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Clark County Bat Recording Analysis Final Project Report

Prepared for

Desert Conservation Program
Clark County Department of Air Quality

Prepared by

SWCA Environmental Consultants

March 2020

CLARK COUNTY BAT RECORDING ANALYSIS
FINAL PROJECT REPORT

Prepared for

Desert Conservation Program
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EXECUTIVE SUMMARY

In 2018 and 2019, the Clark County (the County) Desert Conservation Program deployed acoustic bat detectors at 29 survey points within the Boulder City Conservation Easement and the Riparian Reserve Units. Acoustic bat surveys were conducted to establish a baseline dataset of bat species presence and distribution at these County properties. These baseline data can be compared with future data to quantify the success of management and restoration efforts at the County's surveyed properties. The County contracted with SWCA Environmental Consultants to analyze these data, determine species presence through manual call identification, present bat activity by habitat type, and describe habitat features within each of the County's surveyed properties that are utilized by bats.

Acoustic bat surveys detected one of the three species designated as "covered" by the *Clark County Multiple Species Habitat Conservation Plan*: silver-haired bat (*Lasionycteris noctivagans*). These surveys also detected two species of bat designated as "evaluation": pale Townsend's big-eared bat (*Corynorhinus townsendii*) and small-footed myotis (*Myotis ciliolabrum*) and 10 undesignated species of bat. In total, 13 bat species were recorded across all the County's surveyed properties. A description of bat activity and habitat features at each of the County's surveyed properties is described herein.

1 INTRODUCTION

Clark County's (the County's) Desert Conservation Program manages compliance with the Endangered Species Act (ESA) through the *Clark County Multiple Species Habitat Conservation Plan* (MSHCP) (Clark County 2000). This is accomplished, in part, through the management of a reserve system, which includes Riparian Reserve Units (RRUs), as well as the Boulder City Conservation Easement (BCCE). Under the current MSHCP (Clark County 2000), special status plant and animal species are listed as either "covered," "evaluation," or "watch list" species. The MSHCP and incidental take permit from U.S. Fish and Wildlife Service (USFWS) provide coverage for 78 species for which sufficient information was available to allow incidental take coverage and for which adequate management prescriptions exist to help protect them. Evaluation species require additional information and development of management plans. Watch list species have inadequate information to assess population range, status, conservation potential, or risk of extinction within the county (Clark County 2000).

In the current MSHCP, three species of bats are listed as covered (silver-haired bat [*Lasionycteris noctivagans*], long-eared myotis [*Myotis evotis*], and long-legged myotis [*Myotis volans*]), and two species are listed as evaluation species (pale Townsend's big-eared bat [*Corynorhinus townsendii*] and Western small-footed myotis [*Myotis ciliolabrum*]). As part of a proposed update to the MSHCP scheduled for 2020, two additional bat species are proposed to be listed as covered: spotted bat (*Euderma maculatum*) and pale Townsend's big-eared bat (Clark County 2019a).The purpose of this project is to document presence and activity of these covered, evaluation, and proposed covered bat species at the RRUs and BCCE; these data establish a baseline record against which future restoration activities can be measured.

1.1 Description of the Project

In 2019, the County solicited proposals to analyze acoustic bat survey data collected on its RRUs (Figure 1) and on the BCCE (Figure 2), collectively referred to hereafter as the project area. SWCA Environmental Consultants (SWCA) was selected to conduct analysis of these data, including manual call identification to species, description of activity patterns, and analysis of bat habitat use within each survey location. Acoustic bat detectors were deployed by the County at a total of 13 points located within the following RRUs: Muddy River, Virgin River Subunit 1 (Mormon Mesa), Virgin River Subunit 2 (Bunkerville South and Bunkerville North), and Virgin River Subunit 3 (Riverside) (see Figure 1). Bat detectors were also deployed at 16 survey points within the BCCE (see Figure 2). These surveys will build on baseline presence/absence and activity data for all bat species on these properties, including any current or proposed MSHCP-covered and evaluation bat species.

1.2 Background and Need

On November 19, 2000, the USFWS issued the *Intra-Service Biological and Conference Opinion on Issuance of an Incidental Take Permit to Clark County, Nevada, for a Multiple Species Habitat Conservation Plan* (Biological and Conference Opinion) (USFWS 2000). On March 28, 2001, the USFWS issued an amended incidental take permit for the County MSHCP (USFWS 2001).

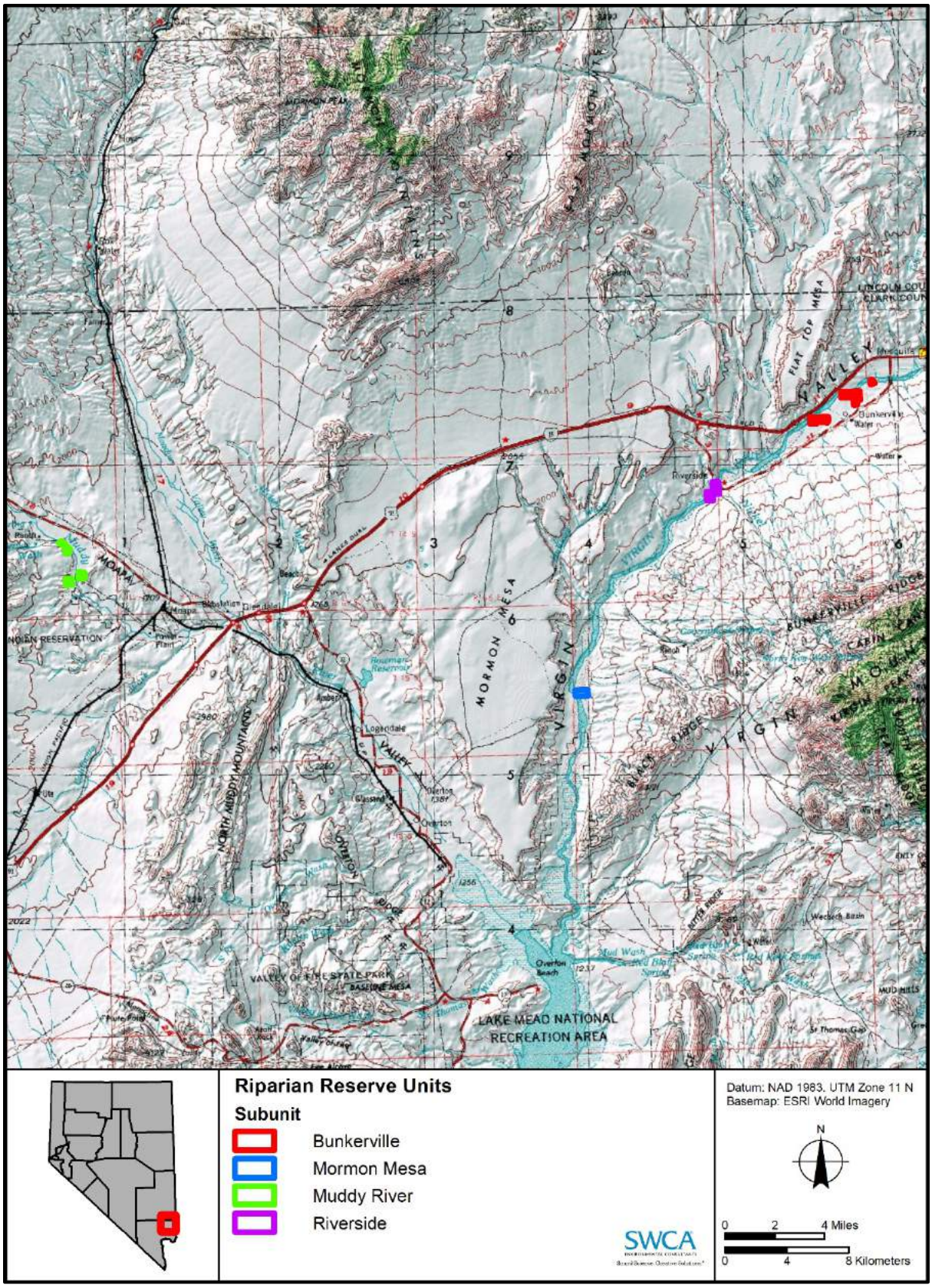

Figure 1. RRU locations.

