to better inform biologist of site-specific characteristics of avian decomposition that could be expected at the Project.

Decomposition test carcasses were placed in tamper-proof containers, exposed to onsite environmental conditions, and allowed to decompose. Carcasses used in decomposition tests were placed to account for variation in space (e.g. underneath fans in the ACC unit versus shaded under a heliostat) and time (e.g. ephemeral weather patterns). As the test carcasses aged, the biologists photographed and recorded the condition of body tissue and fluids, eyes, feathers, and indications of rigor mortis. All decomposition specimens were placed during the 2015 spring monitoring season.

To correctly account for searcher efficiency in the fatality estimate model, when partial carcasses are initially identified as feather spots by the observer in the field, they are modeled (in the fatality estimates) as a feather spot. In other words, the primary means of identification of the detection (feather spot, small carcass, or large carcass) is the appropriate classification to utilize in the modeled estimates. The primary identification approach is appropriate since different searcher efficiency rates are estimated for feather spots as opposed to carcasses. Because searcher efficiency is an important component of the fatality estimator, what the surveyors detect first (i.e., feather spot versus a complete or partial carcass) influences how that detection should be included in the model. Such detections are noted in Appendix A as "partial carcass + feather spot" in the "Description of Carcass/Injury" column.

2.2 Deterrence Measures

2.2.1 Avian Measures

Ivanpah commenced an investigation of the use of various deterrence measures to reduce avian mortality at the facility in 2013. These initial investigations combined with the results of the monitoring conducted during 2014 resulted in a list of potential deterrence measures for adaptive management. As monitoring has identified patterns of detections, additional measures have been identified, tested and if successful are ultimately deployed. This cycle of adaptive management provides a process where scientifically-based measures are identified and deployed to work to reduce avian mortality.

Based on the location of greater roadrunner detections along the fenceline, an adaptive management measure was developed in 2016 to allow roadrunners to escape through the unit fence. Hawks were observed to pursue and entrap roadrunners along the fence and depredate them. The measure deployed consisted of installing egress routes through the fence with an elevated platform. The elevated platform allows the egress route to be installed without impacting the desert tortoise fencing. The shade cloth was installed to increase visibility of the egress route. The measure was initially tested at Unit 1 and monitored with a game camera and evidence of roadrunners use was captured on camera. This measure

is now considered a best management practice and additional egress routes will be installed along fences for the remaining units.

Several other deterrence measures have been implemented for birds at Ivanpah. Specifically, new ground-level LED lighting and spikes were installed at Unit 1 5 February 2015. As approved by the TAC, a chemosensory deterrence measure commercially known as BirdBuffer, was deployed on 12 October 2014 at Unit 1, and a sonic deterrence measure commercially known as BirdGard, was deployed on 13 March 2015 at Unit 1. Bird Buffer was installed at Unit 2 and Unit 3 on 29 September 2015; BirdGard was installed at Unit 2 on 25 August 2015 and Unit 3 on 31 August 2015. The chemosensory deterrence measure is hypothesized to deter resident species, since the deterrent induces a conditioned response over time, and the sonic deterrence measure is hypothesized to deter transient and migrant species, as the sounds produced by the system are thought to startle and deter subjects. Together, the combination of BirdBuffer and BirdGard systems are intended to deter avian species from entering this area associated with elevated flux mortality.

Enhancements to BirdBuffer were designed in fall 2016 and implemented in early March of 2017. Enhancements included replacing the single output device at each Unit tower with two double output devices at each Unit tower. Enhancements to BirdGard were designed in fall 2016 and implemented in February of 2017. The enhancements included upgrading each speaker device containing 20 speakers to 3 speaker devices containing 20 speakers. Each speaker device has 7 hyper-directional speakers, for a total of 21 directional speakers targeted towards a specific path. The four independent three-speaker-devices will remain positioned on the north, east, south, and west side of each tower area.

2.2.2 Bat Measures

Bat fatalities were detected primarily in the ACC, and as the ACC provides a roosting location, a Binary Acoustic Technology Ultrasonic Bat Deterrence was tested at Unit 3. The bat deterrence measure is not designed to elicit a fear response in bats, but is designed to interfere with the echolocation capabilities of bats. As bats navigate utilizing sonar, the method deployed "jams" the sonar signals and bats species avoid the area as a result of the inherent difficulties to navigate under these conditions. Although bats can adjust echolocation under jamming conditions, the use of broadband ultrasound requires bats to shift frequencies to avoid overlap that interferes with echolocation and therefore deters within the area subject to broadband ultrasound (Arnett, et al, 2013). As a result of the broadband ultrasonic signal and the inherent "jamming" effect, adaptation to the deterrence measure is minimal. The deterrence measure has been installed at all Units, and the installation dates are as follows: 10 September 2014 at Unit 1, 23 April 2015 at Unit 2, and 23 April 2015 at Unit 3. In November 2015, an ultrasonic testing protocol was implemented to ensure proper function of all deterrence units. The testing of each deterrence device occurs monthly, with a contractor using a lift to access the space approximately 15 feet from each installed deterrence device. An ultrasonic sound detector is then used to determine if each individual deterrence device is functioning properly. A record is maintained of each inspection.

Section 3.0 Monitoring Results

3.1 Summary of Avian Detections

The average search interval in the tower area was 19.6 days (range 6 to 27, median 21 days), and in the heliostat arrays the average search interval was 19.0 days (range 5 to 37, median 21 days), during the 2016 – 2017 winter season for the three solar units. Variation in search interval was anticipated to occur due to the transition between 7-day and 21-day search intervals associated with seasons of differing length, the transition to the monitoring protocol developed in Revision 13 of the Plan, and multiple holidays during the winter season.

During the 2016 – 2017 winter season, a total of 65 avian detections (including injured birds and incidentals) of 18 identified species (Table 2) were recorded. Approximately 64% of detections were songbirds, with 27% being other types of bird; 9% could not be identified to an appropriate level. The most numerous detection of an identified species was yellow-rumped warbler followed by American pipit. Most detections occurred in the tower area (Figures 4, 5, 6, and 7), where approximately 154 acres were surveyed, representing 100% of the total tower area.

Table 2. Number of Individual Bird Detections, by Species, 2016 – 2017 Winter Season.

Species	Scientific Name	Injuries	Fatalities	Songbird?
unidentified bird (small)	unidentified	0	14	NA
yellow-rumped warbler	*Setophaga coronata*	0	7	Yes
American pipit	*Anthus rubescens*	0	5	Yes
white-crowned sparrow	*Zonotrichia leucophrys*	0	5	Yes
western meadowlark	*Sturnella neglecta*	0	4	Yes
unidentified sparrow	unidentified	0	4	Yes
mourning dove	*Zenaida macroura*	0	2	No
house finch	*Haemorhous mexicanus*	0	2	Yes
loggerhead shrike	*Lanius ludovicianus*	0	2	Yes
yellow warbler	*Setophaga petechia*	0	2	Yes
tree swallow	*Tachycineta bicolor*	0	2	Yes
American robin	*Turdus migratorius*	0	2	Yes
rock pigeon	*Columba livia*	0	1	No
eared grebe	*Podiceps nigricollis*	0	1	No
sagebrush sparrow	*Artemisiospiza nevadensis*	0	1	Yes
verdin	*Auriparus flaviceps*	0	1	Yes
brewer's blackbird	*Euphagus cyanocephalus*	0	1	Yes
barn swallow	*Hirundo rustica*	0	1	Yes
brown-headed cowbird	*Molothrus ater*	0	1	Yes
bushtit	*Psaltriparus minimus*	0	1	Yes
black-throated gray warbler	*Setophaga nigrescens*	0	1	Yes
unidentified warbler	unidentified	0	1	Yes

Species	Scientific Name	Injuries	Fatalities	Songbird?
unidentified large bird	unidentified	0	1	NA
green-winged teal	*Anas crecca*	0	1	No
northern flicker	*Colaptes auratus*	0	1	No
American kestrel	*Falco sparverius*	1	0	No
Total		1	64	NA*

*NA – Not Applicable

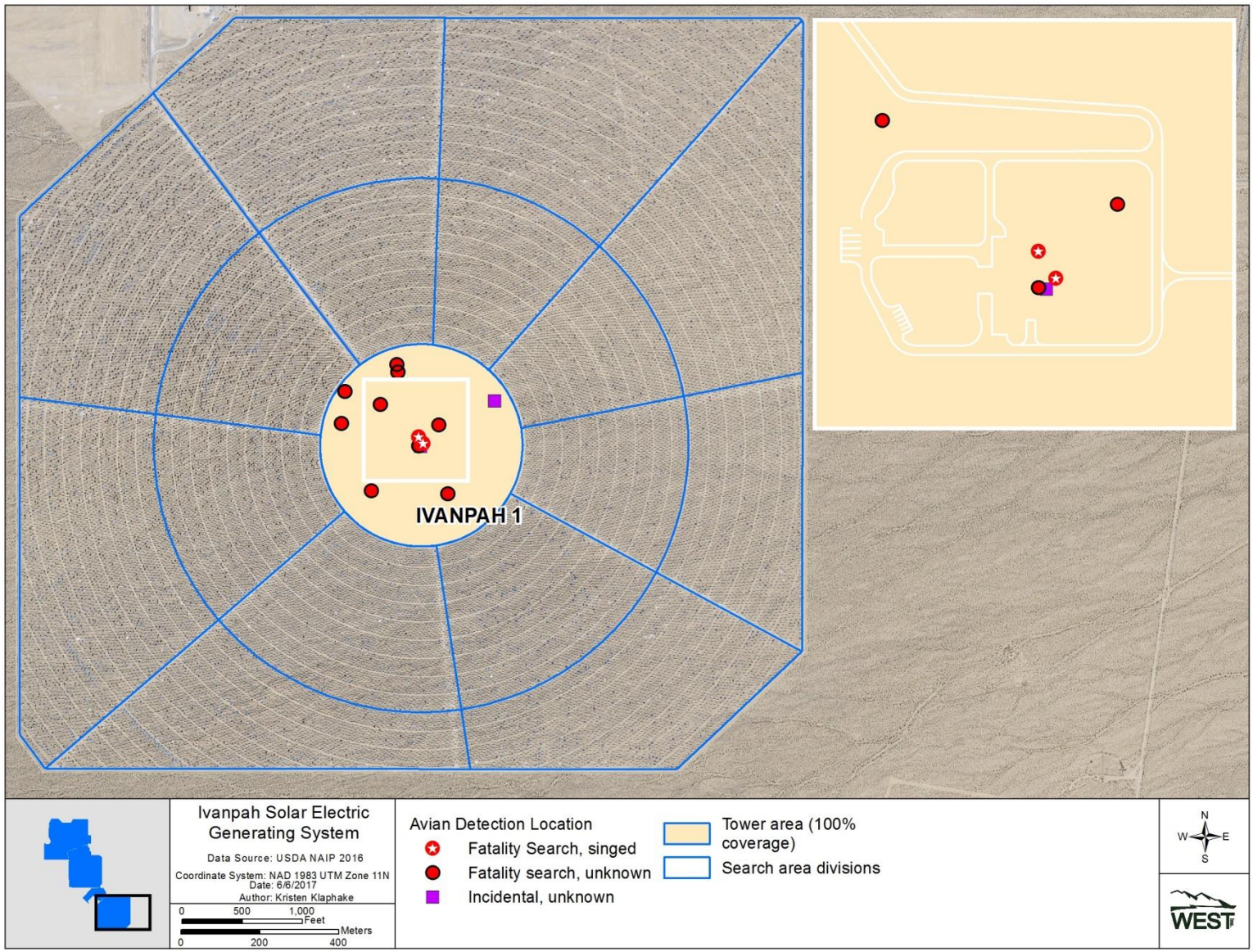

Figure 4. Ivanpah 1 Detections.

