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Mojave Solar Project
California Energy Commission (09-AFC-5C)
Condition of Certification BIO-17

BIO-17 Bird Monitoring Study
Fall 2017 Quarterly Interim Report
Final Draft

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Corvus Ecological Consulting, LLC. 2018. BIO-17 Bird Monitoring Study at the Mojave Solar Project, San Bernardino County, California. 2017 Fall Quarterly Report. 33 pp.

## Executive Summary

Avian and bat fatality and injury monitoring began on the Mojave Solar Project in September of 2017. This report presents results from the first quarter of fatality monitoring surveys which were conducted 5 September 2017 through 30 November 2017 according to protocols established by the BIO-17 Bird Monitoring Study Plan (CH2MHill Engineers 2017). In addition to systematic carcass searches within five (5) strata of the project, carcass persistence and searcher efficiency trials were conducted throughout the fall season.

The five strata defined in the monitoring plan includes: Solar Collector Fields (SCFs), Evaporation Ponds, Perimeter Fence, Power Blocks, and Power Generation Tie-in (Gen-tie). These strata were surveyed every 7 days from 11 September through 2 November and every 21 days after that through the end of November.

Coturnix quail of two sizes and domestic chickens were used for carcass persistence and searcher efficiency trials. A total of sixty (60) specimens were placed for carcass persistence trials during the fall 2017 quarter. Forty (40) of these were placed concurrently with systematic searches and were designed to also serve as trial specimens to test searcher efficiency.

All bird and bat fatalities, both those located during systematic searches and those located incidentally, are reported for BIO-17. In fall 2017, there were fifty-three (53) incidents of fatalities or injuries, forty-five (45) of which were detected within the search area for BIO-17 and within the Perimeter Fence of the Mojave Solar Project. Thirty-four percent (34%) of all fatalities and injuries were associated with the Power Blocks; where Brown-headed Cowbirds (*Molothrus ater)* comprised the species majority. Eared Grebes (*Podiceps nigricollis*) were the most common species detected for BIO-17 reporting purposes. Four (4) of the detections included injured or stranded birds rather than deceased.

We analyzed carcass persistence data using the *carcass* package in R (R Core Team 2018, Korner-Nievergelt et al. 2015). Models that compared carcass persistence across project components and carcass size found no significant difference across the five strata, therefore all data were pooled and inference was drawn for the entire project and all carcass sizes. The mean number of days that a carcass persisted at the Mojave Solar Project in fall 2017 was 3.1 days with the median value being 2.19 days. The probability of a carcass persisting from one day to the next was 87.7% (95% CI: 84.2%-90.6%).

As with carcass persistence, models available in the *carcass* package in R could not detect a significant difference in searcher efficiency across project components and carcass sizes, therefore all data was pooled and no fixed effects were included in the model. According to these models, the probability that the searcher would find a carcass that was available to be detected was 47.6% (95% CI: 28.4% - 67.8%) in Fall of 2017.

Because carcass persistence and searcher efficiency were pooled across all project components and carcass sizes, the estimate of detection probability and the final estimate of fatalities were also pooled. Incorporating the 45 fatalities found within the search area into the Huso Estimator (Huso 2010) and adding fatalities from the cooling tower portion of the Power Block, the total number of estimated bird fatalities during the fall of 2017 was 247 (95% CI: 150 – 422).

These results are preliminary, based on the first three months of survey data. Fatality estimates will become more refined as sample sizes increase over time and once we are able to determine a detection function for individual project components.

Study Participants

***Corvus* Ecological Consulting, LLC**

| | |
|---|---|
| Brooks Hart | Project Manager |
| Marguerite Hendrie | Data Manager |
| Peter Motyka | Statistician |
| Frank Treadway | Field Biologist |
| Brian Sandstrom | Field Biologist |

**Mojave Solar LLC**

| | |
|---|---|
| Gerald Monks | Designated Biologist/Field Lead |
| Jose Manuel Bravo Romero | Permitting & Compliance Manager |

# 1.0 Introduction

## 1.1 Background and Project Overview

Mojave Solar Project (hereafter referred to in this document as the “Project”) is a solar-thermal electric generating facility located in San Bernardino County, California, approximately 20 miles west of Barstow, California (Figure 1). The project sits on private property that was once occupied by crop production, cattle ranching, and dairy farming. The intent of choosing disturbed habitat for the project site was, in part, to limit impacts to natural vegetation that could provide habitat for wildlife, including avian species. The technology for solar collection in use on the Project is mirrored solar parabolic troughs used to convert water to steam. The steam is converted to electricity using a steam turbine generator. The gross electrical output is 280 MW.

The basic project layout consists of two independently operable units each with its own power block: Alpha (915 acres) and Beta (782 acres). In addition, each independent unit is further divided into subunits: East and West. The area devoted to Solar Collector Fields (SCFs) is roughly 75% of the total project area. The remaining 25% consists of 2 power blocks, drainage improvements, evaporation ponds, a substation, and other elements. The Alpha Unit is divided into Alpha West and Alpha East by Harper Lake Road, and Lockhart Ranch Road runs between Alpha and Beta fields. A combined tortoise-exclusion and security fence surrounds each of the two Alpha subunits separately while the Beta units are encompassed by a single fence. Output from each power block runs in an overhead transmission line to a substation located within the Beta sub-area (Figure 2).