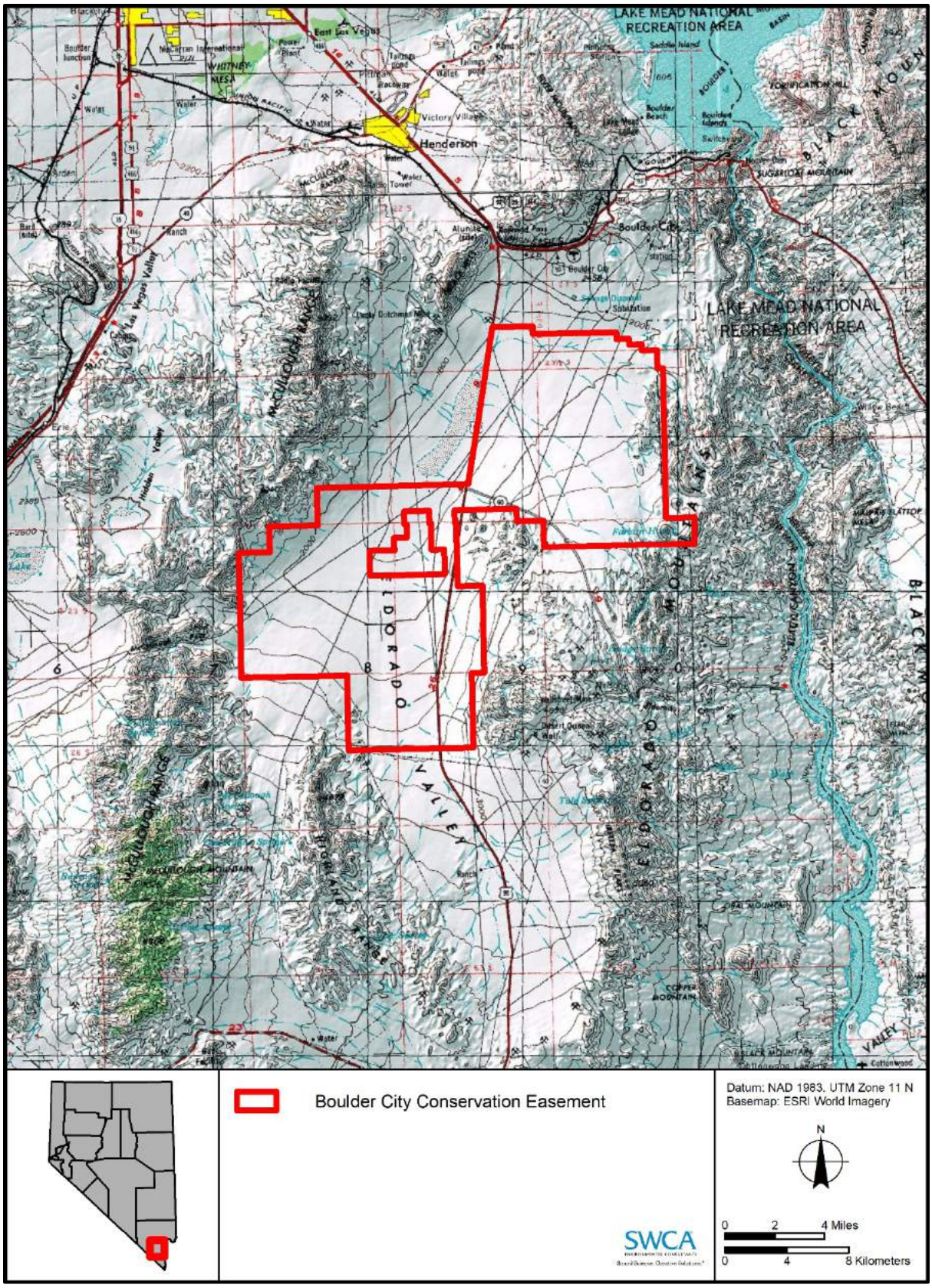

Figure 2. BCCE location.

1.2.1 RRUs

According to both the Biological and Conference Opinion and Condition K.1 of the associated incidental take permit, the County must acquire private property that contains desert riparian habitat along the Virgin River, Muddy River, and Meadow Valley Wash in Clark County. Many of the wildlife species covered under the MSHCP are reliant on desert riparian habitat for such activities such as breeding, foraging, and roosting, and the acquisition of these properties serves to ensure durable conservation and management of these areas. To date, the County has acquired approximately 243 ha (601 acres) of land along the Muddy and Virgin Rivers in northeastern Clark County, Nevada.

1.2.2 BCCE

Implementation of the MSHCP required the establishment of a conservation easement in the Eldorado Valley. This easement, known as the BCCE, was established in July 1995 through an agreement between Clark County and Boulder City. According to both the Biological and Conference Opinion (USFWS 2000) and Condition P of the associated incidental take permit (USFWS 2001), the County is required to take measures necessary to ensure maintenance of connectivity for Mojave desert tortoise (*Gopherus agassizii*) and other covered species within the BCCE. While the BCCE is primarily managed for protection of the desert tortoise, it was recognized that proper management of desert tortoise habitat could also be beneficial for protecting habitat for other species covered by the MSHCP, including bats (Clark County 2019b).

1.3 Management Actions, Goals, and Objectives

The *Clark County Desert Conservation Program Riparian Reserve Units Management Plan* (RRU Management Plant) (Clark County 2015) identifies goals and objectives that help guide management directives on the RRUs. The second goal listed in this plan is to "manage reserve units to support resource values for other MSHCP and sensitive species when practicable" (Clark County 2015:35). The objective identified to reach this goal is to "manage habitat to benefit other MSHCP species" (Clark County 2015:35). In addition, the *Clark County Desert Conservation Program Boulder City Conservation Easement Management Plan* (BCCE Management Plan) (Clark County 2019b) identifies goals and objectives that help guide management directives within the BCCE. The second goal listed in the BCCE Management Plan is to "protect and manage the BCCE for other MSHCP covered species" (Clark County 2019b:78).

Management of species covered under the MSHCP and their habitats requires an in-depth understanding of baseline conditions within a given management unit. Collection of species' abundance and distribution data is a critical first step in monitoring of and conservation management efforts for the MSHCP-covered species found in Clark County. The primary goal of this project is to determine which bat species utilize properties managed by the County so that future management decisions can be tailored to support and enhance the presence of those species. The objective for this project is to establish a baseline record of all bat species recorded on the County's reserve system properties. These data can be used to track changes in presence and activity of MSHCP-covered bat species that use these properties, and to measure the success of management and restoration efforts conducted therein.