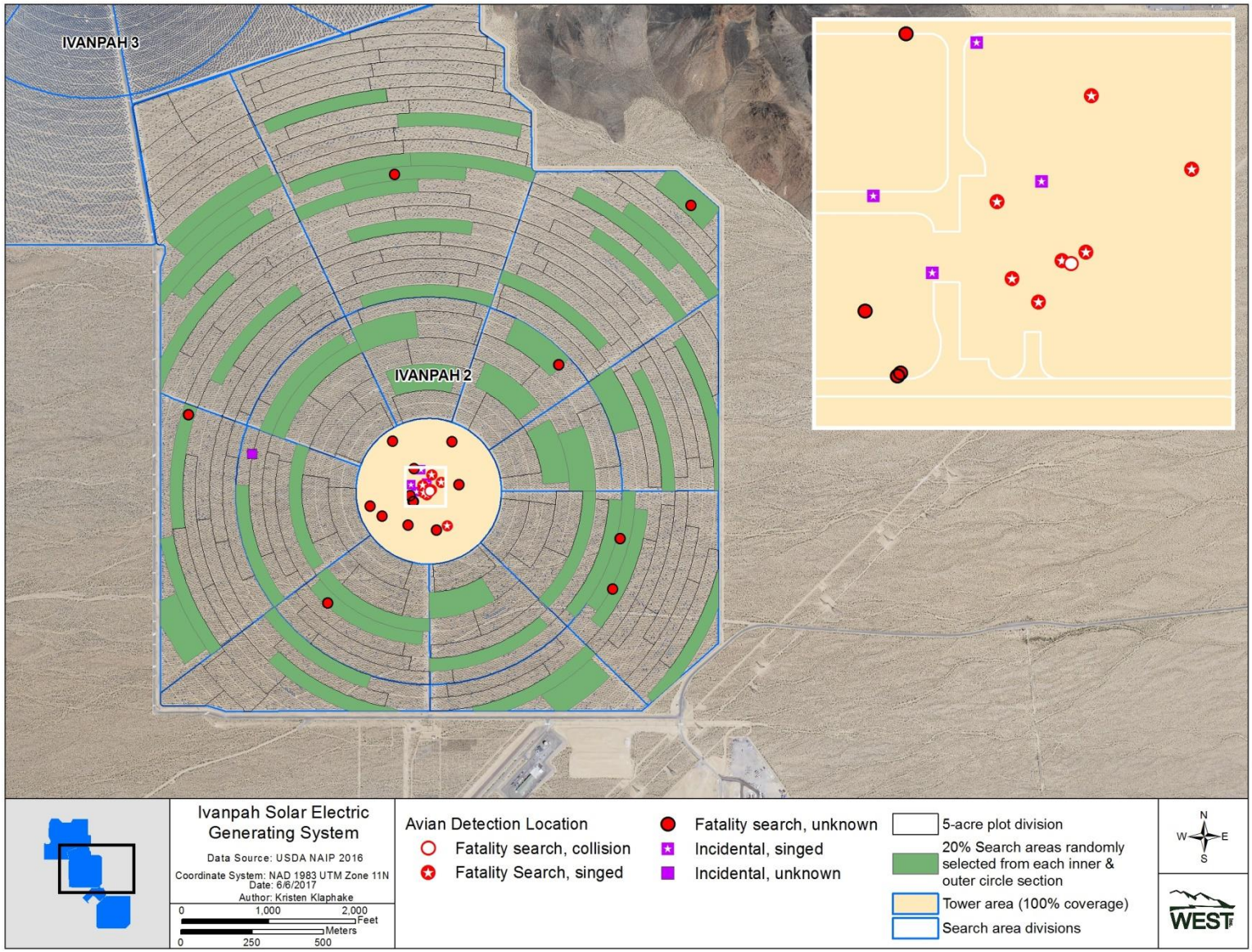

Figure 5. Ivanpah 2 Detections.

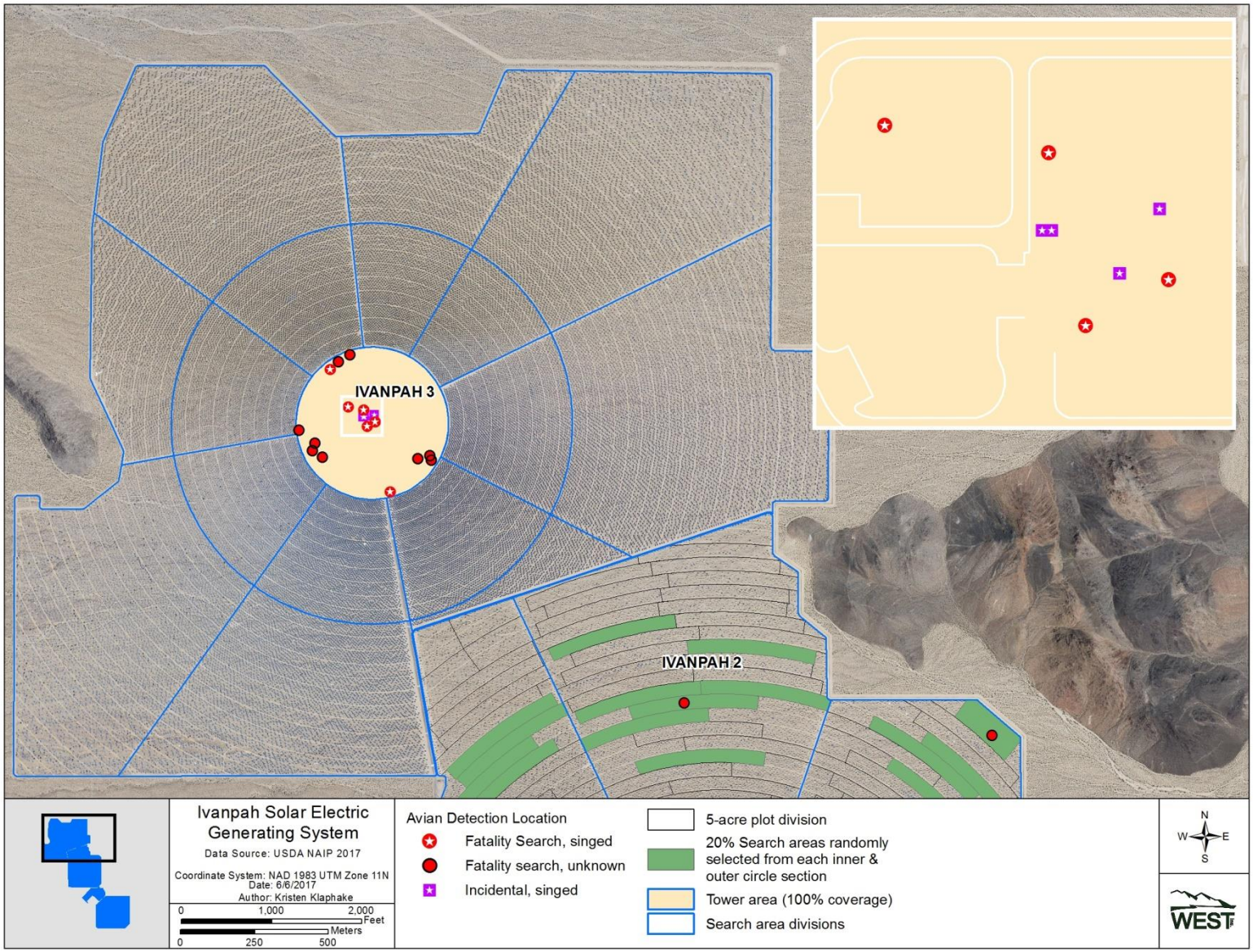

Figure 6. Ivanpah 3 Detections.

3.1.1 Temporal Patterns of Avian Detections

The number of detections reported per day was low throughout the 2016 – 2017 winter season with limited peaks though mid-November. BirdCast reported local light movements of migrants in the Desert Southwest though early November. Early season flights of migrants were light in the Desert Southwest in early March increasing to moderate from mid to late March. No peaks in detections were reported in late March.

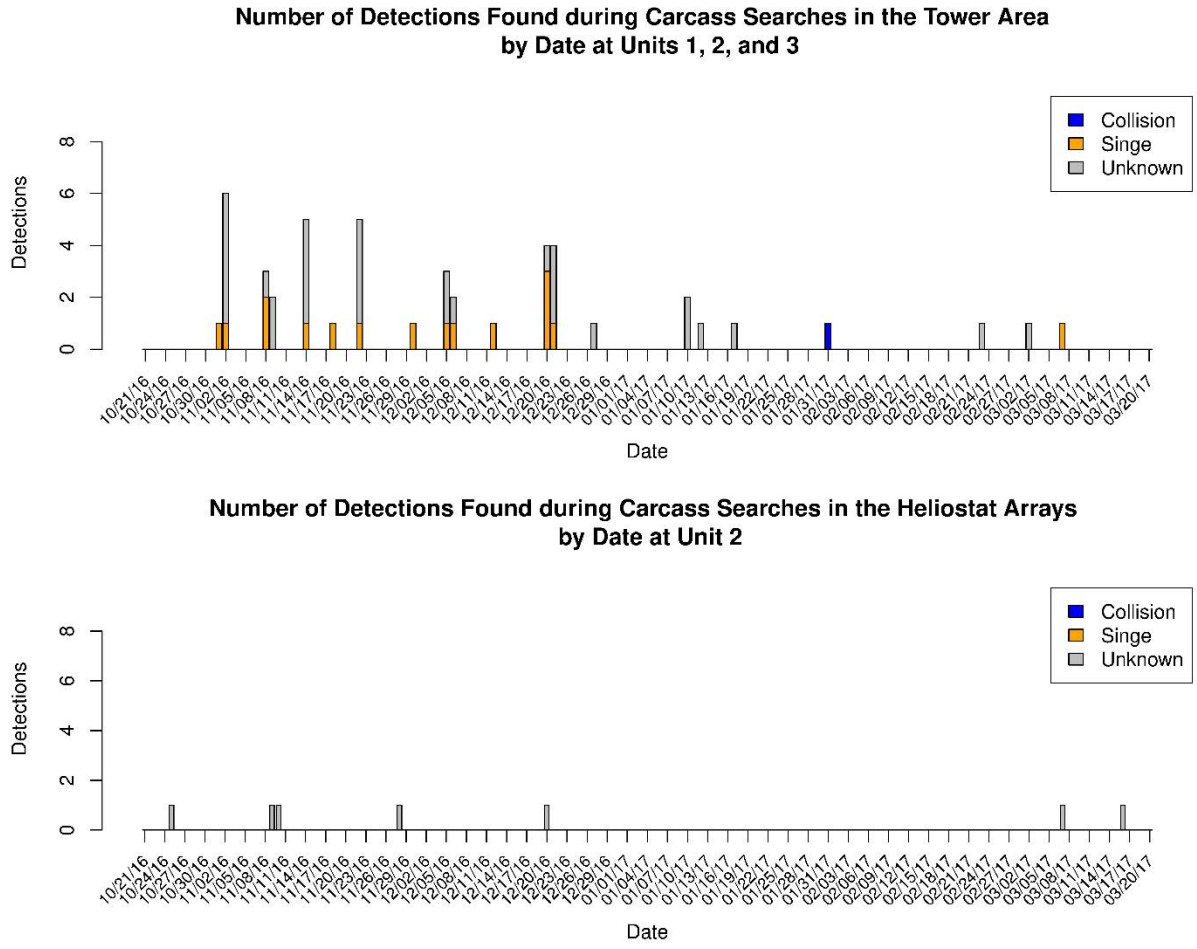

Figure 7. Number of Detections on Each Survey Date, 21 October 2015 – 25 March.