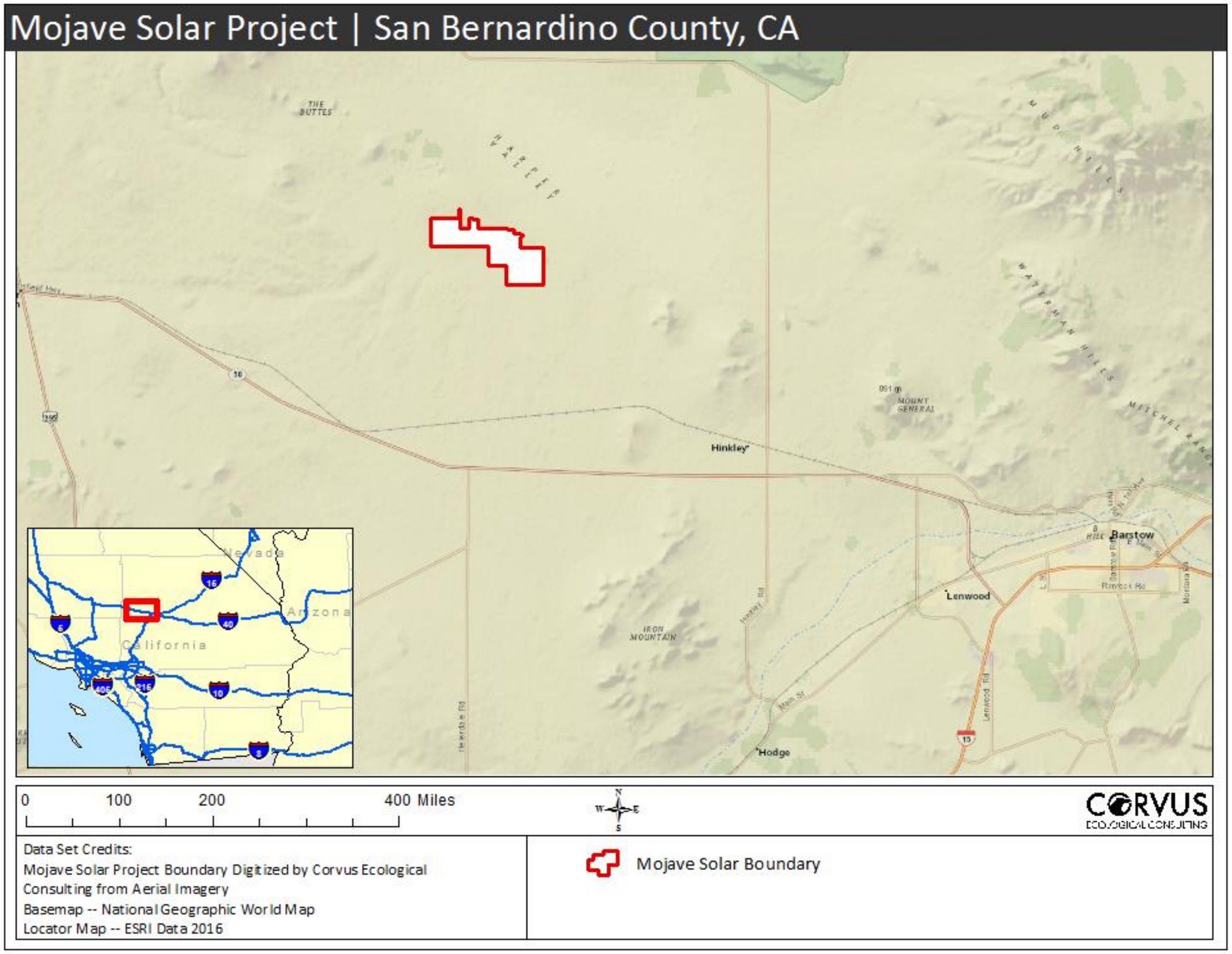


*Figure 1. Project vicinity and overview.*

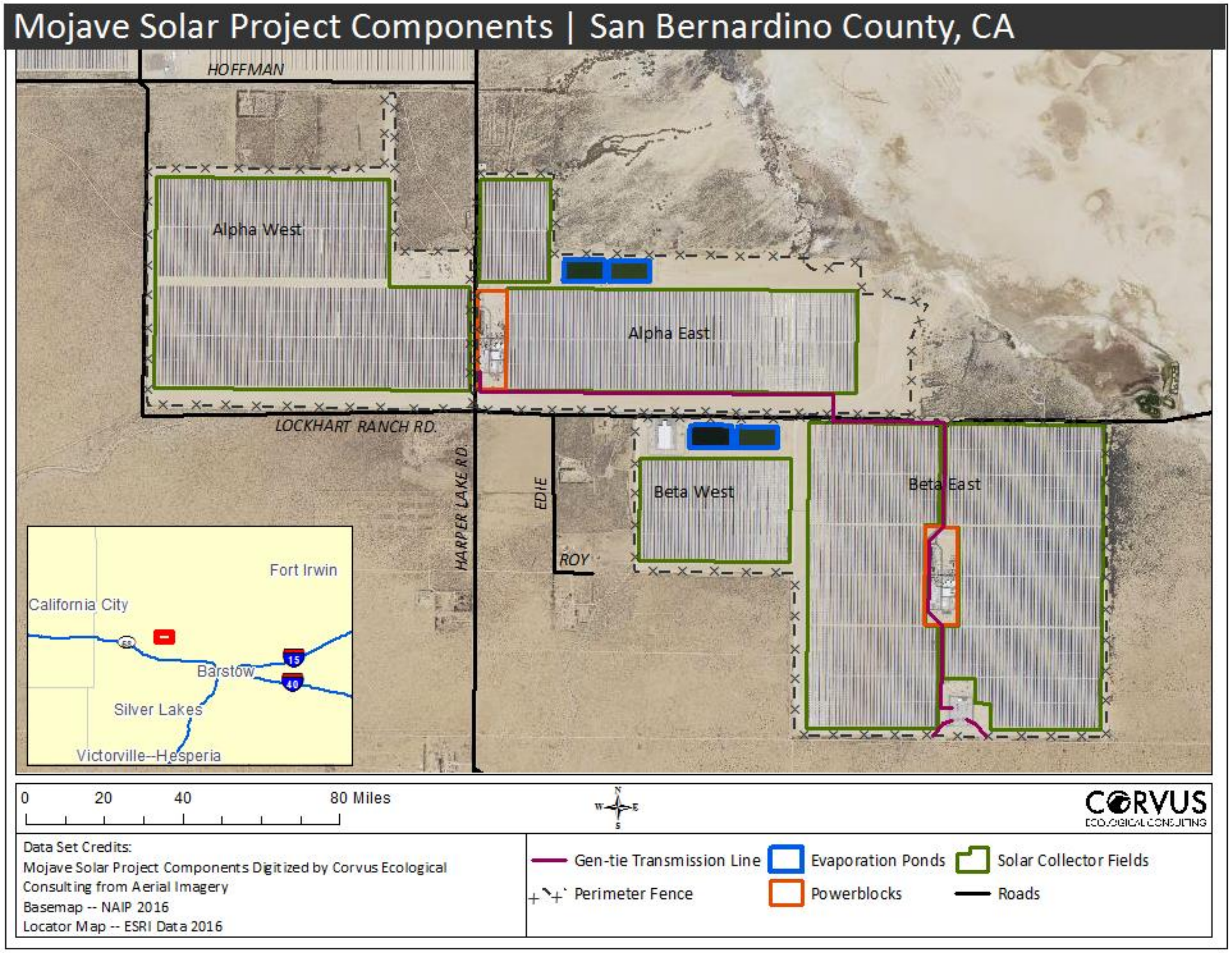


*Figure 2. Mojave Solar project components.*

## 1.2 Monitoring Plan Overview and Goals

In 2017, the BIO-17 Bird Monitoring Study Plan [CH2MHill Engineers 2017, (hereafter referred to as “the Plan”)] was submitted for approval to the California Energy Commission (CEC) pursuant to the CEC’s Condition of Certification (COC) BIO-17. The purpose of the monitoring plan was to outline the activities that would be undertaken to monitor the death and injury of birds from collisions with project features such as overhead power lines, fences, and reflective surfaces.

> **COC BIO-17:** The project owner shall prepare and implement a Bird Monitoring Study to monitor the death and injury of birds from collisions with facility features such as reflective mirror-like surfaces and from heat, and bright light from concentrating sunlight. The study design shall be approved by the CPM in consultation with CDFG [CDFW] and USFWS, and shall be incorporated into the project’s BRMIMP and implemented. The Bird Monitoring Study shall include detailed specifications on data and carcass collection protocol and a rationale justifying the proposed schedule of carcass searches. The study shall also include seasonal trials to assess bias from carcass removal by scavengers as well as searcher bias.

## 1.3 Purpose of this Report

This report details the activities performed during the first quarter of monitoring. This report summarizes the methods employed and provides preliminary results for avian and bat fatalities and injuries. The actions described in this report took place during the 13-week period from 5 September 2017 through 30 November 2017. The data presented in this quarterly report and in future quarterly reports is preliminary. A full comprehensive report will be prepared after the completion of one full year of the program. Where possible, preliminary statistical analyses have been provided, but small sample sizes inhibited the ability to perform a thorough or complete analyses at this early stage.

# 2.0 Methods

Detailed methods for all components of the study are provided in the Plan, which is provided in Appendix A. Below is a summary of key activities performed during the fall Quarter 2017.

## 2.1 Clearance Surveys

Prior to the start of systematic carcass searches, a facility-wide clearance survey was conducted to remove all bird carcasses and sign present so that the first survey would have a defined interval. All remains collected were handled in accordance with the USFWS’s Project-specific Special Purpose Utility Permit (SPUT) and Scientific Collecting Permit (SCP).

## 2.2 Systematic Carcass Searches

### 2.2.1 Areas Surveyed

The Plan outlined the project components to be surveyed as well as the percentage of each. Five strata were identified: Solar Collector Fields (SCFs), Evaporation Ponds, Perimeter Fence, Power Blocks, and Power Generation Tie-in (Gen-tie).

The SCFs were divided into small blocks and sampling units were created consisting of twelve (12) contiguous collector rows within a block (Figure 3 and 4). Sampling units were randomly selected such that approximately 43% of the total collector rows are sampled in an area. Sampling blocks assume a clear observation distance of 51 m is available when the troughs are in a horizontal position and the ground is devoid of vegetation.

There are two evaporation ponds each in Alpha East and Beta West subunits. Each pond was surveyed 100% using a transect at the perimeter of pond. We assume a minimum observation distance of 110 meters over the ponds on these transects.

The entirety of the perimeter fence (100%) was surveyed during each survey period. Perimeter fence surveys were for the interior of the fence only. A minimum observation distance of 50 meters in either direction from the surveyor was assumed although in most locations, the actual observation distance was much higher. Any carcasses located outside the fence were noted if present, but not counted as a survey specimen.

Each of the power blocks has a road or series of roads that travel the length and/or perimeter of the area. Each survey period, these roads were traveled to search for carcasses. The observation distance is variable within the power block due to buildings and equipment.

The Gen-tie is wholly contained within the greater project boundary. Surveyors traveled under the Gen-tie where it did not overlap with other sampling strata. Much like in the other non-SCF strata, a minimum observation distance of 50 meters to either side of the observer is expected in areas devoid of vegetation.

The total area of each strata, as well as the percent of each component that was searched, is include in Table 1.

### 2.2.2 Search Frequency and Timing

The fall season began on September 1 and ran through November 20, 2017. This period corresponds with fall migration in this region. Due to logistics, the carcass clearance surveys began on September 5 and systematic searches began the following week on September 11, 2017. Carcass searches were performed during daylight hours between 07:00 and 18:00.

During the peak of migration, from September through the end of October, the desired search interval was every 7 days. In November, during the tail-end of migration, the search interval switched to every 21 days. There were weather and logistical reasons that prevented a uniform search interval (discussed in the results below).