2 METHODS AND MATERIALS

2.1 Acoustic Bat Surveys

In 2018 and 2019, the County's Desert Conservation Program deployed acoustic bat detectors at 29 survey points (16 points in the BCCE and 13 points within the Virgin and Muddy River RRUs) to document species occurrence and habitat use (Table 1. Figure 3 through Figure 7). The County collected these data to inform management decisions for current and proposed MSHCP-covered, proposed covered, and evaluation species, including silver-haired bat, long-eared myotis, long-legged myotis, pale Townsend's big-eared bat, and spotted bat. The County contracted with SWCA to analyze these data, determine species presence through manual call identification, present bat activity by habitat type, and describe habitat characteristics within each of the County's properties that may be utilized by bats.

Acoustic bat surveys of the BCCE were conducted from May 3 to July 3, 2018. Acoustic bat surveys of the RRUs were conducted from May 16 to August 14, 2019, within the Muddy River Unit, Virgin River Subunit 1 (Mormon Mesa), Virgin River Subunit 2 (Bunkerville South and Bunkerville North), and Virgin River Subunit 3 (Riverside) (see Figure 1). All County-managed parcels within the RRUs were acoustically surveyed, except for Bunkerville North Parcel 2-H, where dense riparian vegetation limits favorable acoustic sampling locations. At each survey point, an Anabat Swift (Titley Scientific) acoustic detector was secured to either a telescoping painter's pole or an existing, fixed structure (i.e., fencing). Microphones were elevated several meters above ground and were generally oriented towards, and parallel with, potential bat attractant features such as streambeds, springs, and natural corridors, if present. Detectors were set to run on a nightly basis from approximately sunset to sunrise. The sampling period of each acoustic survey varied between six and nine nights (see Table 1.

2.2 Data Processing and Analysis

A total of approximately 70,000 acoustic files were recorded during acoustic bat surveys in 2018 and 2019. These data were batch processed by the County using Kaleidoscope Pro (Wildlife Acoustics) software, which resulted in the removal of noise (non-bat) files and the identification of 16,643 potential bat files. These files were further batch processed by SWCA bat biologist Michael Swink using Sonobat version 4.4.5 bat call analysis software, which resulted in the automated identification of 7,652 bat files to species at 80% accuracy. Sonobat provides multiple regional classifier suites that contain various bat species lists known to occur within each geographic region. Due to the high species diversity of bats historically documented to occur within Clark County (Williams et al. 2006; Bradley et al. 2006; Reid 2006; Las Vegas Wash Coordinating Committee 2011; Wildlife Action Plan Team 2012), both the southeastern and northern Arizona regional classifiers were selected for batch processing and manual file vetting in order to confirm presence for all of the potential bat species identified for the project area.

A total of 3,622 bat echolocation files were manually identified to species using multiple reference materials, including acoustic bat identification keys (Szewczak 2017, 2018; Tyburec 2019) and vouchered reference recordings provided by Sonobat. Due to various factors, including environmental noise, echoes, and non-bat vocalizations, a subset of manually reviewed files were not identifiable to species. These files were assigned one of the user-defined frequency classes defined in Table 2. All files identified by the Sonobat and Kaleidoscope Pro automated classifiers as MSHCP-covered, proposed covered, or evaluation bat species were manually reviewed and identified to species or a user-defined category. A subset of files identified as other bat species not managed under the MSHCP were also manually reviewed, for a total of 3,622 files. Manually identified call files, in addition to all files identified to species using the Sonobat classifier, were carried forward for analysis, for a total of 7,690 files. Files that were not carried forward

for analysis (n=8,690) consisted of relatively lower quality files that were either not manually reviewed, or not identified to species by the Sonobat classifier. Due to multiple observed errors, automated species identifications generated through Kaleidoscope Pro software were not utilized in subsequent analyses. For this project, bat activity was calculated as the number of files for each species and survey point location. Acoustic bat data files cannot be used to directly estimate bat populations since an individual may be responsible for numerous detected calls. However, these data can be used to determine species occurrence and relative activity levels among bat species and survey locations.

Table 1. 2018-2019 Acoustic Bat Survey Schedule and Locations.

Location	Survey Point ID	Set up Date	Retrieval Date	Survey-Nights	easting	northing
BCCE	BCCE_BAT_01	5/30/2018	6/6/2018	7	696187	3975627
	BCCE_BAT_02	5/30/2018	6/6/2018	7	690559	3975046
	BCCE_BAT_03	5/30/2018	6/6/2018	7	694502	3970998
	BCCE_BAT_04	5/3/2018	5/10/2018	7	689574	3970354
	BCCE_BAT_05	5/16/2018	5/23/2018	7	696059	3968693
	BCCE_BAT_06	5/10/2018	5/16/2018	6	692411	3965521
	BCCE_BAT_07	5/23/2018	5/30/2018	7	698537	3964364
	BCCE_BAT_08	6/13/2018	6/20/2018	7	677609	3966723
	BCCE_BAT_09	6/13/2018	6/20/2018	7	674837	3961981
	BCCE_BAT_10	6/20/2018	6/27/2018	7	678328	3962246
	BCCE_BAT_11	6/27/2018	7/3/2018	6	683396	3960234
	BCCE_BAT_12	6/13/2018	6/20/2018	7	672410	3958452
	BCCE_BAT_13	6/6/2018	6/13/2018	7	685823	3957709
	BCCE_BAT_14	6/20/2018	6/27/2018	7	677959	3956613
	BCCE_BAT_15	6/27/2018	7/3/2018	6	684038	3953941
	BCCE_BAT_16	6/6/2018	6/13/2018	7	684932	3950693
RRU	RRU_MR_01	5/16/2019	5/22/2019	6	4065000	706094
	RRU_MR_02	5/16/2019	5/22/2019	6	4064796	706302
	RRU_MR_03	5/16/2019	5/22/2019	6	4062564	706281
	RRU_MR_04	5/22/2019	5/29/2019	7	4062964	707135
	RRU_MR_05	5/22/2019	5/29/2019	7	4063200	706956
	RRU_MM_06	6/17/2019	6/26/2019	9	4055304	738998
	RRU_MM_07	6/17/2019	6/26/2019	9	4055564	739214
	RRU_RS_08	7/3/2019	7/11/2019	8	4068408	747580
	RRU_RS_09	7/3/2019	7/11/2019	8	4067918	747513
	RRU_BS_10	7/24/2019	8/1/2019	8	4072960	754388

Location	Survey Point ID	Set up Date	Retrieval Date	Survey-Nights	easting	northing
	RRU_BS_11	7/24/2019	8/1/2019	8	4073034	754761
	RRU_BN_12	8/7/2019	8/14/2019	7	4074882	757206
	RRU_BN_13	8/7/2019	8/14/2019	7	4074661	756206

Table 2. Frequency Class Labels for Files Not Identified to Species.