One injured bird was detected during the 2016 – 2017 winter season (Table 3). An American kestrel was discovered with evidence of singing. The bird was taken to Animal Kingdom Veterinary Hospital the day it was detected, where it expired later the same day.

Table 3. Avian Injuries Detected 21 October 2015 – 25 March.

Date	Species	Age	Sex	Cause of Injury	Flux Grade	Fate
12/6/2016	American kestrel	Adult	Male	Singed	2,3	Transported to rehab; expired later the same day.

3.1.3 Summary of Bat Detections

Two bats representing one species and one unidentified species were detected during the 2016 – 2017 winter season. A big brown bat was located in the Unit 1 ACC, and an unidentified bat was located in the Unit 3 ACC. Given the few detections of bats, they are not discussed further.

3.2 Locations of Avian Detections

3.2.1 Detections by Project Area

During winter 2016 – 2017, of the 65 total detections, 57 detections (87.7%) were recorded at the tower area and 8 detections (12.3%) were recorded over the heliostat area (Table 4). Of the 65 avian detections, 14 (21.5%) were detected in Unit 1, 32 (49.2%) in Unit 2, and 19 (29.2%) in Unit 3.

Table 4. Locations of Avian Detections, 21 October 2016 – 20 March 2017.

Location	Carcasses	Injuries	Percent of Total
Tower Area	56	1	87.7%
Heliostat Area	8	0	12.3%
Total	64	1	100.0%

3.3 Cause of Injury or Fatality

The following section describes the number of detections with evidence of singeing or collision; the number from other known causes; the number for which cause of injury or fatality is unknown; and the spatial distributions of detections with these causes. Figure 8 shows the distribution of detections by cause.

3.3.1 Singeing Effects

Of the 65 avian detections during the 2016 – 2017 winter season, 24 detections (36.9%) showed signs of singed feather damage, and 100% of singed detections were recorded in the tower area (Table 5).

3.3.2 Collisions

Of the 65 avian detections, evidence of collision was observed in the case of 1 (1.5%). As described in Section 2.2.1.3, the evidence that was used to classify this detections as collisions was obvious physical trauma, proximity to heliostats that had smudge marks, body imprints, and/or feathers on or near the surface of the mirror (although birds that collide with structures do not always leave visible evidence).

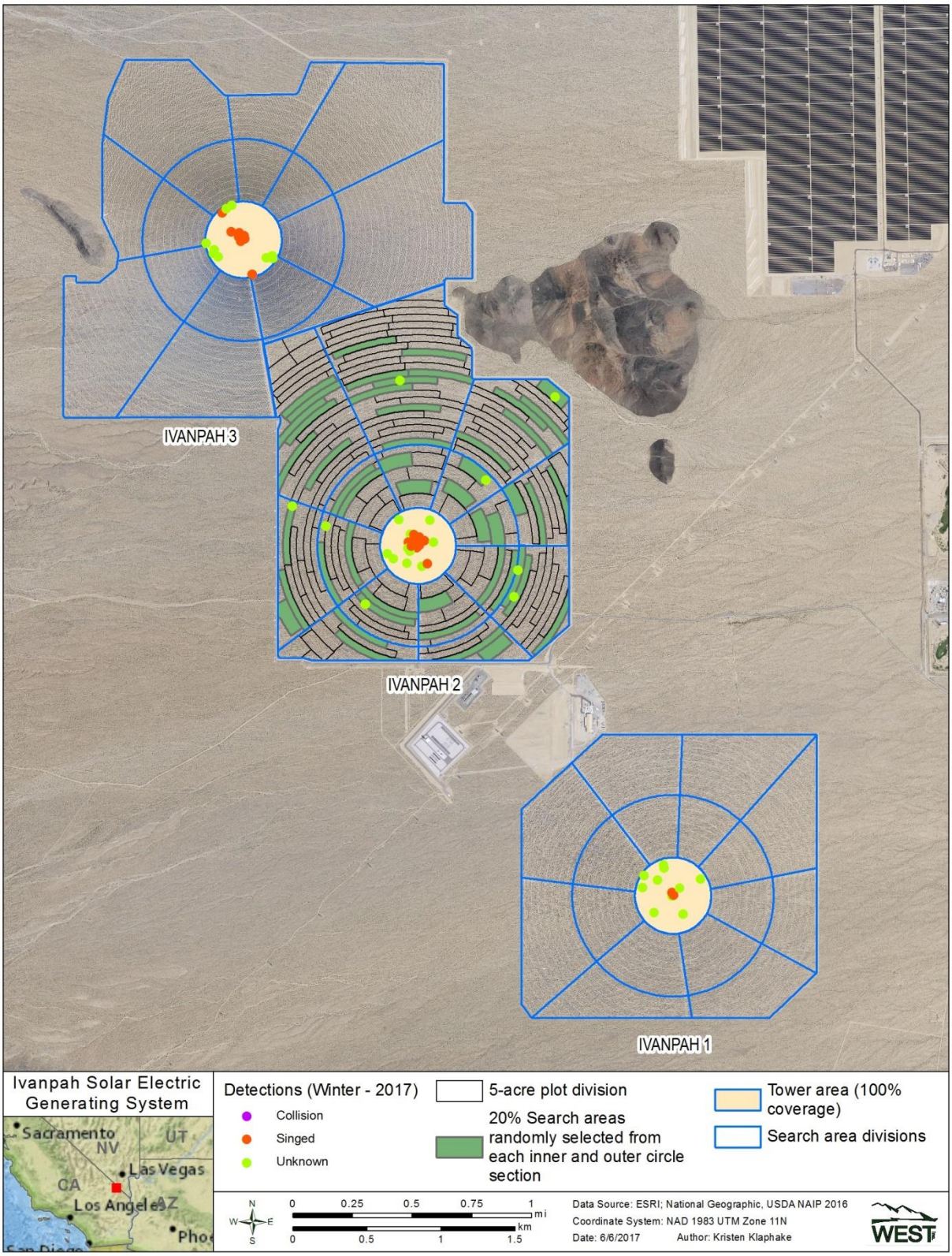

Figure 8. Locations of Singed and Unsinged Detections within Solar Units.

3.3.4 Detections of Unknown Cause

Of the 65 avian detections, evidence of singeing, collision, or other cause could not be assigned for 40 detections (61.5%; Table 5). Per the Plan section 2.1, these detections cannot be presumed with or presumed without a reasonable doubt to be caused by the facility; see Section 6.2 of this report for further discussion. Of the unknown cause detections, 32 (80%) were recorded in the tower area and 8 (20%) were recorded in the heliostat area. These detections showed no evidence of collision effects, and microscopic analysis did not indicate signs of singeing. Of these 40 unknown detections, 23 (57.5%) were feather spots, 15 (37.5%) were broken-up carcasses that had been scavenged, and only 2 (5.0%) were of a whole carcass or live, injured bird.

Table 5. Locations of Bird Detections, 21 October 2016 – 20 March 2017.

Location	Singeing	Collision	Unknown	Total
Tower Area	24	1	32	57
Heliostat Area	0	0	8	8
Total	24	1	40	65

3.4 Types of Detections

Forty-three (66.1%) of the 65 detections consisted only of feather spots (Table 6a). Feather spots accounted for 75% of detections in the heliostats area, and 64.9% of detection in the tower area. Percent of the detections that were feather spots was lowest in the tower area (64.9%), and no detections in the ACC were feather spots. Evidence of singeing was noted through direct and microscopic examination on one of these 43 feather spots; evidence of collision (i.e., an impact imprint on a nearby mirror) was noted in the case of seven feather spots. Otherwise, the causes of the feather spots for the other 35 detections are unknown (Table 6b).

Table 6a. Percent Composition Feather Spots to Carcasses Relative to Site Locations.

Location	Carcasses	Feather Spots/Partial Carcasses	Total	Percent Feather Spot*
Tower Area	20	37	57	64.9%
Heliostat Area	2	6	8	75.0%
Total	22	43	65	64.9%

Table 6b. Percent Composition Feather Spots to Carcasses Relative to Cause.

Cause	Carcasses	Feather Spots	Total Detections	Percent Feather Spot*
Collision	0	1	1	100%
Singed	17	7	24	29.2%
Unknown	5	35	40	87.5%
Total	22	43	65	66.2

*Total percent feather spot is total feather spots divided by total detections.

Section 4.0 Fatality Estimation

This section utilizes the detection data as described in Section 3 to develop an overall fatality estimate in accordance with the Plan (2015). The total estimate for the entire facility is presented separately for fatalities with evidence of singeing or collision effects, or for detections in the ACC buildings, and fatalities of unknown cause. Following presentation of the total fatality estimates, estimates are provided separately for the tower area, and heliostat area.

4.1 Estimating Model Parameters

4.1.1 Carcass persistence Trials

A total of 20 small bird carcass persistence trials were conducted during the 2016 – 2017 winter monitoring season. Trials were distributed throughout the facility. Consistent with previous seasons, scavengers included common ravens (*Corvus corax*, N=6), desert kit fox (*Vulpes macrotis*; N=9), and white-tailed antelope squirrels (*Ammospermophilus leucurus*; N=3). In 3 instances no scavenger was captured on film. Small bird carcass persistence ranged from less than one day in the case of 9 carcasses to 10 days; no carcasses lasted the full six week trial period (Figure 9). Large bird carcass persistence trials were discontinued beginning fall 2015 per TAC approval because no seasonal effects were found in previous large bird models and most trial carcasses persisted at least 42 days (Figure 10).

In addition to the 2016 – 2017 winter trials described above, carcass persistence trials from the first three years of monitoring were also used in the model. Carcass persistence data from 92 carcass persistence trials conducted during the 2015 - 2016 monitoring year (92 small birds), carcass persistence data from 127 carcass persistence trials conducted during the 2014 - 2015 monitoring year (97 small birds and 30 large birds distributed throughout the facility), and data from 87 trials (57 small birds and 30 large birds distributed throughout the facility) performed during the first year of monitoring (29 October 2013 – 20 October 2014) were used to model carcass persistence time. Details on carcass persistence times can be found in each respective seasonal report.