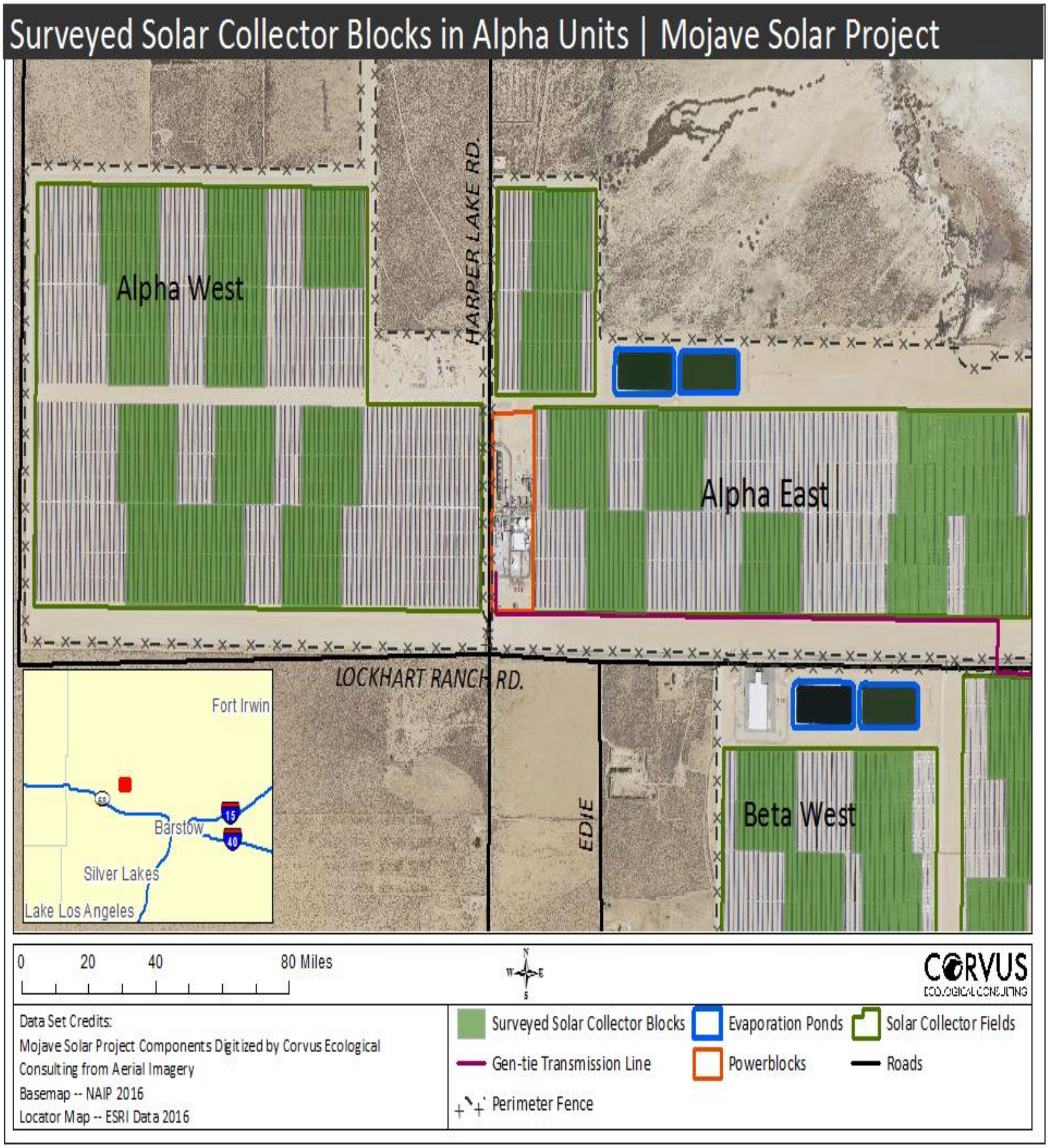


*Figure 3. Solar collector blocks in Alpha units surveyed using systematic searches.*

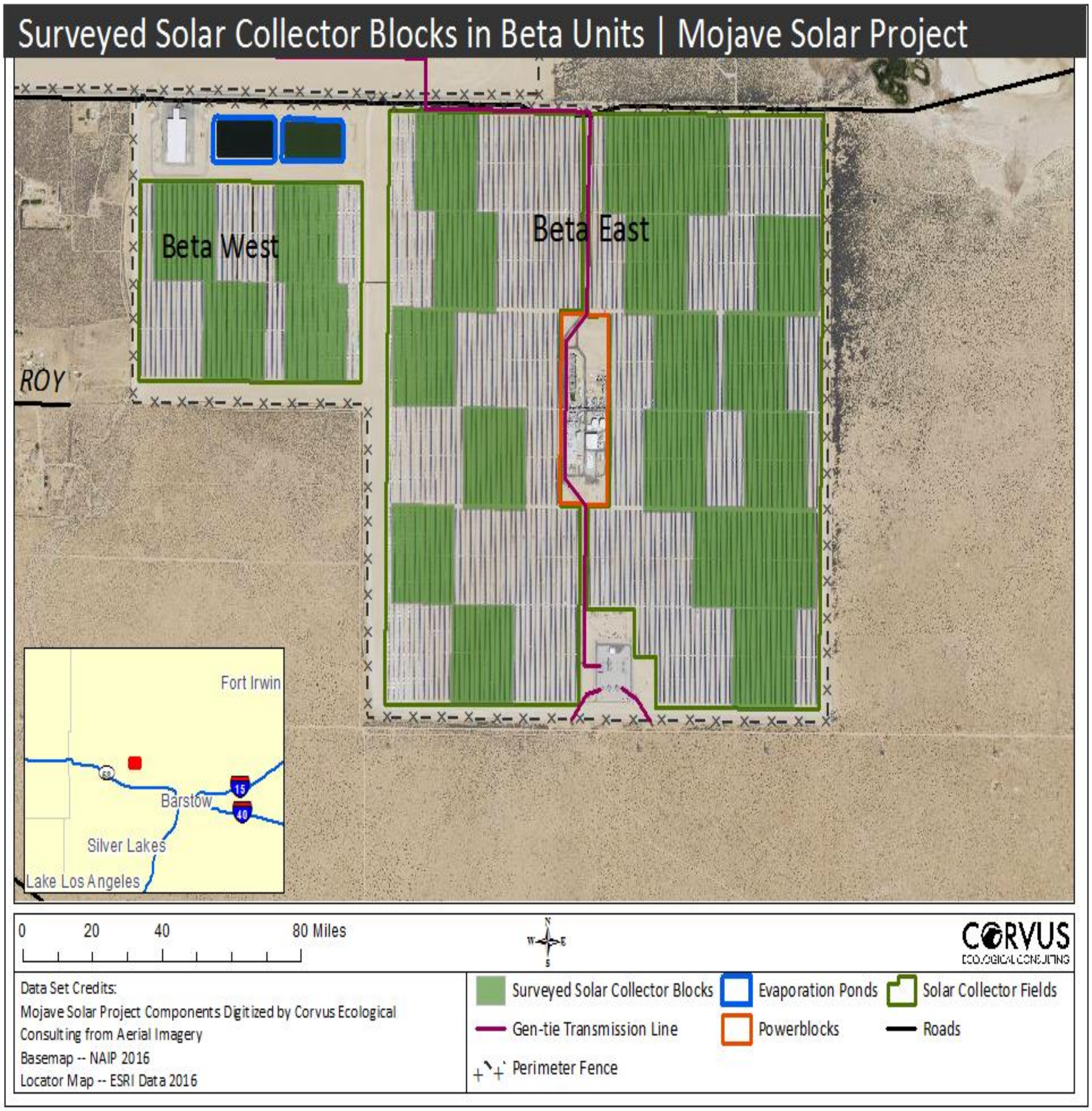


*Figure 4. Solar collector blocks in Beta units surveyed using systematic searches.*

*Table 1. Areas included in systematic carcass searches at Mojave Solar Project during fall 2017.*

| PROJECT COMPONENT | TOTAL SIZE | UNITS | PERCENT OF COMPONENT SEARCHED |
|---|---|---|---|
| **SCF** | 1160.00 | Rows of solar troughs | 43 |
| **ALPHA WEST** | 320.00 | Rows of solar troughs | 41 |
| **ALPHA EAST** | 244.00 | Rows of solar troughs | 49 |
| **BETA WEST** | 88.00 | Rows of solar troughs | 55 |
| **BETA EAST** | 508.00 | Rows of solar troughs | 40 |
| **POWER BLOCK** | 15.50 | Hectares | Difficult to Measure[1] |
| **EVAPORATION PONDS** | 9.50 | Hectares | 100 |
| **GENERATION TIE LINE** | 4.20 | Kilometers | 100 |
| **PERIMETER FENCE** | 21.40 | Kilometers | 100 (Interior only) |

[1]Due to the nature of the power block areas with buildings and machinery and the driving transect outlined in the Plan, it is difficult to fully assess how much of the Power Block is covered using this method

### 2.2.3 Search Methodology

Standardized systematic carcass searches were performed by Corvus Ecological Consulting (Corvus) biologists which were CEC-approved according to project protocols described in the Plan.