File ID	Code	User-defined categories
User-defined frequency class	HiF	Various species with pulses having a minimum frequency higher than ~30 kilohertz
User-defined frequency class	LoF	Various species with pulses having a minimum frequency lower than ~30 kilohertz
User-defined frequency class	NotBat	Species recorded is not a bat
User-defined frequency class	NoID	Bat, but no grouping or user-defined category applies

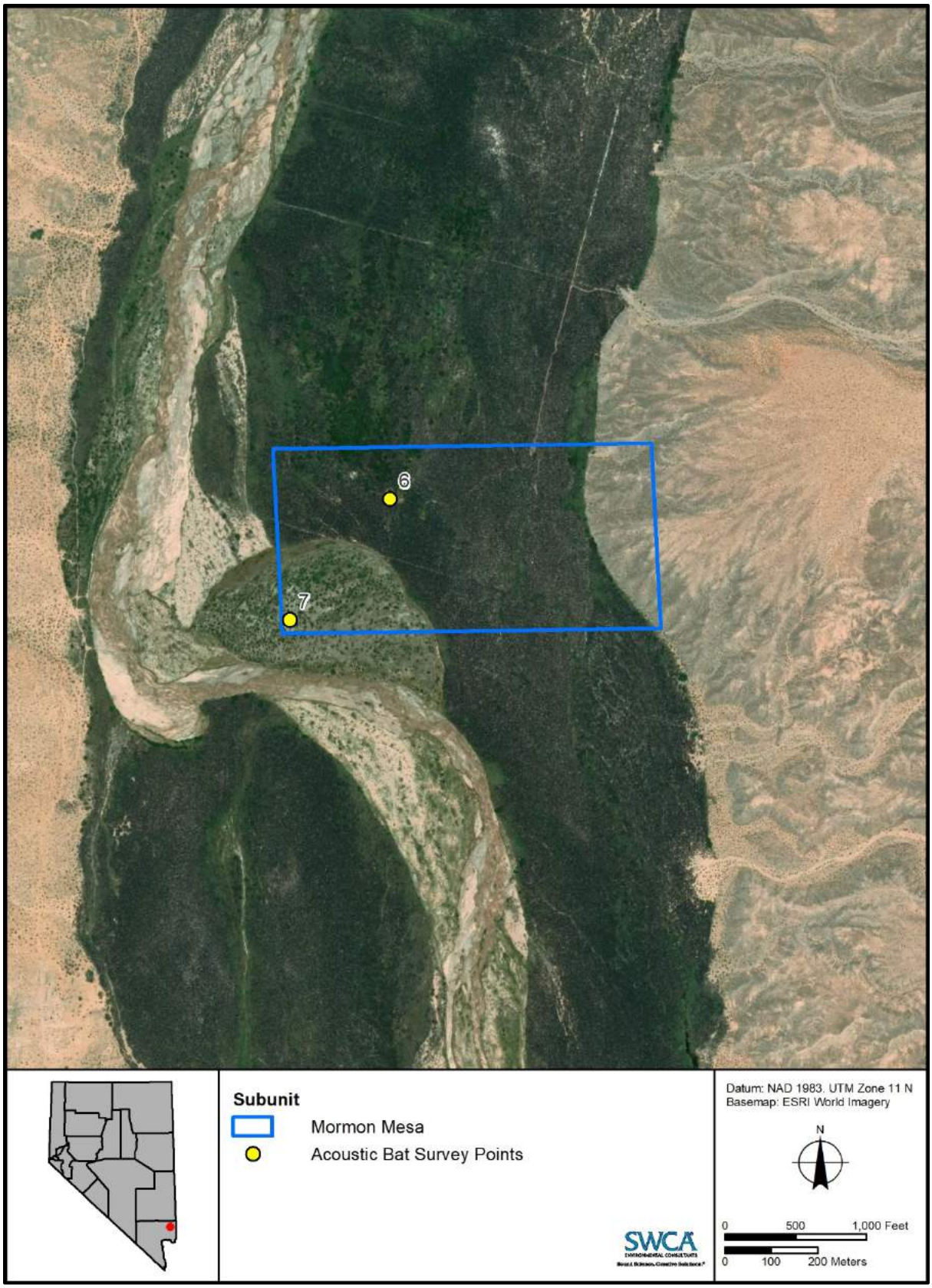

Figure 3. Acoustic bat survey locations at the Mormon Mesa Riparian Reserve Subunit.

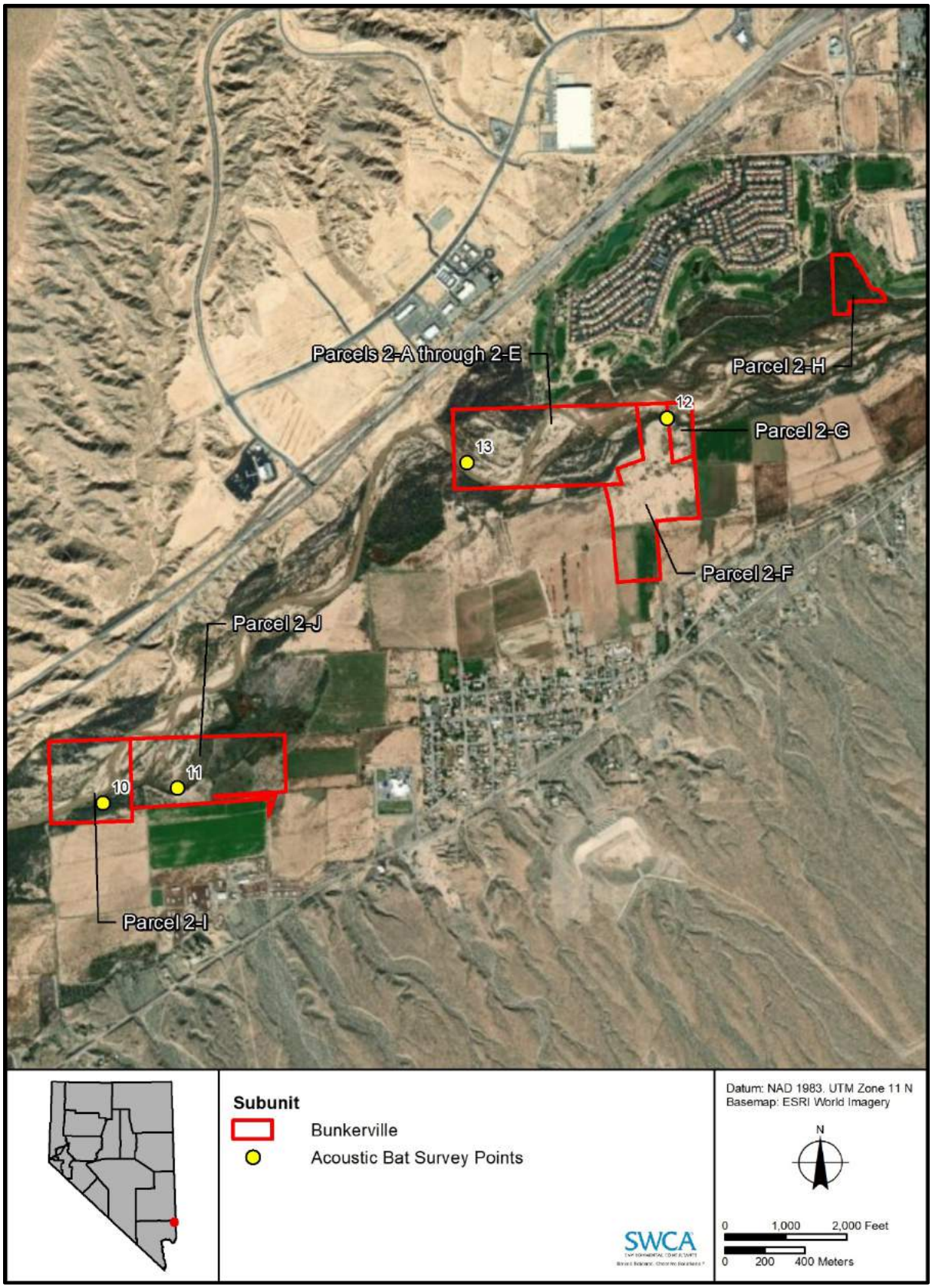

Figure 4. Acoustic bat survey locations at the Bunkerville Riparian Reserve Subunit.