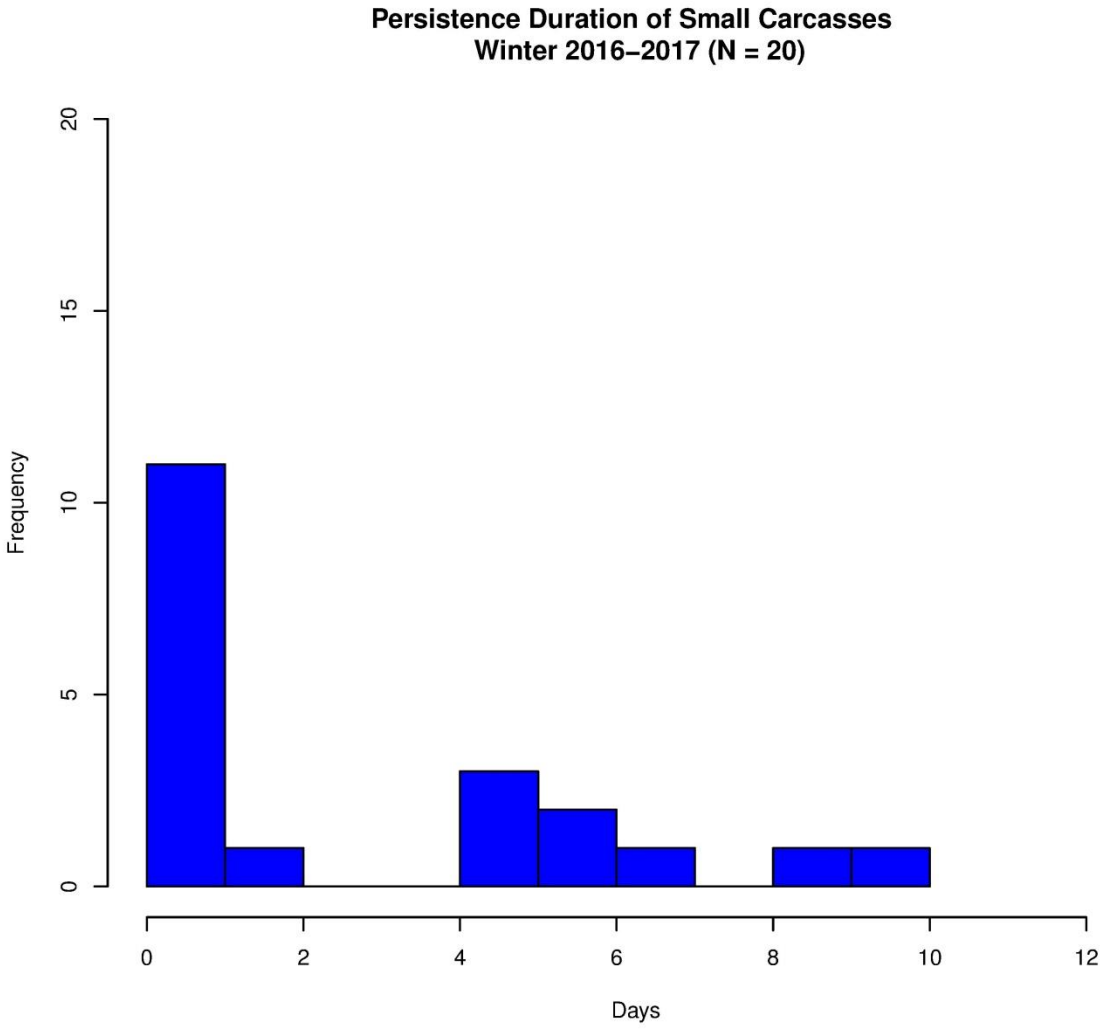

Figure 9. Persistence Durations for Small Carcasses Placed for 2016 - 2017 Winter Carcass Persistence Trials (N = 20).

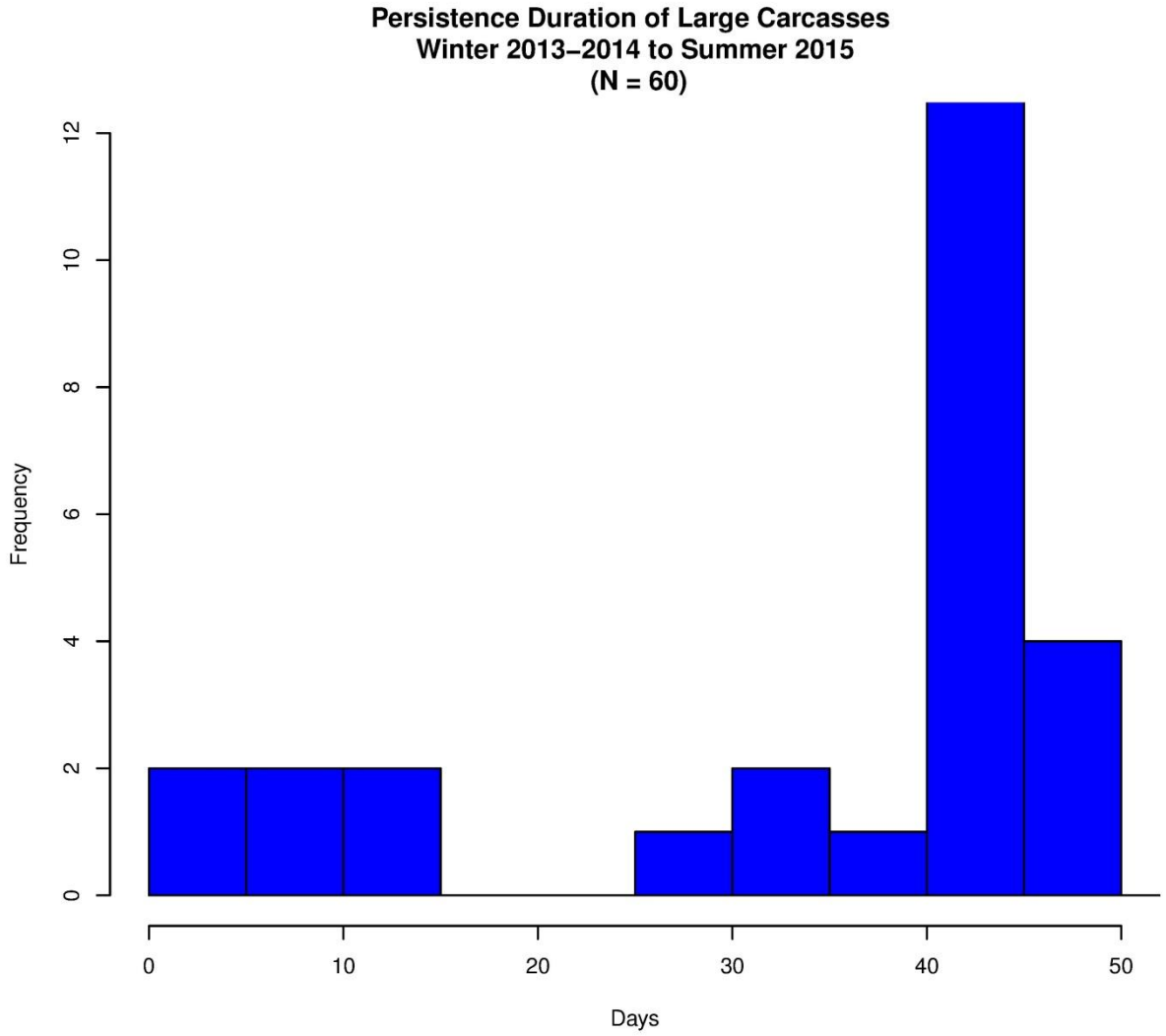

Figure 10. Persistence Durations for Large Carcasses Placed for All Carcass Persistence Trials.

4.1.2 Model Selection for Carcass Persistence Distribution

Consistent with the findings that the removal process for small birds and large birds has been markedly different, two separate carcass persistence models were fit to this dataset: one for small birds and one for large birds. Specifically, large birds consistently persist for long periods of time (typically greater than six weeks), while small birds tend to be removed with days or hours, and exhibit seasonal variability. Fitting separate models by size allows for more flexibility, enabling different distributions with different shapes to be fit to the small bird and large bird data, respectively.

Based on the carcass persistence data from the cumulative trials, 16 survival models were compared for the small bird and large bird datasets, respectively. Models were compared for relative explanatory power using the corrected Akaike information criterion (AICc) score (Akaike 1973), as suggested in Huso (2010). AICc provides a relative measure of model fit and parsimony among a selection of candidate models. Season was considered as a possible covariate due to cyclical variation in scavenging pressure and environmental conditions associated with seasons. Year was also incorporated as a covariate to

assess whether respective seasons could be pooled across the first three years (i.e. combine 2014 fall with 2015 fall and 2016 fall persistence trial results). At the conclusion of the first year of monitoring, the location of a carcass (unvegetated tower area or the vegetated heliostat area, fenceline, or collector line) was not present in the top models for carcass persistence. Thus, carcass location was not included as a covariate for this report.

The model with lowest AICc is typically chosen as the "best-fit" model relative to other models tested; however, any model within two AICc point of the best model is considered strongly supported (Burnham and Anderson 2004). For small birds the loglogistic model that included year+season had ΔAICc values ≤ 2; for large birds, the exponential, Weibull, loglogistic, and lognormal models with intercept only had ΔAICc values ≤ 2 (Tables 7a and 7b). Ultimately, a loglogistic model with year + season covariate was chosen for small birds, and an exponential model with no covariates was chosen for large birds. Thus, the selected model for small birds can be interpreted to treat as separate the persistence probability for each season in each year. For large birds, the top model does not have any temporal covariates, and thus uses all large bird data collected to date to estimate persistence probability. The chosen models predicted 96.5% of large carcasses persisted for the nominal search interval (21 days), and 19.7% of small bird carcasses persisted for the nominal search interval of during the 2016 – 2017 winter monitoring season.

Table 7a. AICc Values for Small Bird Carcass Persistence Models

Small Bird Trials			
Covariates	Distribution	AICc	Δ AICc
Year + Season	loglogistic	1313.00	0
Season + Year + Project Area	loglogistic	1315.09	2.09
Year + Season	lognormal	1315.34	2.34
Season	loglogistic	1315.72	2.72
Season	lognormal	1316.89	3.89
Season + Year + Project Area	lognormal	1317.39	4.39
Season + Project Area	loglogistic	1317.79	4.79
Season + Project Area	lognormal	1318.96	5.96
Year + Season + Year*Season	loglogistic	1319.07	6.07
Season + Year + Project Area	weibull	1320.29	7.29
Year + Season	weibull	1321.73	8.73
Intercept	lognormal	1323.42	10.42
Year + Season + Year*Season	lognormal	1323.45	10.45
Intercept	loglogistic	1323.53	10.53
Year + Season + Year*Season	weibull	1331.09	18.09
Season	weibull	1333.44	20.44

Table 7b. AICc Values for Large Bird Carcass Persistence Models

Large Bird Trials			
Covariates	Distribution	AICc	Δ AICc
Intercept	exponential	97.00	0
Intercept	weibull	97.96	0.96
Intercept	loglogistic	98.03	1.03
Intercept	lognormal	98.15	1.15
Year + Season	exponential	101.15	4.15
Year + Season	lognormal	101.42	4.42
Season	exponential	101.48	4.48
Year + Season	loglogistic	102.22	5.22
Season	lognormal	102.38	5.38
Year + Season	weibull	102.60	5.6
Season	loglogistic	102.70	5.7
Season	weibull	102.73	5.73
Year + Season + Year*Season	exponential	107.18	10.18
Year + Season + Year*Season	lognormal	108.6	11.6
Year + Season + Year*Season	loglogistic	108.88	11.88
Year + Season + Year*Season	weibull	108.93	11.93

4.1.3 Searcher Efficiency Trials

During the 2016 – 2017 winter season, a total of 74 searcher efficiency trials (22 small birds, 29 large birds, and 23 feather spots) were placed. Trials were placed in locations with various vegetation heights and with a range of contrast between the soil and vegetation to represent the various conditions under which searches occur. Carcasses were placed in most areas where searches occurred (tower area and heliostat area). Fourteen trials (2 small birds, 9 large birds, and 3 feather spots) were removed (scavenged) prior to a searcher having the opportunity to detect the carcass.