For the SCF strata, the timing of transects did not begin until the troughs were near parallel to ensure adequate viewing distance. Biologists drove at speeds less than 5 mph down the access roads parallel to the troughs searching ahead and to the driver's side of the vehicle for signs of bird or bat mortalities. Once the vehicle reached the steam pipe at the end of the transect, the biologist would carefully turn around and drive back up the row searching on the opposite side and ahead. Each sampling block had two rows of driving in this manner. There were 11 sampling blocks in Alpha West, 10 in Alpha East, 4 in Beta West, and 17 in Beta West.

For the evaporation ponds, the biologists would drive or walk a transect (≤ 5 mph) that encircled each pond focusing the search forward and toward the pond. Biologists would stop periodically to scan the surface of the pond with binoculars.

The perimeter fences were surveyed from a vehicle (≤ 5 mph) where possible. Where driving along the fence became difficult or unsafe, the biologist would walk the sections.

The power block is inherently difficult to survey due to restrictions on access and the presence of equipment and machinery blocking views. Corvus biologists followed the path outlined in the Plan and drove slowly or walked through the roads bisecting the Power Block carefully searching ahead and to either side. Casualties within the power block were more likely to be reported to the designated biologists by site personnel. Such casualties were recorded as incidental detections.

The Gen-tie was surveyed using a driving transect when possible. Biologists would scan to either side of the vehicle to search for signs of injuries or mortalities.

Once a carcass was detected, the biologist would walk out to the location and record coordinates using a Global Positioning System (GPS). A range finder was used to measure the perpendicular distance from the carcass to the current transect. At times this would require the biologist to move the vehicle forward or backward, and, using the waypoint in the GPS unit, find the perpendicular location. Photographs and a comprehensive set of data were collected and recorded on provided data sheets. Example datasheets for this project are included in Appendix B.

## 2.3 Carcass Persistence Trials

A total of 6 carcass persistence trials were conducted during the fall 2017 quarter. Trial specimens were of 3 size classes: small (0-100 g), medium (101-999 g) and large (1000+ g). Small trial specimens included juvenile coturnix quail (*Coturnix coturnix*), medium trial specimens were adult coturnix quail, and large trial specimens were domestic chickens (*Gallus gallus domesticus*).

### 2.3.1 Carcass Persistence Data Collection

Ten carcasses were placed for carcass persistence twice per month and remained in place for 30 days or until removed by a scavenger. Ground-based observations were made every day for the first five days post placement and then every third or fourth day afterwards. Remote game cameras were also used to monitor scavenging activity. Carcass placement was randomly determined using the sampling strata and ArcGIS randomization routines. Samples were allocated based on the percentage of total area in each stratum and the rule that each stratum must have at least 2 carcasses. During each ground-based monitoring visit, field staff recorded the condition of the carcass: present and wholly intact, evidence of scavenging, feather spot, or removed. A feather spot was defined as groups of feathers composed of at least two or more primary flight feathers, five or more tail feathers, two primaries within five meters or less of each other, or 10 or more feathers of any type within three (3) square meters. Field staff also checked remote cameras and batteries to ensure proper focus and sufficient battery power.

### 2.3.2 Estimating Carcass Persistence Times, *s*.

Survival models are ideal for analyzing time-to-event data such as carcass persistence times because they can account for censored data. When the exact time of carcass removal is unknown, data can be censored to produce an unbiased estimate of persistence probability. For example, if a carcass is removed between the survey on day 5 and the survey on day 8 (interval censored), there is no way to know exactly which day the carcass was removed. Also, some carcasses can last longer than the 30-day survey period, so the removal time is unknown (right censored).

These models include a variety of parametric, semiparametric, and nonparametric methods of analyses, each with their own set of assumptions and limitations. Candidate models were considered for their flexibility, sample size requirements, reliability of outputs, and how well their assumptions could be justified biologically. Models were tested and fit using the package carcass, which was developed by the USGS and collaborators (Korner-Nievergelt 2015). These packages were run in the programming software R (R Core Team 2018).

Model output from the package *carcass* included an estimate of the probability that a carcass will persist to the next day, *s,* the error of this estimate in the form of a 95% confidence interval, and the mean persistence for the carcasses.

## 2.4 Searcher Efficiency Trials

For the fall monitoring period, searcher efficiency trials were conducted in conjunction with carcass persistence trials. The Field Lead was provided with randomized locations for carcass persistence specimens, and when the timing corresponded with a systematic search, was instructed to not place cameras until the searcher had a chance to survey the area where the trial specimen was located. The same size classes were used as for carcass persistence.

### 2.4.1 Searcher Efficiency Data Collection

Forty (40) carcasses were placed with the intention of having them be used for both searcher efficiency and carcass persistence. These locations were chosen randomly (see Carcass Persistence Data Collection) in all strata. Carcasses were placed in the morning of the first day of surveys prior to the searcher beginning systematic searches. Placement was done without the knowledge of the searcher.

### 2.4.2 Estimating Searcher Efficiency, *f*.

Generalized linear mixed models with binomial error and logit link function were used to estimate the probability that a carcass will be found by the searcher, given that it was not removed by a scavenger first (it must be available to be found) (Korner-Nievergelt 2015, Huso et al. 2012). These models allow for the testing of covariates as either fixed or random effects. The covariates tested here were project component and carcass size. Inclusion of these covariates was chosen using the AIC model selection criterion.

Error in the estimate of searcher efficiency was measured using Bayesian inference, where a 95% confidence interval is produced by the 2.5% and 97.5% quantiles of the posterior distribution of the bootstrapped data (Korner-Nievergelt et al. 2015).

This analysis was done with the *carcass* package in R (R Core Team 2018).

### 2.5 Fatality Estimator

There are many factors that must be considered when providing an estimate of fatalities at a facility. The raw number of carcasses found is insufficient at describing the complex set of circumstances that have to be in place in order for that carcass to be detected by an observer. Carcass size and condition, vegetation, scavenger activity can all impact the probability that a carcass is found. Several statistical methods have been developed to provide more accurate estimates of fatalities incorporating these factors. One such method was developed by Manuela Huso in 2010.

Using the Huso estimator, carcass persistence, *s*, and searcher efficiency, *f*, were combined to calculate the probability that an avian fatality will be detected by an observer. This produced the detection probability, *p*, which was then incorporated with the proportion of total project area that was searched to produce the final estimate of the number of dead birds.

### 2.6 Incidental Reporting

Bird carcasses were located by solar farm staff not conducting systematic searches in support of BIO-17 and by designated fatality surveyors while traveling between strata or to and from transects. Incidental fatalities were detected by biologists working on other plans, such as BIO-19. BIO-19 calls for monitoring and adaptive management of the evaporation ponds on site. Work conducted specifically under BIO-19 is not included in this report except where data collection overlaps as in the case of collection of injured and deceased birds and bats.

Any detection made outside of BIO-17 systematic search transects were considered incidental. Data on incidental detections were reported monthly in the SPUT Avian Injury and Mortality Report Forms September – November 2017 and are included in this report. Incidental detections of fatalities were pooled with those found during searches because it was assumed that these would be found during the next scheduled search. Incidental detections made outside of the BIO-17 survey area were not included in fatality estimates.

## 3.0 Monitoring Results

### 3.1 Avian Fatality or Injury Detections

During fall 2017 survey efforts, fifty-three (53) detections of twenty-one (21) identified species were recorded; including injured birds, incidental detections, and fatalities detected during systematic surveys (Table 2). The species detected in greatest abundance was eared grebe (*Podiceps nigricolis*) with ten (10) followed by brown-headed cowbird (*Molothrus ater*) with eight (8). The stratum with the highest number of fatalities or injuries was the power block with eighteen [(18) 34% of total; Figures 4 and 5 and Tables 2, 3, and 4]. Eleven [(11) 21% of total] detections were made during systematic searches and forty-two [(42) 79% of total] were the result of incidental detections. Five (5) of the incidental detections were made during survey efforts for BIO-19.

Forty-nine (49) of the birds detected in this quarter were deceased with four (4) found injured. Eight (8) incidental detections were made outside of the survey area and not included in the fatality estimate.