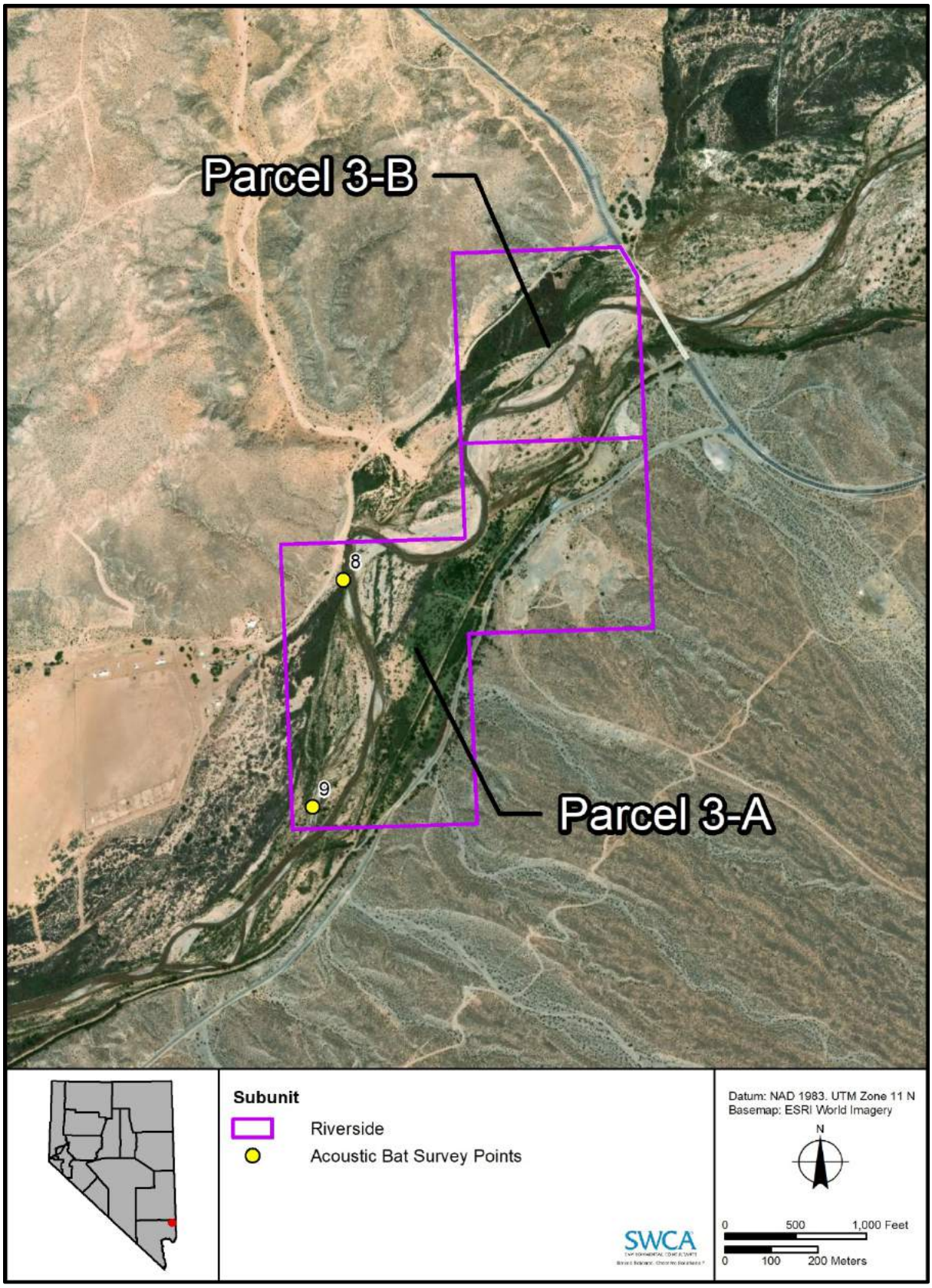

Figure 5. Acoustic bat survey locations on Riverside Riparian Reserve Subunit.