Trial data from the first three years of monitoring were used to fit a searcher efficiency model for the 2016 – 2017 winter season. Of the 306 human searcher efficiency trials conducted during the 2015-2016 monitoring year (124 small birds, 93 large birds, and 89 feather spots), 263 (95 small carcasses, 83 large carcasses, and 85 feather spots) were available to be found; 43 carcasses (29 small carcasses, 10 large carcasses, and 4 feather spot) were removed from the trial location before searchers had an opportunity to detect the carcass. Of the 320 human searcher efficiency trials conducted in the 2014 – 2015 monitoring year (129 small birds, 96 large birds, and 95 feather spots) 268 (129 small carcasses, 96 large carcasses, and 95 feather spots) were available to be found; 52 carcasses (42 small carcasses, 8 large carcass, and 2 feather spots) were removed from the trial location before searchers had an opportunity to detect the carcass. An additional 154 searcher efficiency trials from the first year of study (2013 – 2014) were also included in searcher efficiency model building. Of 154 trials from the first year of monitoring, 144 were not removed and thus available to be found by a searcher.

Human searcher efficiency rates based on raw data collected during the 2016-2017 winter season were variable by project area. Detection rates were better for feather spots in the unvegetated tower area than the vegetated heliostat area, while detection rates were better for small bird and large bird carcasses in the vegetated areas compared to the unvegetated areas. During the 2016 – 2017 winter season, in unvegetated areas, human searcher efficiency was 40% for small birds, 70% for large birds, and 80% for feather spots. In the vegetated areas in the heliostat arrays, human searcher efficiency was 60% for small birds, 80% for large birds, and 60% for feather spots.

Table 8. Covariates, AICc Values, and ΔAICc values for the top ten searcher efficiency models. Data consist of all human searcher efficiency trials for carcasses from the initiation of trials through March 25, 2016.

Covariates	AICc	Δ AICc
Size + Project Area + Year + Project Area*Year	890.26	0.00
Size + Project Area + Year + Size*Project Area + Project Area*Year	892.01	1.75
Size + Project Area	892.47	2.21
Size + Project Area + Season + Year + Project Area*Year	892.61	2.34
Size + Project Area + Year	892.90	2.64
Size + Project Area + Size*Project Area	894.21	3.95
Size + Project Area + Season + Year + Size*Project Area + Project Area*Year	894.28	4.02
Size + Project Area + Year + Size*Project Area	894.52	4.26
Size + Project Area + Season + Year + Project Area*Season + Project Area*Year	895.00	4.73
Size + Project Area + Season + Year	895.72	5.46

The best model for searcher efficiency included carcass size, project area, year, and a project area × year interaction with an AICc value 1.75 points lower than the second best model (Table 8). Thus, the most supported searcher efficiency model produces searcher efficiency estimates based on carcass size, project area (unvegetated tower area and vegetated heliostat area), year, and project area by year (project area-year interaction); the interaction term can be interpreted to mean that searcher efficiency may differ by year at dissimilar rates within each project area (for example, searcher efficiency could increase by 20% from year 2 to year 3 in the unvegetated tower area, and increase by 5% from year 2 to year 3 in the vegetated heliostat area). Searcher efficiency values used to adjust detections to calculate a fatality estimate are provided in Table 9 and are based on all searcher efficiency data collected to date.

Table 9. Human Searcher Efficiency Sample Sizes Used for Modeling, and Model Predictions for Size and Project Area Categories Winter 1 – Winter 4.

Size	Location	Found	Available	Placed	Predicted Searcher Efficiency (90% CI)
Feather spot	Tower area (Unvegetated)	88	124	128	0.59 (0.43-0.74)
Large bird	Tower area (Unvegetated)	97	113	128	0.76 (0.63-0.87)
Small bird	Tower area (Unvegetated)	93	125	164	0.55 (0.39-0.71)
Feather spot	Heliostat area (Vegetated)	62	131	136	0.63 (0.46-0.78)
Large bird	Heliostat area (Vegetated)	76	117	134	0.79 (0.67-0.89)
Small bird	Heliostat area (Vegetated)	47	125	164	0.58 (0.42-0.75)

4.2 Fatality Estimates of Known Causes for 2016 – 2017 Winter Monitoring

Fatality estimates were calculated separately for the tower area (power block and inner HD heliostats) and heliostat area. Note that estimates are not provided for factor combinations with five or fewer detections; thus, marginal totals (e.g. total singed, total known cause in the heliostat area, etc.) for the tables below may not reflect the sum of estimates within a given row or column (and are generally higher).

4.3.1 Total Fatality Estimates for Known Causes

There were 25 bird detections where the cause of death or injury could be determined and were facility related, of which 14 were included in the fatality estimate model (Tables 10a and 10b); of these 14 detections, 1 was from the ACC that were added unadjusted to the estimator output, to produce the total fatality estimate of known cause (Tables 11 and 12). There were 11 detections showing evidence of singeing or collision outside the ACC buildings that were not included in the fatality estimates; one was excluded because it was outside the standardized survey area and 10 were excluded because they were determined to be older than the search interval.

Table 10a. Number of Bird Detections Based on Known Causes in Each Project Element Included or Excluded from Fatality Estimates, by Cause.

	Included			Excluded			
Location	Collision	Singed	Other	Collision	Singed	Other	Total
Tower Area	1	13	0	0	11	0	25
Heliostat Area	0	0	0	0	0	0	0
Total	1	13	0	0	11	0	25

Table 10b. Number of Bird Detections Based on Known Causes in Each Project Element Included or Excluded from Fatality Estimates, by Carcass Size.

	Included			Excluded			
Location	Large Birds	Small Birds	Raptors*	Large Birds	Small Birds	Raptors*	Total
Tower Area	3	11	1	0	11	0	14
Heliostat Area	0	0	0	0	1	0	1
Total	3	11	1	0	1	0	25

* All raptors are considered "Large Birds", therefore the number of raptor detections in a row or column is not added to the total.

Table 11. 2016 – 2017 Winter Season Avian Fatality Estimates by Cause and Project Element (with Lower and Upper 90% Confidence Intervals) Based on Detections of Known Causes Included in the Model.

Location	Collision	Singed	Total Known Cause
Tower Area	N ≤ 5	62 (43-104)	70 (48-118)
Heliostat Area	0	0	0
Total	N ≤ 5	62 (43-104)	70 (48-118)

* N ≤ 5 indicates 5 or fewer detections and no fatality estimate is provided

Table 12. 2016 – 2017 Winter Season Avian Fatality Estimates by Carcass Size and Project Element (with Lower and Upper 90% Confidence Intervals) Based on Detections of Known Causes Included in the Model.

Location	Large Birds	Small Birds	Raptors	Total
Tower Area	N ≤ 5	66 (44-113)	N ≤ 5	70 (48-118)
Heliostat Area	0	0	0	0
Total	N ≤ 5	66 (44-113)	N ≤ 5	70 (48-118)

* N ≤ 5 indicates 5 or fewer detections and no fatality estimate is provided

4.3.2 Fatality Estimate for Tower Area and Heliostat Area

Tables 11 and 12 present the fatality estimates for known causes within the tower area, broken down by cause or carcass size, respectively. A subset of the incidental detections in the power block were included within the tower area total estimate, due to the assumption of a daily search interval; those incidental detections in the power block which were determined to be older than 24 hours were not included in the fatality estimator. Estimates from the tower area should be interpreted with caution due to the inclusion of numerous incidental discoveries in the power block.

During the period 21 October 2016 – 20 March 2017 (151 days of monitoring), there were an estimated 70 fatalities (90% confidence interval 48-118) based on detections from known causes (i.e., singeing, collision; Table 11). Of these, all 70 fatalities (100%) were estimated for the 154 acre tower area. Small birds accounted for 94% of the estimated fatalities of known causes (Table 12).

4.4 Fatality Estimates from Unknown Causes

Per Section 3.1 of the Plan, fatality estimates are also to be provided based on detections of birds that were injured or that died of unknown causes. Because no observable evidence of known causes (i.e., singeing, collision, entrapment, or predation) was noted in the case of these unknown detections, they cannot be clearly included in an estimate attributed to a specific cause. The methods for determining fatality estimates for these unknown detections are the same as those described in Section 5.2 for detections with direct evidence of the cause of the fatality (i.e., singeing, collision, or other).

There were 40 detections where the cause of death could not be determined, of which 37 were included in the fatality estimator (Tables 13a and 13b). Of the 11 detections of unknown cause excluded from the fatality estimator, 7 detections were determined to be older than the search interval. Of the remaining four excluded detections, two were discovered at the unit fence and two were discovered in the heliostat areas of units 1 and 3, which are not part of the standard search area required under the Plan (2015).

Table 13a Number of Detections from Unknown Causes in Each Project Element, and Number Included in Fatality Estimates, by Cause.

Location	Included	Excluded	Total
Tower Area	30	2	32
Heliostat Area	7	1	8
Total	37	3	40

Table 13b. Number of Detections from Unknown Causes in Each Project Element, and Number Included in Fatality Estimates, by Carcass Size.

	Included			Excluded			
Location	Large Birds	Small Birds	Raptors*	Large Birds	Small Birds	Raptors*	Total
Tower Area	1	29	0	2	0	0	32
Heliostat Area	2	5	0	0	1	0	8
Total	3	34	0	2	1	0	40

* All raptors are considered "Large Birds", therefore the number of raptor detections in a row or column is not added to the total.

4.4.1 Total Fatality Estimates from Unknown Causes

During the period of 21 October 2016 – 20 March 2017, the total estimate of fatalities from unknown cause was 715 (90% confidence interval 376-1392; Table 14). A total of 237 (90% confidence interval 155-415) were in the tower area, and 478 (90% confidence interval estimates 168-1033) in the heliostat area). Of the estimated unknown cause fatalities, small birds accounted for 94% of the estimated fatalities (Table 15).

Table 14. Site-Wide Fatality Estimates from Unknown Causes by Location, 21 October 2015 – 25 March.

Project Area	Estimate (90% CI)
Tower Area	237 (155-415)
Heliostat Area	478(168-1033)
Total	715 (376-1392)

Table 15. Site-Wide Fatality Estimates from Unknown Causes by Size and Location, 21 October 2015 – 25 March.

Location	Large Birds	Small Birds	Raptors	Total
Tower Area	N ≤ 5	236 (153-413)	0	237 (155-415)
Heliostat Area	N ≤ 5	437 (142-986)	0	478(168-1033)
Total	N ≤ 5	673 (335-1341)	0	715 (376-1392)

* N ≤ 5 indicates 5 or fewer detections and no fatality estimate is provided

4.6 Regional Awareness Monitoring

During the 2016-2017 winter season, 1 injured bird was taken to rehab. Neither the facility nor its designated biologist was contacted by any veterinarian or rehab center about singed birds brought in by non-project staff. In addition, Dr. Craig Himmelwright, who performs periodic raven surveys across the Ivanpah Valley has not reported singed detections occurring outside of the Project.

Section 5.0 Discussion

The 2016 – 2017 winter season represented the continuation of standardized monitoring of avian and bat detections and avian use of the Ivanpah site as revised per the Avian & Bat Monitoring and Management Plan (2015).

5.1 Temporal Patterns in Detections

The number of detections reported at the tower area was low throughout the 2016 – 2017 winter season with several small peaks in November and none towards the onset of spring migration in March. Scattered light migration movements in the Desert Southwest were reported by the BirdCast analysis through 20 November 2015. BirdCast did not report migration analysis after 20 November 2015 suggesting fall migration had ended in the West region by this date. Thus, it can be assumed that some migrant birds were passing through the Project area through early to mid-November. BirdCast reported light to moderate flights of migrants from early March through late March; however, only four detections were found after March 1. The 21-day search interval results in an accumulation of carcasses at the tower area, and peaks in detections are associated with tower searches. Thus, a tower area search during the 2016 – 2017 winter season is a look back over approximately 21 days, so lag effects in detections per day compared to migrant songbird activity is expected. In other words, it would be expected that singed detections of migrant birds would be found after migration has slowed or started regionally due to the search schedule.