*Table 2. Number of individual detections (systematic searches, incidental, and surveys for other project requirements), by species and component during fall (September 1 - November 30) 2017 at the Mojave Solar Project.*

| COMMON NAME | LATIN NAME | MIGRATORY BEHAVIOR*[1] | COUNT OF CARCASSES IN EACH STRATUM | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | SCF | POWER-BLOCK | EVAP. PONDS | PERIMETER FENCE | GEN-TIE LINE | OTHER[2] | TOTAL |
| **GREATER WHITE-FRONTED GOOSE** | *Anser albifrons* | nocturnal and diurnal | 1 | | | | | | **1** |
| **BLUE-WINGED TEAL** | *Spatula discors* | mostly nocturnal | | | | 1 | | | **1** |
| **NORTHERN PINTAIL** | *Anas acuta* | nocturnal | | | | 1 | | | **1** |
| **GREEN-WINGED TEAL** | *Anas crecca* | mostly nocturnal | | | 1 | | | | **1** |

[1] This information was obtained from the Birds of North America online edition. References provided in Literature Cited.
[2] These detections were made outside of the project boundary.

| COMMON NAME | LATIN NAME | MIGRATORY BEHAVIOR*[1] | COUNT OF CARCASSES IN EACH STRATUM | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | SCF | POWER-BLOCK | EVAP. PONDS | PERIMETER FENCE | GEN-TIE LINE | OTHER[2] | TOTAL |
| **RUDDY DUCK** | *Oxyura jamaicensis* | nocturnal | | 1 | | | | 1[3] | **2** |
| **COMMON LOON** | *Gavia immer* | diurnal | | | 1 | 1 | | | **2** |
| **EARED GREBE** | *Podiceps nigricollis* | nocturnal | 3 | | | 1 | | 6[4] | **10** |
| **WESTERN GREBE** | *Aechmophorus occidentalis* | nocturnal | | | 3 | | | | **3** |
| **RED-NECKED PHALAROPE** | *Phalaropus lobatus* | nocturnal | | | 1 | | | | **1** |

[3] This specimen was located on Lockhart Road and likely caused by strike associated with the residential PG and E power line that runs along the south side of Lockhart Road.

[4] These specimens were located on Lockhart Road and likely caused by strike associated with the residential power line that runs along the south side of Lockhart Road.

| COMMON NAME | LATIN NAME | MIGRATORY BEHAVIOR*[1] | COUNT OF CARCASSES IN EACH STRATUM | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | SCF | POWER-BLOCK | EVAP. PONDS | PERIMETER FENCE | GEN-TIE LINE | OTHER[2] | TOTAL |
| **ROCK PIGEON** | *Columba livia* | resident | | | | 1 | | | **1** |
| **EURASIAN COLLARED-DOVE** | *Streptopelia decaocto* | resident | 1 | | | | | | **1** |
| **BURROWING OWL** | *Athene cunicularia* | diurnal/resident | | | | | | 1[5] | **1** |
| **AMERICAN COOT** | *Fulica americana* | nocturnal | 2 | | | | | | **2** |
| **PEREGRINE FALCON** | *Falco peregrinus* | diurnal | | | 1 | | | | **1** |

[5] This specimen was located over 3 miles south of the project on Harper Lake Road and was likely the result of a vehicle strike at night or in the early hours of the morning

| COMMON NAME | LATIN NAME | MIGRATORY BEHAVIOR*[1] | COUNT OF CARCASSES IN EACH STRATUM | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | SCF | POWER-BLOCK | EVAP. PONDS | PERIMETER FENCE | GEN-TIE LINE | OTHER[2] | TOTAL |
| **UNKNOWN WARBLER SP** | | | | 1 | | | | | **1** |
| **HORNED LARK** | *Eremophila alpestris* | resident | | | | | 1 | | **1** |
| **CLIFF SWALLOW** | *Petrochelidon pyrrhonota* | diurnal | 1 | | | | | | **1** |
| **YELLOW-RUMPED WARBLER** | *Setophaga coronata* | nocturnal | | 1 | | | | | **1** |
| **DARK-EYED JUNCO** | *Junco hyemalis* | nocturnal | | 1 | | | | | **1** |
| **YELLOW-HEADED BLACKBIRD** | *Xanthocephalus xanthocephalus* | diurnal | | 1 | | | | | **1** |

| COMMON NAME | LATIN NAME | MIGRATORY BEHAVIOR*[1] | COUNT OF CARCASSES IN EACH STRATUM | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | SCF | POWER-BLOCK | EVAP. PONDS | PERIMETER FENCE | GEN-TIE LINE | OTHER[2] | TOTAL |
| **RED-WINGED BLACKBIRD** | *Agelaius phoeniceus* | diurnal/resident | | 3 | 1 | | | | **4** |
| **BROWN-HEADED COWBIRD** | *Molothrus ater* | diurnal/resident | | 8 | | | | | **8** |
| **HOUSE FINCH** | *Haemorhous mexicanus* | resident | | | 1 | | | | **1** |
| **UNKNOWN SPECIES** | | | 2 | 2 | | 2 | | | **6** |
| ***TOTALS*** | | | **10** | **18** | **9** | **7** | **1** | **8** | **53** |

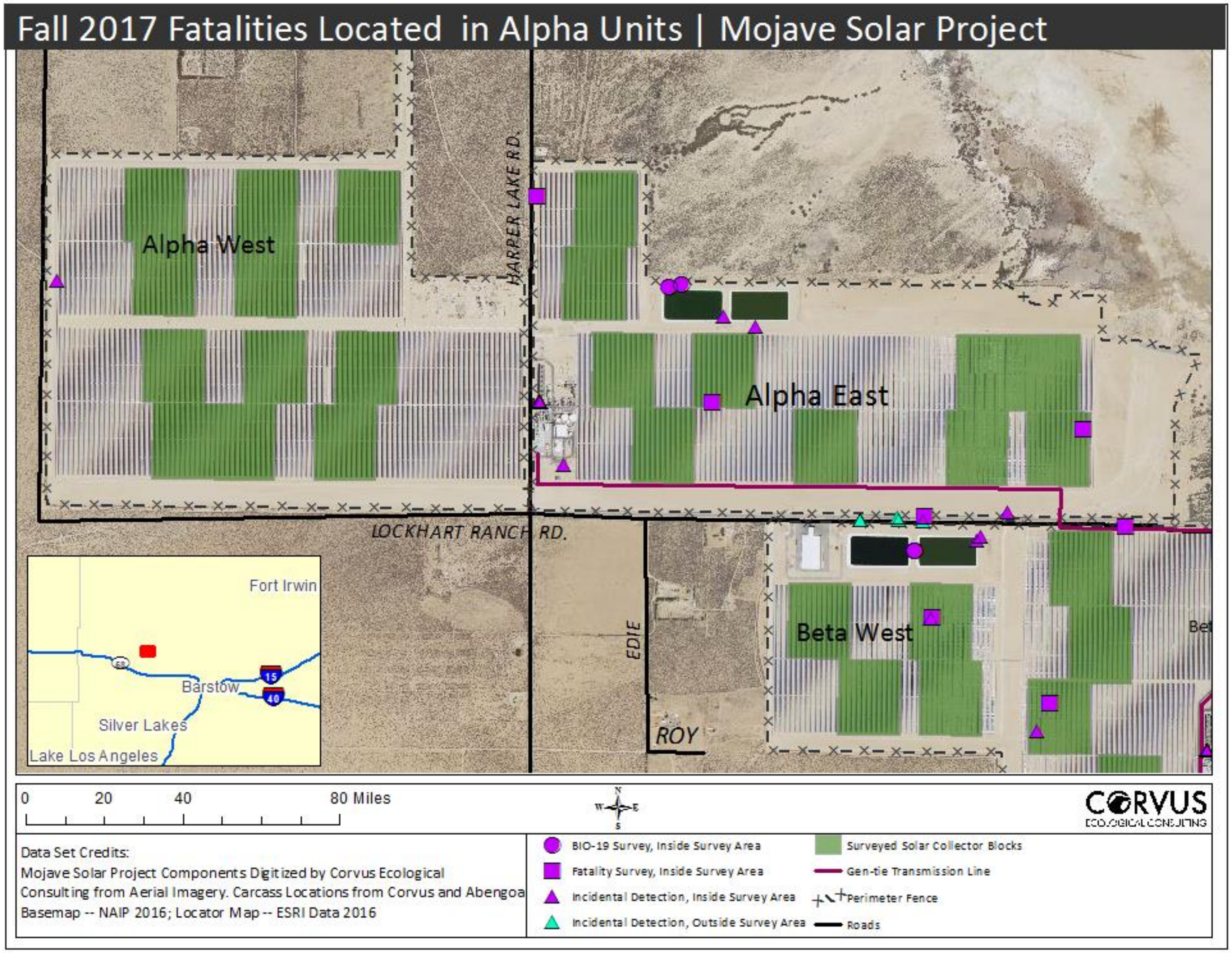


*Figure 5. Locations of carcasses and injured birds found in Fall 2017 on the Alpha Unit Components of the Mojave Solar Project.*