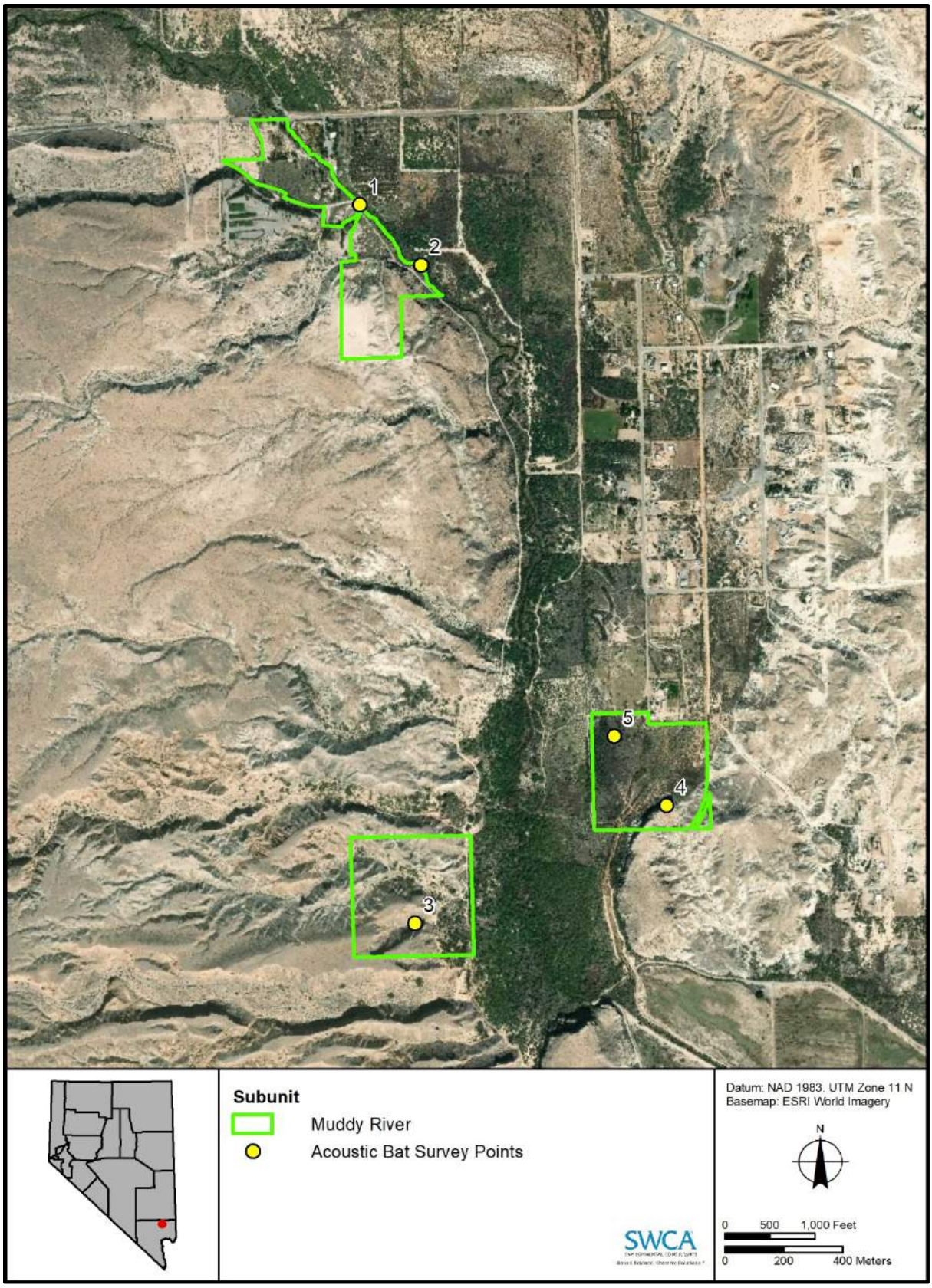

Figure 6. Acoustic bat survey locations on Muddy River Riparian Reserve Unit.

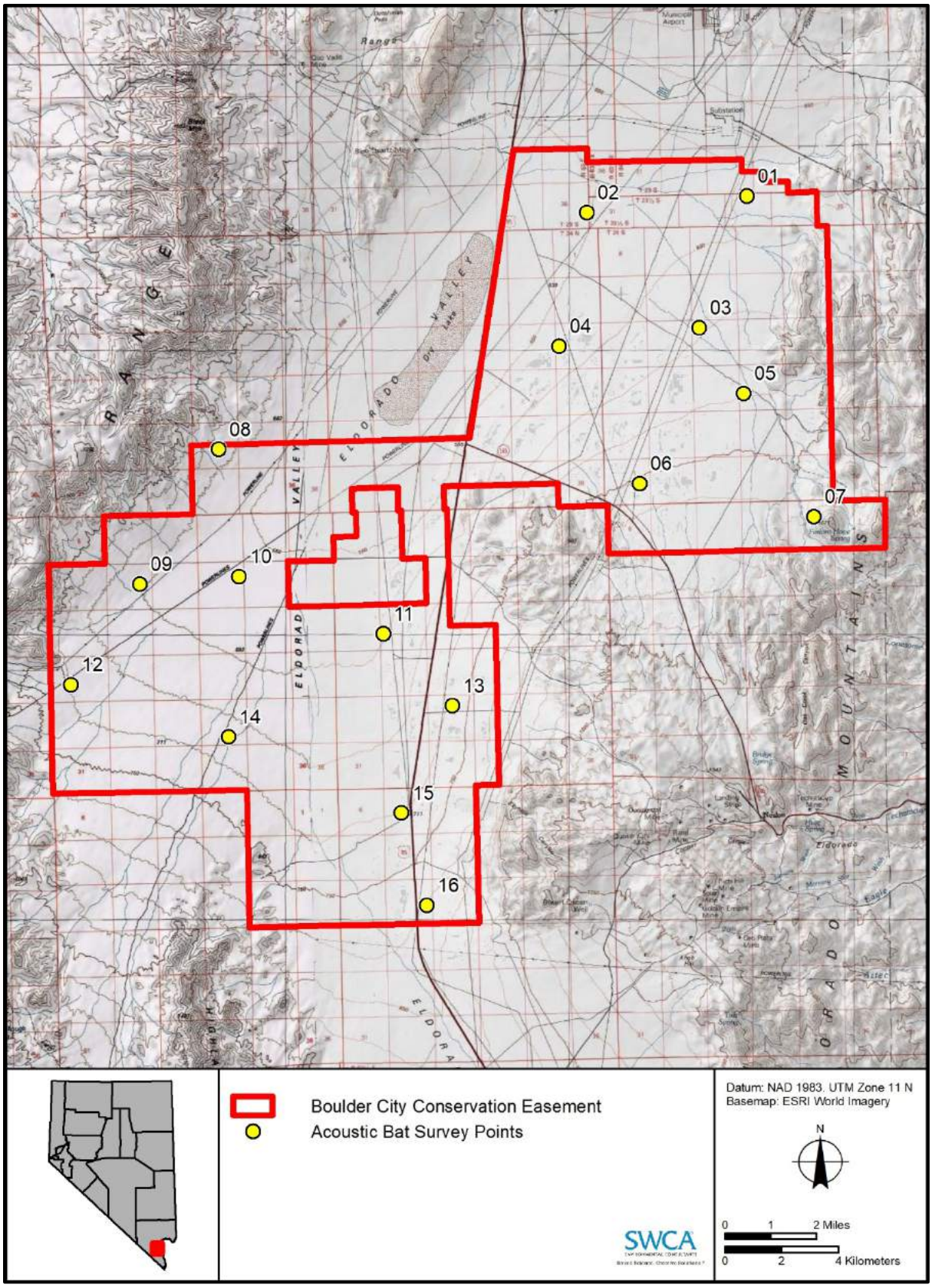

Figure 7. Acoustic bat survey locations at the BCCE.

3 RESULTS AND EVIDENCE OF THE RESULTS

3.1 Objectives Completed

The objective for this project was to develop a baseline record of bat species present at both the RRUs and at the BCCE that could be used to compare with future datasets to measure the success of management and restoration efforts at those properties; those baseline data are presented here.

3.2 Survey Effort

For this project, acoustic detectors were deployed at a total of 29 points throughout the BCCE and RRUs and recorded a total of approximately 70,000 files. Detectors operated for a total 205 survey-nights; 109 survey-nights were completed at the BCCE in 2018, and 96 survey-nights were completed at the RRUs in 2019. The total number of survey nights at any given acoustic survey point varied between six and nine nights (see Table 1). In order to conduct an unbiased analysis between survey locations, bat activity was calculated for each species as the number of files per survey-night (number of files per point divided by the number of survey-nights per point) to control for variation in sampling effort among survey points.

3.3 Findings

In total, 13 bat species were recorded across all the County's properties (Table 3). All 13 bat species were detected at one or more of the RRUs; in contrast, a total of seven bat species were documented utilizing the BCCE. Within the BCCE, bat activity was highest at survey point BCCE-08, accounting for 34% of the total activity recorded at the BCCE (Figure 8; Appendix A). Most of this activity is represented by two species, canyon bat (*Parastrellus hesperus*) and Brazilian free-tailed bat (*Tadarida brasiliensis*). Within the RRUs, bat activity was highest at survey point MR-02, accounting for 30% of the total activity recorded at the RRUs (Figure 9); however, 88% of these files were not identifiable to species. Similar to data recorded at the BCCE, the majority of bat activity that was documented during acoustic surveys of the RRUs was attributable to canyon bat and Brazilian free-tailed bat.

3.3.1 MSHCP Species

Based on the results of the automated and manual call identification processes, acoustic bat surveys detected one species covered by the County MSHCP, silver-haired bat. Silver-haired bat was recorded at five survey points within the BCCE and at all of the RRUs. Highest activity estimates for this species were observed within the Muddy River RRU at point MR-04 and in the Bunkerville South Subunit at BS-10. Silver-haired bat roosts under bark or in woodpecker holes in large trees in the summer. In southern Nevada, silver-haired bats are most commonly documented within riparian forest areas but are known to travel up to 9 miles (15 kilometers) to foraging areas (Wilson et al. 1999; Bradley et al. 2006).