5.2 Spatial Patterns Detections and Fatality Estimates

The distribution of known cause detections varied by facility area. Of singed detections, 100% occurred in the tower area. Unknown cause detections accounted for approximately 61.5% of all detections during the 2016 – 2017 winter season, and the distribution of the unknown cause detections varied by facility type with 80% occurring outside of the tower area, suggesting unknown cause detections were not associated with singed birds as feather spots were closely examined for signs of singeing. Of the unknown cause detections, 87.5% were feather spots or partial carcasses that showed signs of scavenging. Determining a cause of mortality from a feather spot or partial carcass is challenging because sources of mortality such as collision or predation would rarely leave visible evidence on the feathers as would flux effects. Thus, feather spots with an unknown cause of mortality could be encountered anywhere birds occur, and an unknown cause of mortality is not unique to the Project. However, feather spots are included in the analysis here to provide a more conservative fatality estimate because the origin of feather spots is generally unknown.

Section 6.0 Framework for Management and Risk Response

According to Section 5.3 of the Plan, migratory bird mortality at Ivanpah is categorized as high, medium, or low to provide an appropriate biological basis for TAC review and decision making, based on the following definitions:

1. "High: Estimated avian mortality or injury levels are facility-caused and likely to seriously and negatively affect local, regional, or national avian populations within a particular species or group of species."
2. "Medium: Estimated avian mortality or injury levels are facility-caused and have the potential to negatively affect local, regional, or national populations within a particular avian species or group of species."
3. "Low: Estimated avian mortality or injury levels that have minimal or no potential to negatively affect local, regional, or national populations within a particular species or group of species."

Only limited conclusions can be drawn from the 2016 – 2017 winter season fatality data owing to the low numbers of detections within "a particular species or group of species"; however, the results indicate that the potential migratory bird mortality by species or groups of species from this project would be categorized as low. Approximately 73% of the detections were songbirds, and in general songbirds are short-lived, have high reproductive output, and their population growth rates are less sensitive to changes in survival rates than to changes in reproductive rates (Stahl and Oli 2006). Therefore, mortality of most songbird species is expected to have negligible effects on population dynamics. A more complete analysis will be conducted for the annual report.

None of the four identifiable species represented by more than three detections is particularly rare locally, regionally, or nationally. Rather, all four species are relatively abundant and widespread. Thus, the magnitude of detections of these species at Ivanpah during the 2015 fall season does not rise above the "low" category. Special-status species recorded as detections were two yellow warblers (California species of special concern) and two loggerhead shrikes (California species of special concern). Loggerhead shrikes breed in the vicinity of the Project, whereas yellow warbler is a transient that breeds elsewhere.

Yellow warblers are one of the most abundant warblers in North America and occur as both migrants and summer residents in California (Shuford and Gardali 2008). Yellow warblers occur in the Mojave Desert as common migrants, but they typically do not breed there. An estimated 600,000 yellow warblers occur within California and an estimated 34,000,000 occur in the United States (Partners in Flight Science Committee 2013). The two yellow warblers detected represented a very small proportion of these populations; thus, the estimated yellow warbler fatalities during the 2016 – 2017 winter season not rise above the "low" category, as loss of this magnitude would have a minimal effect on populations at all geographic scales (local, regional, national or global).

The loggerhead shrike is common in desert habitats of California, despite its declines in other regions. The southeastern deserts represent one of the areas of highest abundance in the state (Humple 2008),

and Breeding Bird Survey data indicate no significant declining population trends, or perhaps even a slight increase, in the Mojave Desert since the mid-1960s (Sauer et al. 2015). The North American population of this species is estimated at 2,900,000 birds (http://birds.audubon.org/species/logshr). The single detection recorded on the site indicates a low number of impacted individuals that would not substantially affect local, regional, or national populations of the species; thus the 2016 – 2017 winter season estimated fatalities do not rise above the "low" category.

Section 7.0 Literature Cited

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Appendix A. Individual Avian Detections.

USFWS #	Common Name	Species Code	How Found	Detection Date	Collection Date	Condition	Time Since Death/Injury	Description of Carcass/Injury	Cause of Death/Injury	Burn Grade	Unit	Nearest Project Feature	UTM Coordinates	SPUT Revisions
2016_662_ISEGS	Unknown Sparrow	UNSP	Carcass Survey	10/25/2016	10/25/2016	Broken up	8-24 hours	Broken up carcass consisting of partial right wing. No evidence of collision or singe.	Unknown		2	Heliostat	639327, 3935683	NA
2016_663_ISEGS	Barn Swallow	BARS	Carcass Survey	11/1/2016	11/1/2016	Broken up	2 weeks	Broken up carcass consisting of body cavity and wings without head, tail, and legs. Evidence of curling to primaries and secondaries in both wings, singeing to rump.	Scorched or singed	2~3	3	Powerblock	637447, 3937958	NA
2016_664_ISEGS	American Pipit	AMPI	Carcass Survey	11/2/2016	11/2/2016	Feather spot	3-6 days	Feather spot size small consisting of 8 tail feathers and 30 body feathers. No evidence of collision or singe.	Unknown		3	Heliostat	637273, 3937819	NA
2016_665_ISEGS	Brown-headed cowbird	BHCO	Carcass Survey	11/2/2016	11/2/2016	Feather spot	2 days	Feather spot size large consisting of 9 primaries, 10 secondaries, 2 undertail coverts, several wing coverts, and 100 body feathers. No evidence of collision or singe.	Unknown		3	Heliostat	637281, 3937844	NA
2016_666_ISEGS	Sagebrush Sparrow	SAGS	Carcass Survey	11/2/2016	11/2/2016	Feather spot	3-6 days	Feather spot size large consisting of 2 right primaries, 2 right secondaries, 7 rectrices, 25 contour feathers. Evidence of curling to 1 rect with others rects being singed.	Scorched or singed	Unk	3	Heliostat	637334, 3938095	NA
2016_667_ISEGS	White-Crowned Sparrow	WCSP	Carcass Survey	11/2/2016	11/2/2016	Feather spot	2 days	Feather spot size large consisting of 7 retrices, 10 primaries, 3 tertials, 7 secondaries, and 50 contour feathers. No evidence of singe or collision.	Unknown		3	Heliostat	637361, 3938120	NA
2016_668_ISEGS	Unknown Small Bird	UNID	Carcass Survey	11/2/2016	11/2/2016	Feather spot	3-6 days	Feather spot size small consisting of 3 right primaries. No evidence of collision or singe.	Unknown		3	Heliostat	637399, 3938143	NA
2016_669_ISEGS	American Pipit	AMPI	Carcass Survey	11/2/2016	11/2/2016	Broken up	3-6 days	Broken up carcass consisting of partial right wing held together by dried flesh, 4 wing coverts, 7 secondaries, and 2 primaries. No evidence of collision or singe.	Unknown		3	Heliostat	637671, 3937802	NA

2016_670_ISEGS	Yellow-rumped Warbler	YRWA	Incidental	11/5/2016	11/5/2016	Dead, fresh (eyes moist)	8-24 hours	Whole carcass. Evidence of curling to flight feathers in left wing and rects, singe to flight feathers in right wing, crown, and back.	Scorched or singed	2~3	2	Powerblock	638610, 3935847	NA
2016_671_ISEGS	Western Meadowlark	WEME	Incidental	11/7/2016	11/7/2016	Broken up	3-6 days	Broken up carcass consisting of piece of upper mandible of bill and 30 body feathers. No evidence of collision or singe.	Unknown		2	Heliostat	638033, 3935980	NA
2016_672_ISEGS	White-Crowned Sparrow	WCSP	Carcass Survey	11/8/2016	11/8/2016	Broken up	2 days	Broken up carcass consisting of body cavity but missing head, legs, and wings. No evidence of collision or singe.	Unknown		2	Powerblock	638598, 3935812	NA
2016_673_ISEGS	Yellow-rumped Warbler	YRWA	Carcass Survey	11/8/2016	11/8/2016	Dead, Semi-fresh (eyes desiccated, rigor mortis)	2 days	Whole carcass. Evidence of curling to all tail feathers, primaries, and secondaries, singeing to head, breast, and rump.	Scorched or singed	2~3	2	ACC Building	638664, 3935907	NA
2016_674_ISEGS	Unknown Small Bird	UNID	Carcass Survey	11/8/2016	11/8/2016	Mummified	2 weeks	Partial carcass with detached left wing, 6 secondaries, 4 primaries, 4 rects, 2 unknown flight feathers. Evidence of singeing to 8 flight feathers and some back contour feathers, bill broken.	Scorched or singed	2~3	2	Powerblock	638662, 3935854	NA
2016_675_ISEGS	Unknown Small Bird	UNID	Carcass Survey	11/9/2016	11/9/2016	Broken up	2 days	Partial wing consisting of 3 primaries and 3 wing coverts. No evidence of collision or singe.	Unknown		2	Heliostat	637807, 3936118	NA
2016_676_ISEGS	American Pipit	AMPI	Carcass Survey	11/9/2016	11/9/2016	Broken up	2 days	Broken up carcass consisting of partial leg, piece of dried flesh of wing at bend, 1 undertail covert, 2 rects, 6 secondaries, wing coverts, and 75 body feathers. No evidence of singe or collision.	Unknown		2	Heliostat	638759, 3935872	NA
2016_677_ISEGS	American Robin	AMRO	Carcass Survey	11/9/2016	11/9/2016	Feather spot	0-8 hours	Feather spot size large consisting of 1 central rect, 6 secondaries, 3 trailing edge secondaries, and 200 contour feathers. No evidence of collision or singe.	Unknown		2	Heliostat	638681, 3935712	NA
2016_678_ISEGS	Unknown Small Bird	UNID	Carcass Survey	11/10/2016	11/10/2016	Feather spot	3-6 days	Feather spot size small consisting of 30 body feathers. No evidence of singe or collision.	Unknown		2	Heliostat	639111, 3936293	NA