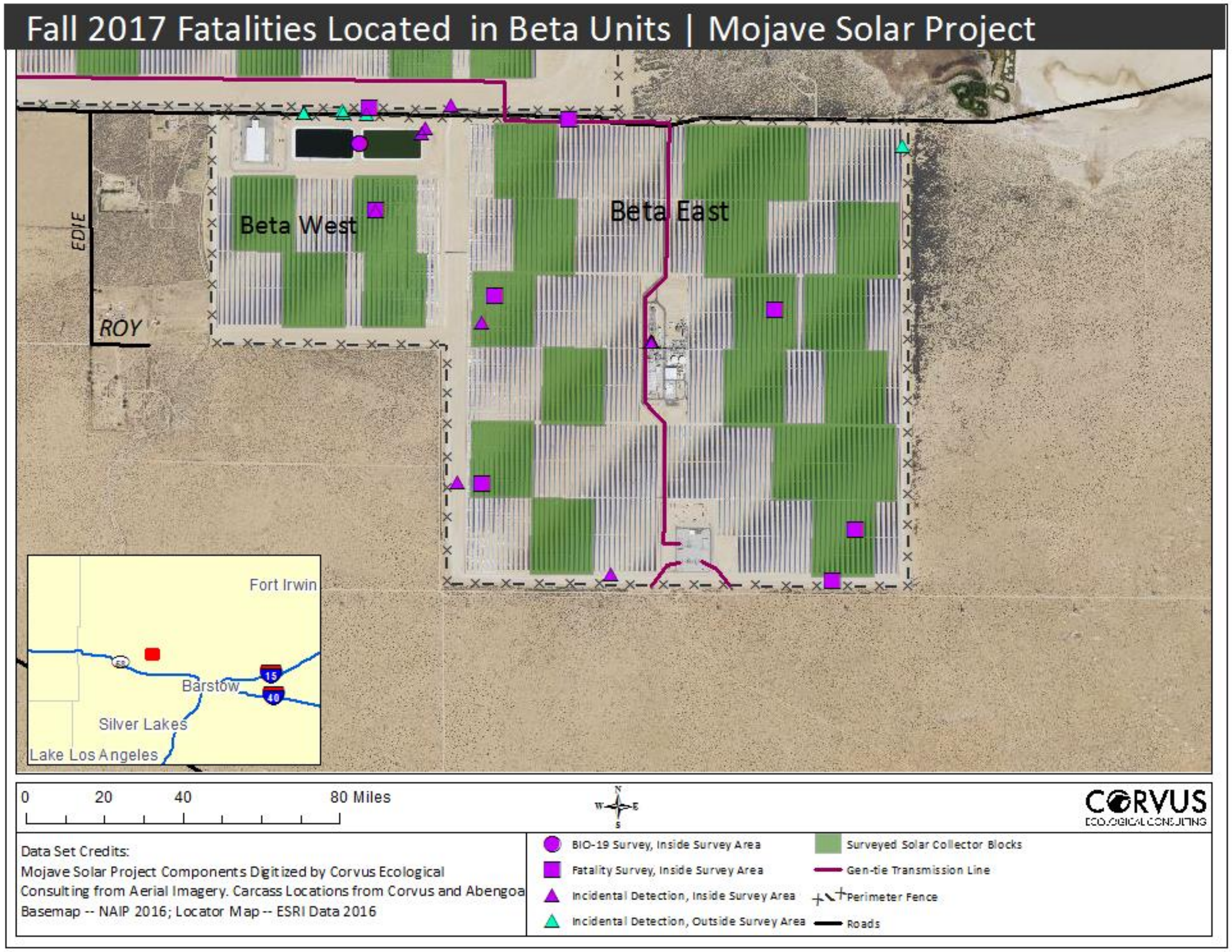


*Figure 6. Locations of carcasses and injured birds found in Fall 2017 on the Beta Unit Components of the Mojave Solar Project*

### 3.1.1 Temporal Patterns of Avian Detections

The highest number of detections on a single day was six (6), which occurred on three separate days: September 5, October 2, and October 16, 2017 (Figure 7). Nine (9) detections in November marked the fewest for any calendar month during the fall quarter. These numbers include totals from systematic searches and incidental detections, including fatalities located in association with BIO-19 monitoring.

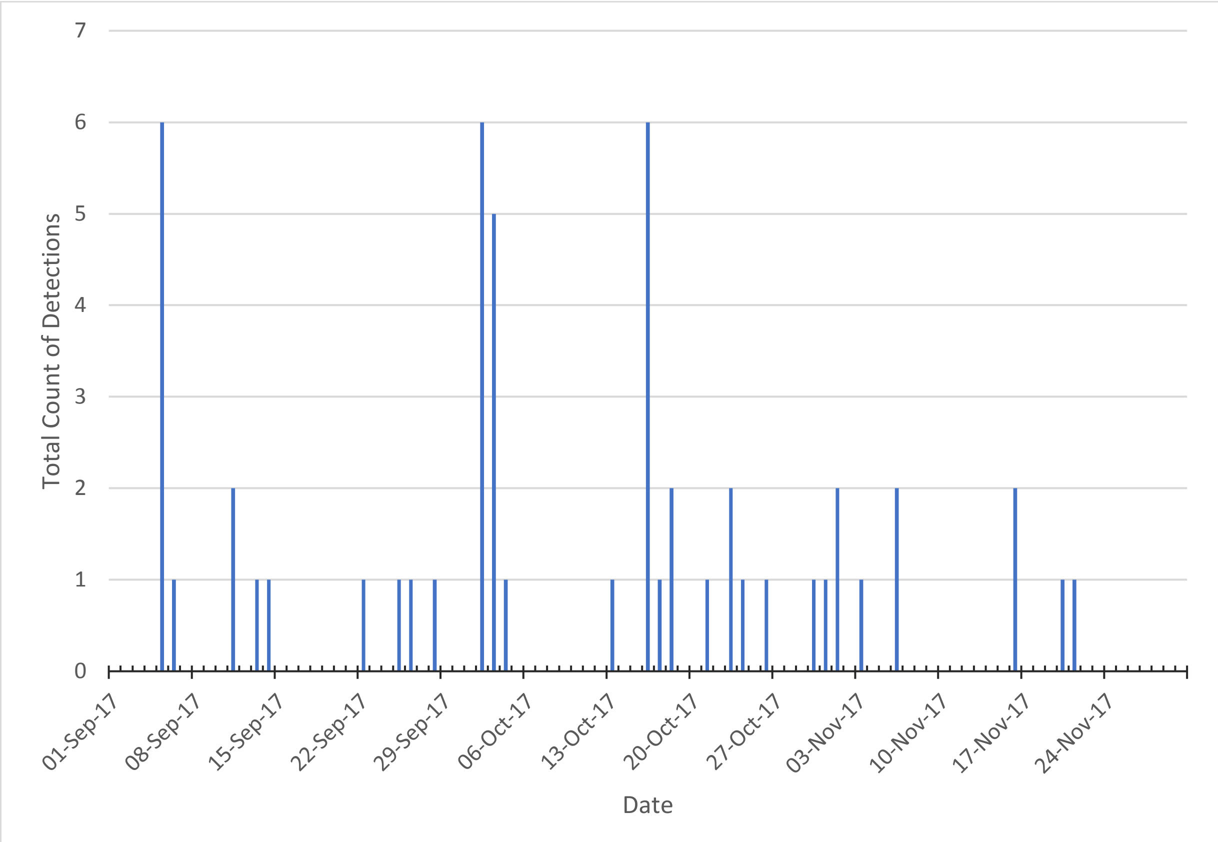


*Figure 7. Total number of detections by date during fall (September 1 - November 30) 2017 at Mojave Solar Project, San Bernardino County, CA.*

### 3.1.2 Spatial Distribution of Avian Detections

During the fall quarter 2017, detections were made within the SCF, along the Perimeter Fence, within the Power Block (especially the cooling tower), along paved roads outside the Perimeter Fence, and in the Evaporation Ponds (Tables 2, 3, and 4). Forty-five (45) of the detected fifty-three (53) avian injuries and mortalities were within the project’s Perimeter Fence and BIO-17 survey area. Eight (8) of the detections during fall 2017 were located outside the project’s Perimeter Fence. Of the 45 within the fence, the breakdown by unit is as follows: 1 in Alpha West, 17 in Alpha East, 7 in Beta West, and 20 in Beta East.