These surveys also detected pale Townsend's big-eared bat, an MSHCP proposed covered and evaluation bat species, and Western small-footed myotis, an evaluation bat species. Pale Townsend's big-eared bat was detected at Muddy River points MR-02, MR-03, and MR-04, and at Riverside point RS-08. Western small-footed myotis was detected at Riverside point RS-09 and at BCCE points 10 and 12 (Appendix A).

MSHCP-covered bat species that were not detected in the project area include long-legged myotis, which is generally found at mid to high elevations, and is generally absent from low desert areas in Nevada; and long-eared myotis, which in Nevada has only been encountered within pinyon-juniper woodland or above (Bradley et al. 2006; Wildlife Action Plan Team 2012). Spotted bat, a species proposed for listing as covered under the MSHCP, was also not detected acoustically during this project. However, there are occurrence records for this species utilizing riparian marshes along the upper Muddy River drainage (Williams et al. 2006), and similar habitat within the project area may be utilized by this species.

Table 3. Bat Species Identified Acoustically Within the Project Area.

Common Name	Scientific Name	4-letter Code	MSHCP*	Survey Site(s) Detected†
Pallid bat	*Antrozous pallidus*	ANPA	–	BS, MM, MR, RS
Pale Townsend's big-eared bat	*Corynorhinus townsendii*	COTO	E, PC	MR, RS
Big brown bat	*Eptesicus fuscus*	EPFU	–	BN, BS, MR, RS
Greater bonneted bat	*Eumops perotis*	EUPE	–	BS, MR, RS
Silver-haired bat	*Lasionycteris noctivagans*	LANO	C	BCCE, BN, BS, MM, MR, RS
Hoary bat	*Lasiurus cinereus*	LACI	–	BN, MR
Western yellow bat	*Lasiurus xanthinus*	LAXA	–	BCCE, BN, BS, MM, MR, RS
California myotis	*Myotis californicus*	MYCA	–	BCCE, BN, BS, MM, MR, RS
Western small-footed myotis	*Myotis ciliolabrum*	MYCI	E	BCCE, RS
Yuma myotis	*Myotis yumanensis*	MYYU	–	BCCE, BN, BS, MM, MR, RS
Big free-tailed bat	*Nyctinomops macrotis*	NYMA	–	BS, MR, RS
Canyon bat	*Parastrellus hesperus*	PAHE	–	BCCE, BN, BS, MM, MR, RS
Brazilian free-tailed bat	*Tadarida brasiliensis*	TABR	–	BCCE, BN, BS, MM, MR, RS

* MSHCP status (Clark County 2000, 2019a): C=covered; E=evaluation; PC=proposed covered

† Clark County Desert Conservation Program Reserve System Study Sites: BCCE=Boulder City Conservation Easement; BN=Bunkerville North; BS=Bunkerville South; MM=Mormon Mesa; MR=Muddy River; RS=Riverside

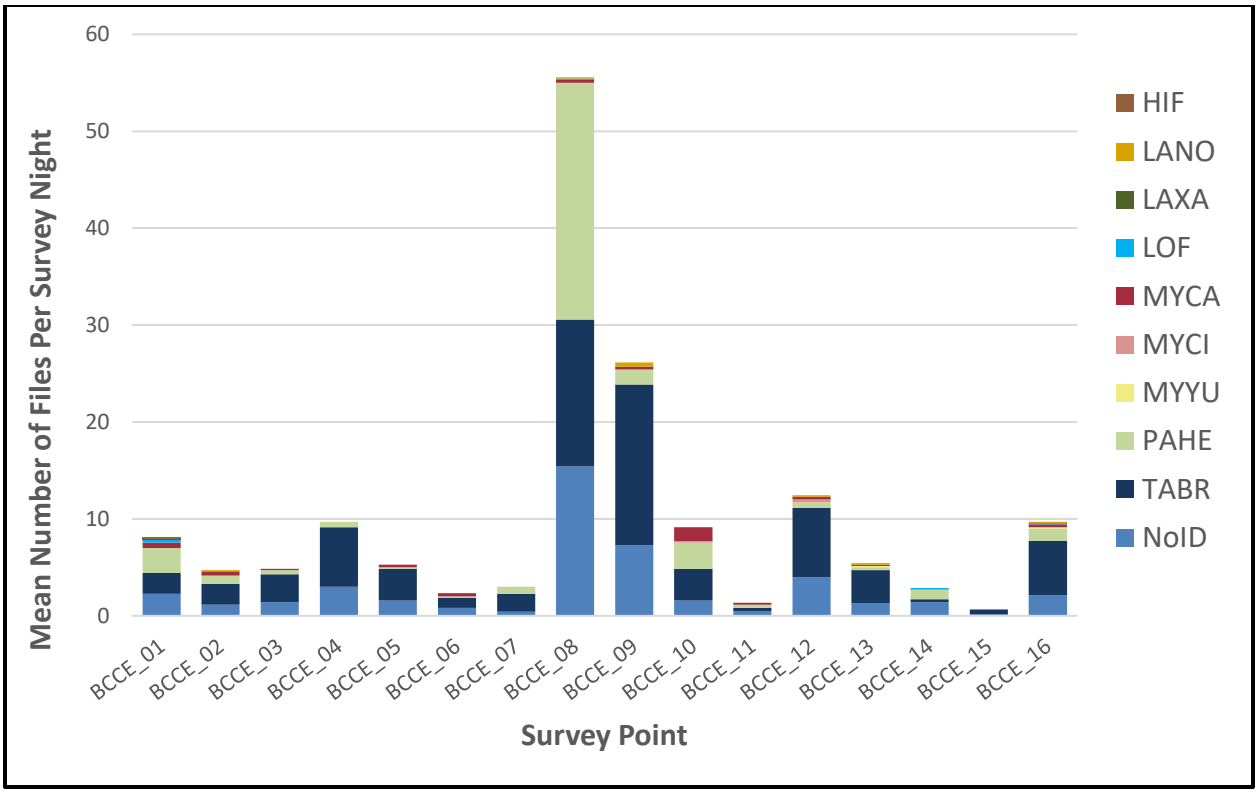

Figure 8. Bat species use by survey-night for BCCE survey points.