2016_679_ISEGS	Yellow-rumped Warbler	YRWA	Incidental	11/10/2016	11/10/2016	Dead, fresh (eyes moist)	0-8 hours	Whole carcass. Evidence of curling to primaries, secondaries, rects, singe to all of upper breast, both sides of face and top of head.	Scorched or singed	2~3	2	Powerblock	638647, 3935878	NA
2016_680_ISEGS	Western Meadowlark	WEME	Carcass Survey	11/14/2016	11/14/2016	Feather spot	3-6 days	Feather spot size small consisting of 16 flight and 20 body feathers. No evidence of singe or collision.	Unknown		1	Heliostat	640313, 3933677	NA
2016_681_ISEGS	Yellow-rumped Warbler	YRWA	Carcass Survey	11/14/2016	11/14/2016	Feather spot	8-24 hours	Feather spot size large consisting of 10 rects, 9 primaries, 5 secondaries, and 79 body feathers. No evidence of collision or singe.	Unknown		1	Heliostat	640440, 3933367	NA
2016_682_ISEGS	Unknow Large Bird	UNLB	Carcass Survey	11/14/2016	11/14/2016	Feather spot	3-6 days	Feather spot size small consisting of 13 contour feathers. Evidence of singe on several tips of the feathers.	Scorched or singed	3	1	Powerblock	640367, 3933512	NA
2016_683_ISEGS	Yellow-rumped Warbler	YRWA	Carcass Survey	11/14/2016	11/14/2016	Feather spot	2 days	Feather spot size small consisting of 6 primaries. No evidence of collision or singe.	Unknown		1	Powerblock	640268, 3933595	NA
2016_684_ISEGS	Unknown Small Bird	UNID	Carcass Survey	11/14/2016	11/14/2016	Feather spot	3-6 days	Feather spot size = large. 30 body feathers, no singe present.	Unknown		1	Heliostat	640169, 3933546	NA
2016_685_ISEGS	Yellow Warbler	YWAR	Carcass Survey	11/18/2016	11/18/2016	Broken up	1 month +	Broken up carcass consisting of partial left wing. Evidence of curling to many of flight feathers.	Scorched or singed	Unk	3	Powerblock	637394, 3937967	NA
2016_686_ISEGS	Unknown Small Bird	UNID	Carcass Survey	11/22/2016	11/22/2016	Feather spot	3-6 days	Large feather spot consisting of 9 retricies with no evidence of singe or collision	Unknown		3	Heliostat	637306, 3937796	NA
2016_687_ISEGS	White-Crowned Sparrow	WCSP	Carcass Survey	11/22/2016	11/22/2016	Feather spot	3-6 days	Large feather spot consisting of 2 retricies, 4 secondaries, 2 primaries and 7 body feathers. No evidence of singe or collision.	Unknown		3	Heliostat	637227, 3937888	NA
2016_688_ISEGS	Unknown Small Bird	UNID	Carcass Survey	11/22/2016	11/22/2016	Feather spot	3-6 days	Small feather spot consisting of 6 retricies and 3 body reathers with no evidence of singe or collision.	Unknown		3	Heliostat	637675, 3937786	NA
2016_689_ISEGS	Western Meadowlark	WEME	Carcass Survey	11/22/2016	11/22/2016	Feather spot	3-6 days	Large feather spot consisting of 1 primary, 4 secondaries and 5 contour feathers. No evidence of singe or collision.	Unknown		3	Heliostat	637630, 3937791	NA
2016_690_ISEGS	Unknown Small Bird	UNID	Carcass Survey	11/22/2016	11/22/2016	Broken up	1 month +	Broken up carcass consisting of tail feathers and undercoverts with attached skin. Singe is present on the inner retricies.	Scorched or singed	Unk	3	Heliostat	637536, 3937679	NA

2016_691_ISEGs	Mourning Dove	MODO	Incidental	11/26/2016	11/26/2016	Broken up	2 weeks	Broken up carcass consisting of partial right wing with coverts and primary flight feather connected by tissue. No evidence of singe or collision.	Unknown		1	Heliostat	640560, 3933603	NA
2016_692_ISEGS	Black-throated Gray Warbler	BTYW	Incidental	11/27/2016	11/28/2016	Mummified	1 month +	Whole carcass. Evidence of singe to head, back, rump, neck, and breast, with primaries, secondaries, and rects singed off.	Scorched or singed	2~3	3	Powerblock	637448, 3937933	NA
2016_693_ISEGS	Yellow Warbler	YWAR	Incidental	11/27/2016	11/28/2016	Mummified	1 month +	Whole carcass. Evidence of curling to primaries and secondaries, singe to face.	Scorched or singed	2~3	3	Powerblock	637445, 3937933	NA
2016_694_ISEGS	Northern Flicker	NOFL	Carcass Survey	11/28/2016	11/28/2016	Broken up	3-6 days	Broken up carcass consisting of 2 secondaries attached by dried skin, 1 contour feather. No evidence of collision or singe.	Unknown		2	Heliostat	638298, 3935456	NA
2016_695_ISEGS	Unknown Sparrow	UNSP	Carcass Survey	11/30/2016	11/30/2016	Feather spot	3-6 days	Feather spot size small consisting of 1 primary and 25 body feathers. Evidence of singing to both primary and body feathers.	Scorched or singed	Unk	2	Powerblock	638632, 3935871	NA
2016_696_ISEGS	Unknown Small Bird	UNID	Carcass Survey	12/5/2016	12/5/2016	Broken up	1 month +	Broken up carcass consisting of skull and partial neck vertebrae, partial wing, and 3 primaries. Evidence of singe to all flight feathers.	Scorched or singed	Unk	1	Powerblock	640378, 3933495	NA
2016_697_ISEGS	Mourning Dove	MODO	Carcass Survey	12/5/2016	12/5/2016	Feather spot	2 weeks	Feather spot size small consisting of 1 primary covert and 20 body feathers. No evidence of collision or singe.	Unknown		1	Powerblock	640367, 3933489	NA
2016_698_ISEGS	Bushtit	BUSH	Carcass Survey	12/5/2016	12/5/2016	Feather spot	3-6 days	Feather spot size small consisting of 2 primaries. No evidence of collision or singe.	Unknown		1	Powerblock	640367, 3933489	NA
2016_699_ISEGS	American Kestrel	AMKE	Incidental	12/6/2016	12/6/2016	alive, injured	8-24 hours	Alive bird. Evidence of curling to primaries, secondaries, and retrices, singeing to coverts and left eye.	Scorched or singed	2~3	2	Powerblock	638698, 3935882	NA
2016_700_ISEGS	Brewer's Blackbird	BRBL	Carcass Survey	12/6/2016	12/6/2016	Broken up	3-6 days	Feather spot size = small. Partial right wing held together by flesh. No singe, no evidence collision.	Unknown		1	Heliostat	640178, 3933627	NA
2016_701_ISEGS	Unknown Small Bird	UNID	Carcass Survey	12/12/2016	12/12/2016	Feather spot	3-6 days	Feather spot size = small. 17 body feathers, 5 rectrices, 2 primaries. Singe on flight feathers visible with microscope.	Scorched or singed	Unk	3	Powerblock	637486, 3937917	NA

2016_702_ISEGS	Yellow-rumped Warbler	YRWA	Incidental	12/13/2016	12/14/2016	Mummified	2 weeks	Mummified Whole Carvass. Flight feathers singed off. Extensive singe to head, upper and lower back.	Scorched or singed	2~3	3	Project Structure	637470, 3937919	NA
2016_703_ISEGS	Verdin	VERD	Carcass Survey	12/20/2016	12/20/2016	Mummified	1 month +	Whole carcass. Evidence of singe on right wing coverts.	Scorched or singed	1	2	Powerblock	638637, 3935845	NA
2016_704_ISEGS	Tree Swallow	TRES	Carcass Survey	12/20/2016	12/20/2016	Broken up	1 month +	Broken up carcass consisting of partial left wing. Evidence of curling to primaries and singeing to primaries and coverts.	Scorched or singed	Unk	2	Powerblock	638654, 3935851	NA
2016_705_ISEGS	Tree Swallow	TRES	Carcass Survey	12/20/2016	12/20/2016	Broken up	1 month +	Broken up carcass consisting of partial left wing. Evidence of singeing to coverts with primaries and secondaries singed off.	Scorched or singed	Unk	2	Powerblock	638646, 3935837	NA
2016_706_ISEGS	Unknown Sparrow	UNSP	Carcass Survey	12/20/2016	12/20/2016	Broken up	3-6 days	Broken up carcass consisting of partial left wing, 100 body feathers, 8 primaries, 1 secondary, and 3 tertials. No evidence of collision or singe.	Unknown		2	Powerblock	638599, 3935813	NA
2016_707_ISEGS	Green-winged Teal	GWTE	Carcass Survey	12/20/2016	12/20/2016	Feather spot	3-6 days	Feather spot size large consisting of 2 secondaries and 50 body feathers. No evidence of collision or singe.	Unknown		2	Heliostat	639576, 3936853	NA
2016_708_ISEGS	Unknown Small Bird	UNID	Carcass Survey	12/21/2016	12/21/2016	Broken up	3-6 days	Broken up carcass consisting of 3 retrices held together by dried flesh, 1 loose primary. No evidence of collision or singe.	Unknown		2	Heliostat	638488, 3935761	NA
2016_709_ISEGS	Unknown Small Bird	UNID	Carcass Survey	12/21/2016	12/21/2016	Feather spot	2 weeks	Feather spot size large consisting of 100 body feathers, 4 primaries, 6 secondaries, and 5 tail feathers. No evidence of collision or singe.	Unknown		2	Heliostat	638447, 3935797	NA
2016_710_ISEGS	Western Meadowlark	WEME	Carcass Survey	12/21/2016	12/21/2016	Feather spot	3-6 days	Feather spot consisting of 6 rectrices, 3 primaries, 5 secondaries, 2 clumps of breast feathers, and 8 contour feathers. No evidence of collision or singe.	Unknown		2	Heliostat	638735, 3936023	NA
2016_711_ISEGS	Unknown Warbler	UNWA	Carcass Survey	12/21/2016	12/21/2016	Broken up	3-6 days	Broken up carcass consisting of partial leg, primaries and several clumps of body feathers held together by dried flesh. Evidence of curling to primaries and singeing to body feathers.	Scorched or singed	2~3	2	Heliostat	638718, 3935729	NA

2016_712_ISEGS	American Pipit	AMPI	Carcass Survey	12/27/2016	12/27/2016	Feather spot	2 weeks	Large Feather spot consisting of 20 body feathers, 8 secondaries, 8 primaries and 6 retricies.	Unknown		1	Heliostat	640310, 3933696	NA
2016_713_ISEGS	Yellow-rumped Warbler	YRWA	Incidental	12/29/2016	12/29/2016	Mummified	1 month +	Mummified carcass missing left wing. All flight feathers singed. 90% body feathers singed.	Scorched or singed	2	3	Powerblock	637483, 3937940	NA
2017_001_ISEGS	Unknown Small Bird	UNID	Carcass Survey	1/10/2017	1/10/2017	Feather spot	8-24 hours	Large feather spot consisting of 100 contour feathers with no evidence of collision or flux.	Unknown		2	Heliostat	638580, 3935731	NA
2017_002_ISEGS	American Pipit	AMPI	Carcass Survey	1/10/2017	1/11/2017	Feather spot	2 days	Small feather spot consisting of 6 primaries, 15 secondaries, 13 retricies and 7 contour feathers. No evidence of collision or flux.	Unknown		2	Heliostat	638525, 3936025	NA
2017_003_ISEGS	American Robin	AMRO	Carcass Survey	1/12/2017	1/12/2017	Broken up	8-24 hours	Broken up carcass consisting of 8 retricies, 5 undertail coverts connected by tissue. No evidence of of collision or singe.	Unknown		2	Powerblock	638601, 3935928	NA
2017_004_ISEGS	White-Crowned Sparrow	WCSP	Carcass Survey	1/17/2017	1/17/2017	Broken up	8-24 hours	Broken up carcass consisting of all pieces of the body excluding the head. No evidence of singe or collision	Unknown		1	Powerblock	640417, 3933542	NA
2017_005_ISEGS	Eared Grebe	EAGR	Carcass Survey	1/20/2017	1/20/2017	Mummified	1 month +	Mummified bird consisting of almost the whole carcass except the head. No evidence of singe or collision.	Unknown		1	Project Structure	640372, 3933488	NA
2017_006_ISEGS	Loggerhead Shrike	LOSH	Carcass Survey	1/31/2017	1/31/2017	Broken up	3-6 days	Broken up carcass consisting of partial head, 2 primaries, 4 secondaries, and 50 body feathers. Evidence of collision by broken bill tip.	Collision (other)		2	Powerblock	638657, 3935850	NA
2017_007_ISEGS	House Finch	HOFI	Incidental	2/9/2017	2/9/2017	Dead, fresh (eyes moist)	0-8 hours	Whole carcass. Evidence of curling to primaries and secondaries on right wing, singeing to top of head and right side of face.	Scorched or singed	3	2	Powerblock	638625, 3935925	NA
2017_008_ISEGS	Unknown Sparrow	UNSP	Carcass Survey	2/23/2017	2/23/2017	Feather spot	3-6 days	Feather spot consisting of 1 secondary, 1 covert, 8 contour feathers. No evidence of collision or singe.	Unknown		2	Powerblock	638587, 3935834	NA
2017_009_ISEGS	White-Crowned Sparrow	WCSP	Carcass Survey	3/2/2017	3/2/2017	Broken up	3-6 days	Broken up carcass consisting of partial left wing attached by dried flesh, 3 retrices, 1 secondary, 2 tertials, 20 body feathers. No evidence of collision or singe.	Unknown		1	Heliostat	640246, 3933375	NA