*Table 3. Total detections by Project component and detection category during fall (September 1- November 30) 2017 at Mojave Solar Project, San Bernardino County, CA. Table 3 totals include only those detections used in fatality estimates.*

| PROJECT COMPONENT | SYSTEMATIC SEARCH | INCIDENTAL OR BIO 19 | % OF TOTAL |
|---|---|---|---|
| **PERIMETER FENCE** | 3 | 4 | **13.21** |
| **OVERHEAD LINE (GEN-TIE)** | 1 | 0 | **1.89** |
| **EVAPORATION PONDS** | 0 | 9 | **16.98** |
| **POWER BLOCK** | 0 | 18 | **33.96** |
| **COOLING TOWER** | *0* | *17* | |
| **OTHER** | *0* | *1* | |
| **SCF** | 7 | 3 | **18.87** |
| **ROADS OUTSIDE PERIMETER FENCE** | 0 | 8 | **15.09** |
| **PERCENT OF TOTAL** | **20.75** | **79.25** | **100.00** |

*Table 4. Total detections (all types) by Project component and suspected cause of death during fall (September 1 - November 30) 2017 at Mojave Solar Project, San Bernardino County, CA.*

| PROJECT COMPONENT | SUSPECTED CAUSE OF DEATH* | | | | | | % OF TOTAL |
|---|---|---|---|---|---|---|---|
| | COLLISION | DROWNED | OTHER | POISONED | PREDATION | UNKNOWN | |
| PERIMETER FENCE | | | 1 | | 2 | 4 | 13.2 |
| OVERHEAD LINE | | | | | | 1 | 1.9 |
| EVAPORATION PONDS | 1 | 1 | | 4 | | 3 | 17.0 |
| POWER BLOCK | | 17 | | | | 1 | 34.0 |
| SCF | 3 | | | | | 7 | 18.8 |
| ROADS | 8 | | | | | | 15.1 |
| % OF TOTAL | 22.6 | 34.0 | 1.9 | 7.5 | 3.8 | 30.2 | 100 |

*No necropsies were performed on the carcasses found, so cause of death is generally based on evidence available such as location in relation to infrastructure. If there was no obvious signs of injury and no further clues given the location, the cause of death was generally listed as “unknown”.

### 3.1.3 Characterization of Detections by Condition

Forty-nine (49) of the detections made during the fall 2017 were of dead birds. Of those, twenty-nine [(29) 59.2%] were freshly deceased; nine [(9) 18.4%] were semi-fresh with some signs of rigor mortis; seven [(7) 14.3%] had sign of scavenging; and four [(4 ) 8%] were feather spots.

### 3.1.4 Injured or Stranded Birds

Four (4) stranded or injured birds were found during the fall 2017. Two (2) were found along the Perimeter Fence, one (1) in the area of the Evaporation Pond, and one (1) along Lockhart Road. The suspected causes of injury were collision with overhead wire, exhaustion or collision, and unknown wing injuries. Species found injured included Blue-winged Teal (*Anas discors*), Red-necked Phalarope (*Phalaropus lobatus*), Eared Grebe (*Podiceps nigricollis*), and Common Loon (*Gavia immer*).

### 3.1.5 Interruption of Fatality Searches Due to Weather and Other Factors

If wind speeds at the solar facility reach 25 mph, a wind warning is issued to all personnel. If the gusts exceed 25 mph, all staff are required to leave the solar fields or stay inside a vehicle. Other conditions which limit the access to the SCF include lightning storms. In addition, if work is being done to the mirrors which require them to remain in a stowed position, systematic searches are hampered due to the limited visibility created by the stowed mirrors. When these events happen, searches can take place on the perimeter fences or other strata, but are generally not possible within the SCF. In first quarter of 2017, wind conditions interfered with systematic searches during the week of September 18-21. A complete search of the SCF was not possible due to these shutdowns.

On November 27, 2017, the facility was also on a wind warning. No systematic searches were scheduled for this day. While ground-based carcass persistence monitoring was not possible on this date, remote game cameras were in place to provide the necessary data.

## 3.2 Bat Detections

There were no bats detected during the fall 2017.

## 3.3 Carcass Persistence Trials

Models that compared carcass persistence across project components and carcass size found no significant difference across these strata, therefore all data were pooled and inference was drawn for the entire project and all carcass sizes. Low sample sizes also limited the reliability of more flexible and complicated analyses, therefore a conservative approach was taken and the most parsimonious models were chosen. The parametric model with an exponential distribution assumes a constant persistence probability, meaning the chances of carcass removal do not change from day to day. The data did not suggest that persistence varies across time, nor was there a sound biological justification to assume that persistence probability changes day to day in a manner that is predictable and robust enough to include in the model.

*Table 5. Carcass persistence estimates calculated from data collected during fall (September 1 - November 30) 2017 at Mojave Solar Project, San Bernardino County, CA*

| MEASUREMENT | VALUE | LOWER CONFIDENCE LIMIT | UPPER CONFIDENCE LIMIT |
|---|---|---|---|
| **MEAN** | 3.1 | 2.17 | 4.34 |
| **MEDIAN[1]** | 2.19 | | |
| **PROBABILITY OF PERSISTING 7 DAYS** | 0.40 | 0.30 | 0.50 |
| **PROBABILITY OF PERSISTING 1 DAY** | 0.88 | 0.84 | 0.91 |

[1]Values presented in this table have been calculated using the Carcass Package as noted in Section 2.3.2 with the exception of the median value which was calculated from the raw data.

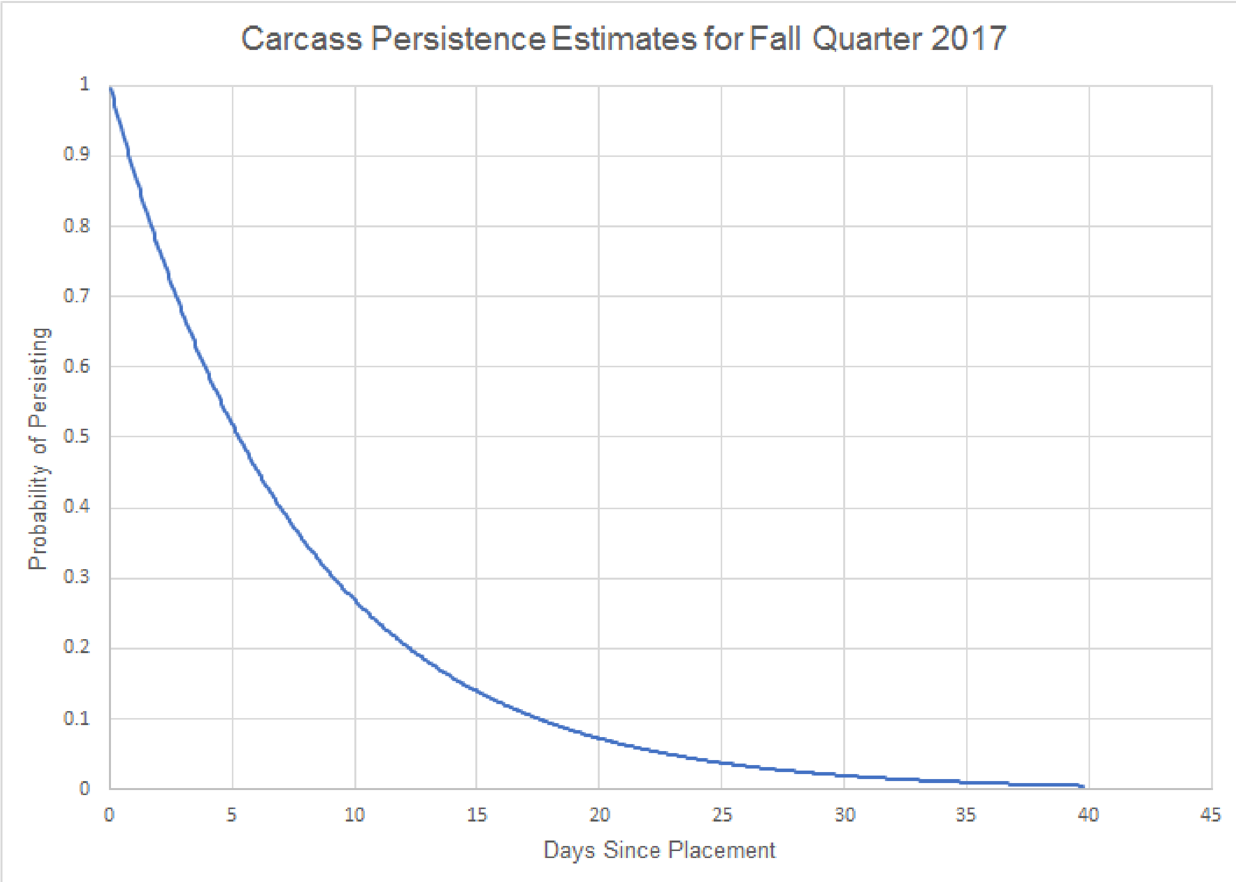


*Figure 8. Graph of estimated carcass persistence over time for fall (September 5 through November 30), 2017 at Mojave Solar Project, San Bernardino County, CA.*

## 3.4 Searcher Efficiency Trials

As with carcass persistence, models could not detect a significant difference in searcher efficiency across project components and carcass sizes, therefore all data was pooled and no fixed effects were included in the model. Differences in AIC of models using project component and carcass size as random effects were negligible, therefore the more parsimonious models were chosen and no covariates were included.