2017_010_ISEGS	Rock Pigeon	ROPI	Incidental	3/4/2017	3/4/2017	Dead, fresh (eyes moist)	0-8 hours	Broken up carcass consisting of lower body with legs and wings. Evidence of curling to primaries and secondaries, singeing to body feathers.	Scorched or singed	3	2	Powerblock	638590, 3935873	NA
2017_011_ISEGS	Unknown Small Bird	UNID	Carcass Survey	3/7/2017	3/7/2017	Feather spot	3-6 days	Feather spot size large consisting of 2 primaries and 6 body feathers. Evidence of curling to primaries, singeing to body feathers.	Scorched or singed	3	3	Powerblock	637459, 3937902	NA
2017_012_ISEGS	House Finch	HOFI	Carcass Survey	3/7/2017	3/7/2017	Dead, fresh (eyes moist)	8-24 hours	Whole carcass. No evidence of collision or singe.	Unknown		2	Heliostat	639300, 3935505	NA
2017_013_ISEGS	Loggerhead Shrike	LOSH	Carcass Survey	3/16/2017	3/16/2017	Broken up	2 weeks	Broken up carcass consisting of whole body except right wing and tail. No evidence of collision or singe,	Unknown		2	Heliostat	638533, 3936963	NA

Appendix B. Additional Detection Data for Fatality Estimates and Documentation of Fatality Estimates in Which Each Detection Was Included.

USFWS #	Species Code	Location	Distance from Tower (m)	Bird Size	Model Size	Cause of Death	How Found	Time Since Last Survey (days)	Used in Estimator	Tower Area	Power Block	Inner HD	Heliostat Area	Estimator Notes
2016_662_ISEGS	UNSP	Outer Segment	690	Small	Feather Spot	unknown	Fatality Search	5	Yes				X	
2016_663_ISEGS	BARS	Power Block	59	Small	Small Carcass	singed	Fatality Search	7	No	X	X			Older than Search Interval
2016_664_ISEGS	AMPI	Inner HD	234	Small	Feather Spot	unknown	Fatality Search	6	Yes	X		X		
2016_665_ISEGS	BHCO	Inner HD	218	Small	Feather Spot	unknown	Fatality Search	6	Yes	X		X		
2016_666_ISEGS	SAGS	Inner HD	236	Small	Feather Spot	singed	Fatality Search	6	Yes	X		X		
2016_667_ISEGS	WCSP	Inner HD	241	Small	Feather Spot	unknown	Fatality Search	6	Yes	X		X		
2016_668_ISEGS	UNID	Inner HD	244	Small	Feather Spot	unknown	Fatality Search	6	Yes	X		X		
2016_669_ISEGS	AMPI	Inner HD	216	Small	Feather Spot	unknown	Fatality Search	6	Yes	X		X		
2016_670_ISEGS	YRWA	Power Block	49	Small	Small Carcass	singed	Incidental	1(1)	Yes	X	X			
2016_671_ISEGS	WEME	Inner Segment	580	Small	Feather Spot	unknown	Incidental	NA	No				X	Older than Search Interval
2016_672_ISEGS	WCSP	Power Block	54	Small	Feather Spot	unknown	Fatality Search	21	Yes	X	X			
2016_673_ISEGS	YRWA	ACC	65	Small	Small Carcass	singed	Fatality Search	21	Yes	X	X			
2016_674_ISEGS	UNID	Power Block	8	Small	Small Carcass	singed	Fatality Search	21	Yes	X	X			
2016_675_ISEGS	UNID	Outer Segment	826	Small	Feather Spot	unknown	Fatality Search	22	Yes				X	
2016_676_ISEGS	AMPI	Inner HD	103	Small	Feather Spot	unknown	Fatality Search	22	Yes	X		X		
2016_677_ISEGS	AMRO	Inner HD	136	Small	Feather Spot	unknown	Fatality Search	22	Yes	X		X		
2016_678_ISEGS	UNID	Inner Segment	630	Small	Feather Spot	unknown	Fatality Search	21	Yes				X	
2016_679_ISEGS	YRWA	Power Block	7	Small	Small Carcass	singed	Incidental	1(1)	Yes	X	X			
2016_680_ISEGS	WEME	Inner HD	191	Small	Feather Spot	unknown	Fatality Search	26	Yes	X		X		
2016_681_ISEGS	YRWA	Inner HD	123	Small	Feather Spot	unknown	Fatality Search	26	Yes	X		X		
2016_682_ISEGS	UNLB	Power Block	24	Large	Feather Spot	singed	Fatality Search	27	Yes	X	X			

2016_683_ISEGS	YRWA	Power Block	151	Small	Feather Spot	unknown	Fatality Search	27	Yes	X	X			
2016_684_ISEGS	UNID	Inner HD	194	Small	Feather Spot	unknown	Fatality Search	26	Yes	X		X		
2016_685_ISEGS	YWAR	Power Block	107	Small	Feather Spot	singed	Fatality Search	17	No	X	X			Older than Search Interval
2016_686_ISEGS	UNID	Inner HD	212	Small	Feather Spot	unknown	Fatality Search	20	Yes	X		X		
2016_687_ISEGS	WCSP	Inner HD	261	Small	Feather Spot	unknown	Fatality Search	20	Yes	X		X		
2016_688_ISEGS	UNID	Inner HD	228	Small	Feather Spot	unknown	Fatality Search	20	Yes	X		X		
2016_689_ISEGS	WEME	Inner HD	185	Small	Feather Spot	unknown	Fatality Search	20	Yes	X		X		
2016_690_ISEGS	UNID	Inner HD	238	Small	Feather Spot	singed	Fatality Search	20	No	X		X		Older than Search Interval
2016_691_ISEGs	MODO	Inner HD	218	Large	Feather Spot	unknown	Incidental	12	No	X		X		Older than Search Interval
2016_692_ISEGS	BTYW	Power Block	40	Small	Small Carcass	singed	Incidental	1(1)	No	X	X			Older than Search Interval
2016_693_ISEGS	YWAR	Power Block	40	Small	Small Carcass	singed	Incidental	1(1)	No	X	X			Older than Search Interval
2016_694_ISEGS	NOFL	Inner Segment	534	Large	Feather Spot	unknown	Fatality Search	25	Yes				X	
2016_695_ISEGS	UNSP	Power Block	38	Small	Feather Spot	singed	Fatality Search	22	Yes	X	X			
2016_696_ISEGS	UNID	Power Block	2	Small	Small Carcass	singed	Fatality Search	21	No	X	X			Older than Search Interval
2016_697_ISEGS	MODO	Power Block	6	Large	Feather Spot	unknown	Fatality Search	21	Yes	X	X			
2016_698_ISEGS	BUSH	Power Block	6	Small	Feather Spot	unknown	Fatality Search	21	Yes	X	X			
2016_699_ISEGS	AMKE	Power Block	53	Large	Large Carcass	singed	Fatality Search	6	Yes	X	X			
2016_700_ISEGS	BRBL	Inner HD	239	Small	Feather Spot	unknown	Fatality Search	22	Yes	X		X		
2016_701_ISEGS	UNID	Power Block	4	Small	Feather Spot	singed	Fatality Search	24	Yes	X	X			
2016_702_ISEGS	YRWA	Outside Search - TOWER	0	Small	Small Carcass	singed	Incidental	NA	No					Outside Standard Search Area
2016_703_ISEGS	VERD	Power Block	22	Small	Small Carcass	singed	Fatality Search	20	No	X	X			Older than Search Interval
2016_704_ISEGS	TRES	Power Block	8	Small	Small Carcass	singed	Fatality Search	20	No	X	X			Older than Search Interval
2016_705_ISEGS	TRES	Power Block	16	Small	Small Carcass	singed	Fatality Search	20	No	X	X			Older than Search Interval
2016_706_ISEGS	UNSP	Power Block	69	Small	Feather Spot	unknown	Fatality Search	20	Yes	X	X			
2016_707_ISEGS	GWTE	Outer Segment	1130	Large	Feather	unknown	Fatality	19	Yes				X	

					Spot		Search						
2016_708_ISEGS	UNID	Inner HD	192	Small	Feather Spot	unknown	Fatality Search	22	Yes	X		X	
2016_709_ISEGS	UNID	Inner HD	220	Small	Feather Spot	unknown	Fatality Search	22	Yes	X		X	
2016_710_ISEGS	WEME	Inner HD	192	Small	Feather Spot	unknown	Fatality Search	22	Yes	X		X	
2016_711_ISEGS	UNWA	Inner HD	131	Small	Small Carcass	singed	Fatality Search	22	Yes	X		X	
2016_712_ISEGS	AMPI	Inner HD	347	Small	Feather Spot	unknown	Fatality Search	21	Yes	X		X	
2016_713_ISEGS	YRWA	Power Block	7	Small	Small Carcass	singed	Incidental	1(1)	No	X	X		Older than Search Interval
2017_001_ISEGS	UNID	Inner HD	111	Small	Feather Spot	unknown	Fatality Search	20	Yes	X		X	
2017_002_ISEGS	AMPI	Inner HD	224	Small	Feather Spot	unknown	Fatality Search	20	Yes	X		X	
2017_003_ISEGS	AMRO	Power Block	86	Small	Small Carcass	unknown	Fatality Search	23	Yes	X	X		
2017_004_ISEGS	WCSP	Power Block	70	Small	Small Carcass	unknown	Fatality Search	20	Yes	X	X		
2017_005_ISEGS	EAGR	Power Block	0	Large	Large Carcass	unknown	Incidental	1(1)	No	X	X		Older than Search Interval
2017_006_ISEGS	LOSH	Power Block	10	Small	Feather Spot	collision	Fatality Search	19	Yes	X	X		
2017_007_ISEGS	HOFI	Power Block	88	Small	Small Carcass	singed	Incidental	1(1)	Yes	X	X		
2017_008_ISEGS	UNSP	Power Block	64	Small	Feather Spot	unknown	Fatality Search	23	Yes	X	X		
2017_009_ISEGS	WCSP	Inner HD	168	Small	Feather Spot	unknown	Fatality Search	22	Yes	X		X	
2017_010_ISEGS	ROPI	Power Block	75	Large	Large Carcass	singed	Incidental	1(1)	Yes	X	X		
2017_011_ISEGS	UNID	Power Block	31	Small	Feather Spot	singed	Fatality Search	19	Yes	X	X		
2017_012_ISEGS	HOFI	Outer Segment	723	Small	Small Carcass	unknown	Fatality Search	19	Yes				X
2017_013_ISEGS	LOSH	Outer Segment	1112	Small	Small Carcass	unknown	Fatality Search	15	Yes				X