The probability that the searcher will find a carcass that is available to be detected is 47.6% (95% CI: 28.4% - 67.8%).

Some searcher efficiency trial specimens were removed by scavengers and other environmental factors before they were encountered by the searcher, making them unavailable for trial purposes. Table 5 details trial specimen availability and searcher detection rates.

*Table 6. Carcasses of three size classes (S,M,L) placed for searcher efficiency trials in each project component of the Mojave Solar Project between September and November 2017. Carcasses removed by scavengers or wind before the survey was conducted were not able to be detected by the searcher.*

| PROJECT COMPONENT | PLACED | | | REMOVED | | | AVAILABLE TO BE DETECTED | | | DETECTED | | | NOT DETECTED | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CARCASS SIZE | | | | | | | | | | | | | | |
| | S | M | L | S | M | L | S | M | L | S | M | L | S | M | L |
| **EVAPORATION PONDS** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **GEN-TIE** | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **PERIMETER FENCE** | 4 | 1 | 2 | 2 | 1 | 0 | 2 | 0 | 2 | 1 | 0 | 2 | 1 | 0 | 0 |
| **POWER BLOCKS** | 2 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| **SCA** | 4 | 11 | 5 | 1 | 3 | 0 | 3 | 8 | 5 | 1 | 2 | 4 | 2 | 6 | 1 |
| **SIZE CLASS TOTAL** | 10 | 13 | 7 | 4 | 5 | 0 | 6 | 8 | 7 | 2 | 2 | 6 | 4 | 6 | 1 |
| **PROJECT TOTAL** | | | 30 | | | 9 | | | 21 | | | 10 | | | 11 |

## 3.5 Fatality Estimates

When estimating the overall fatality rate using a statistical model, it is important to include only those fatalities that fall within the model assumptions. Incidental detections are treated as if they would have been located during the next scheduled survey, if the detections do not occur within the area to be surveyed, they will not be included in the estimator. This applied to eleven (11) of the fatalities found during the fall Quarter. These detections were made either outside of the project boundary altogether or within the portion of the SCF not surveyed.

It came to our attention that fatalities attributed to the cooling tower also did not fit the assumptions of the model. These fatalities were generally found in the washout pond against the pump screen. Searcher efficiency and carcass persistence for these fatalities are likely quite different from the remainder of the project area, thus, these fatalities (seventeen [17] in fall 2017), were not included in the estimator. These seventeen fatalities are added to the estimate to provide a project total.

Because carcass persistence and searcher efficiency were pooled across project components and carcass size, the estimate of detection probability and the final estimate of fatalities were also pooled. Detection probability, *p*, was estimated to be 22.7%.

Incorporating the 26 fatalities found within the search area into the Huso Estimator (Huso 2010), the number of estimated bird fatalities from modeling efforts during the fall of 2017 was 230 (95% CI: 150 –422). Including the seventeen fatalities from the cooling tower, the total number of estimated fatalities for the project during the fall 2017 was 247.

# 4.0 Discussion

The fall 2017 quarter represented the first standardized effort for data collection in support of BIO-17 on the Mojave Solar Project. From these efforts we are able to refine and improve upon our methodologies.

## 4.1 Carcass Persistence and Searcher Efficiency Trials

Because only one quarter was included in this analysis, data was limited and sample sizes were small. This restricted the statistical rigor with which the data can be analyzed. Future analyses that incorporate the addition of more carcass persistence and searcher efficiency trials will possibly allow for a more robust analysis, including the division of estimates and determination of individual detection functions among different project components and carcass sizes.

Despite these limitations, one notable pattern that emerged from this data is the relatively low detection probability. The mean persistence of carcasses being only three days is concerning because that translates to many carcasses being removed between the survey intervals of 7 and 21 days. At the time of this writing, game camera data continue to be reviewed. These data will help to elucidate whether high removal rates and low detection probabilities are due to specific scavengers frequenting the project and the role that high winds may have in scattering remains that may otherwise provide evidence of carcass presence (i.e. feather spots). This high rate of carcass removal will result in increased uncertainty in estimates of mortality. Higher sample sizes will typically increase the precision of these estimates, but wide confidence intervals (uncertainty) should still be expected in subsequent estimates due to these low detection probabilities.

In fall 2017 and subsequently winter 2017, we attempted to reduce the problem of “scavenger swamping” by running carcass persistence and searcher efficiency concurrently using the same carcasses. Due to the fast removal time, and the length of time taken to survey the entire facility, this technique resulted in too few carcasses available for searchers to detect. Starting in spring 2018, we will conduct searcher efficiency trials with a separate set of specimens that will be placed on the same day as the search. There will likely still be some carcasses removed by scavengers before they are subjected to the searcher, but we hope this method will increase our available sample size for searcher efficiency trials. In addition, by having two sets of carcasses for each type of trial, we can place carcass persistence specimens outside of the search area to get a more accurate assessment of removal throughout the entire project area. Further, game cameras can be placed before or concurrently with carcass placement to gather a more complete set of pictures.

There is very little vegetation on this project, and little reason to assume that searcher efficiency will vary seasonally. Searcher efficiency is most likely impacted by the sandy substrate of the project, debris (both natural and anthropogenic) reducing visibility, as well as the basic construction and site preparation within the SCFs. The mirrors are placed in rows and each pair of rows is connected via piping. The ground in the aisle between two connected rows is depressed in relation to the neighboring drivable row. This means that the visibility of a carcass is not uniform across the proposed 51 m transect width, but in fact, every 17 meters or so, the visibility will be reduced (Figure 8).

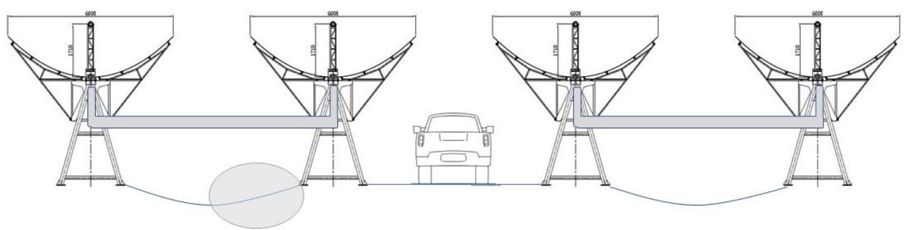

*Figure 9. Diagram showing a view looking down rows of mirrors in the SCF and the visibility issues created by the site preparation.*

Carcass removal rates, however, will likely vary temporally as different cohorts of scavengers visit the site seasonally and other natural food sources come available. The SCF comprises the majority of the project area (75%) and will likely be the site of the majority of carcass placement. Since the Gen-tie is wholly contained within the project area, running very close to the SCFs, there will likely be very little difference in removal rates between the two. In addition, the perimeter fence is typically less than 200 meters from the SCF, and the evaporation ponds are all along perimeter fences so even with a greater sample size, strata may not be much of a factor in removal rates. It may be better to analyze removal times with respect to distance from project edge which we hope to investigate in future reports.

## 4.2 Distribution of Fatalities and Fatality Estimates

Additional data will allow the testing and application of more flexible and robust modeling techniques. The Plan calls for collection of data to perform distance sampling on the carcasses collected during systematic surveys and thus have another possible model for estimating overall fatalities. In fall 2017, however, with only 11 carcasses detected during systematic surveys, we had insufficient data for valid model selection and subsequent estimation. Distance sampling may also prove problematic based on obstructions to the observer view as discussed above.

As seasons vary, we expect avian visitation of the project site to be dynamic and subsequently fatality and injury rates will change. We will continue to monitor throughout the seasons with the survey frequency outlined in the Plan. All strata will be sampled during each systematic survey in an effort to tease apart differences in fatality rates based on project components.

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