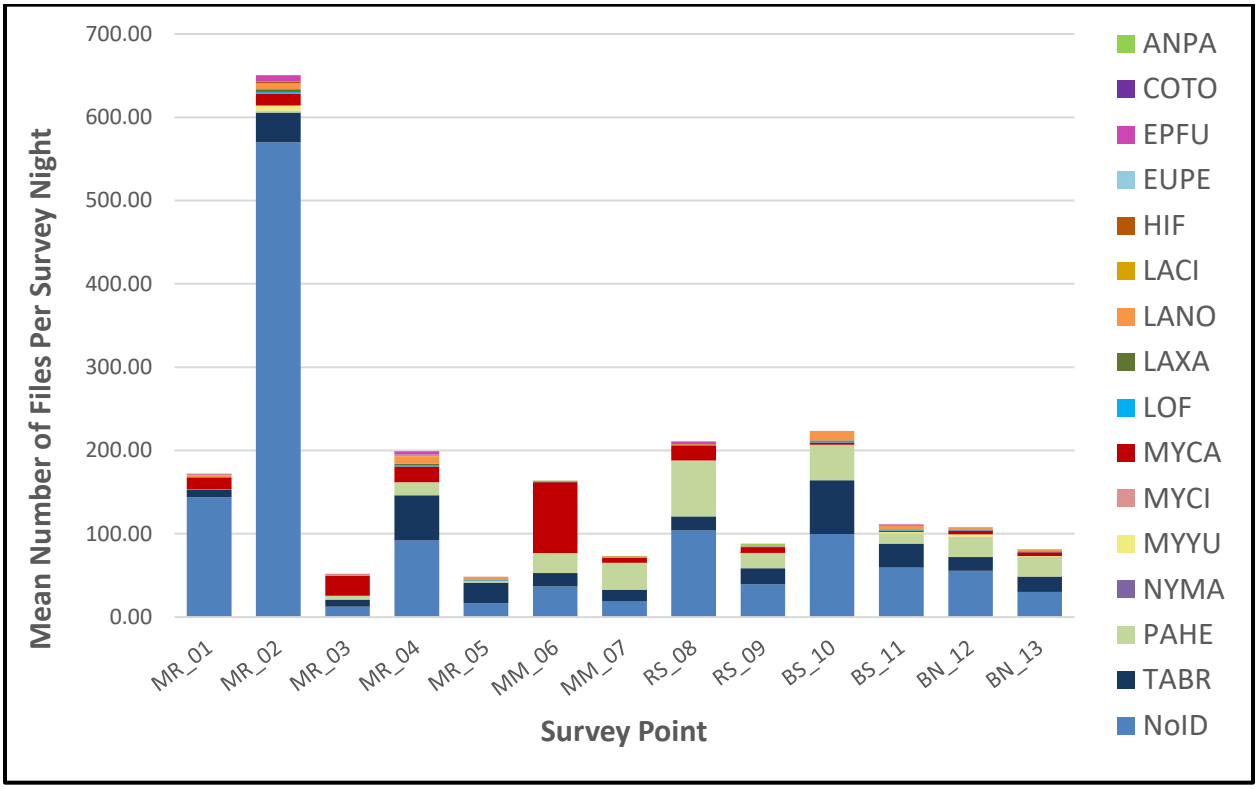

Figure 9. Bat species use by survey-night for survey points in the RRUs.

4 EVALUATION/DISCUSSION OF RESULTS

4.1 Analysis Factors

Many of the manually reviewed files recorded various sources of environmental noise, such as echoes and wind, as well as small mammal, bird, and insect vocalizations. Probable sources of echoes in ultrasonic detector recordings include proximity to solid surfaces and water bodies, which causes call pulse soundwaves to bounce off these surfaces, resulting in a second, lower amplitude pulse being recorded. These types of non-target noise sources can decrease recording quality and confound both automated and manual bat species classification. Similarly, recordings of bat echolocations that are outside the effective microphone range may lack sufficient resolution and diagnostic features to perform accurate species classification.

Acoustic bat data files cannot be used to directly estimate bat populations since an individual may be responsible for numerous detected calls. However, these data can be used to determine species occurrence and relative activity levels among bat species and survey locations. Bat activity and species composition in any given area are highly variable and influenced by a variety of biotic and abiotic factors, including climatic fluctuation; seasonal activity patterns such as reproduction, migration, and hibernation; changes in the abundance and location of prey items and water sources; and roosting and foraging habitat availability. As a result, the species diversity and activity patterns observed in acoustic bat survey data are highly correlated with the temporal and spatial parameters in which these surveys are performed.

4.2 Baseline Vegetation

This project provides a baseline bat occurrence dataset for the County's MSHCP properties. Acoustic bat surveys within the RRUs resulted in a total of 13 bat species detected, including one MSHCP-covered bat species, one proposed covered/evaluation species, and one evaluation species. Acoustic bat surveys within the BCCE yielded seven total bat species, including one MSHCP-covered and one evaluation species. Goals identified in both the RRU Management Plan (Clark County 2015) and the BCCE Management Plan (Clark County 2019) include managing these properties to protect MSHCP-covered species. Baseline vegetation community and structure data for the MSHCP properties are necessary to inform habitat management interventions to successfully manage bat species at these properties. This section includes a closer analysis of bat species presence and distribution for each set of connected parcels within the RRUs and at the BCCE, as well as a qualitative assessment of existing vegetation conditions therein.

4.2.1 Mormon Mesa

The Mormon Mesa Subunit is dominated largely by a monotypic stand of tamarisk. However, much of this vegetation is dead or dying as the result of defoliation by the tamarisk leaf beetle (*Diorhabda* spp.), and 1.7 hectares (ha) (4.3 acres) of dead tamarisk was cleared via mastication by the County in late 2018 (SWCA 2019). An approximately 5-ha (13-acre) patch of screwbean mesquite (*Prosopis pubescens*) and arrowweed (*Pluchea sericea*) shrubland is present in the southwestern corner of this subunit, and some large native Goodding's willow (*Salix gooddingii*) are present in the northwestern corner. Eight restoration plots are also scattered throughout the northwestern corner of the Mormon Mesa Subunit; in 2014, the County cleared non-native tamarisk and planted native vegetation within these plots (Figure 10).

4.2.1.1 BAT HABITAT FEATURES

Acoustic detectors were deployed at two survey points within the Mormon Mesa Subunit; MM-06 was located within the restoration plot and near several large, mature Goodding's willow trees. Plant diversity is high within the plot, and includes willows (*Salix* spp.), sedges (*Carex* spp.), cattails (*Typha* spp.), yerba mansa (*Anemopsis californica*), rabbitsfoot grass (*Polypogon monspeliensis*), and some tamarisk (*Tamarix* sp.). Survey point MM-07 was located at the southwestern corner of the property in screwbean mesquite bosque habitat with an arrowweed shrub layer (Figure 11).

Figure 10. Habitat within restoration plots at the Mormon Mesa Subunit.

A total of seven bat species were recorded at the Mormon Mesa Riparian Reserve Subunit in 2019: pallid bat, silver-haired bat (an MSHCP-covered bat species), Western yellow bat, California myotis, Yuma myotis, canyon bat, and Brazilian free-tailed bat. Apart from Western yellow bat, which was only detected at the restoration plot (MM-6), all other bat species were recorded at both survey locations MM-06 and MM-07. Large, mature tree species present in the restoration plot, such as Fremont cottonwood (*Populus fremontii*) and Goodding's willow, provide potential roosting habitat for tree-roosting bat species such as yellow bats and silver-haired bats (Bradley et al. 2006; Wildlife Action Plan Team 2012). Echolocation files identified as Brazilian free-tailed bat, canyon bat, and California myotis accounted for most of the bat activity recorded at Mormon Mesa in 2019.

Figure 11. Acoustic bat survey points MM-06 (left) and MM-07 (right) in the Mormon Mesa Subunit.

4.2.2 Bunkerville North

Bunkerville North (Parcels 2-A through 2-G; see Figure 4) contain mostly shrubby habitat with frequent openings that have been scoured by flooding or cleared by anthropogenic activities. Parcels 2-A through 2-E are situated mostly within the active floodplain of the Virgin River, which experiences frequent high-flow events. These parcels therefore consist largely of sandy bare ground dotted with sapling arrowweed and tamarisk (Figure 12). In 2019, higher than normal winter precipitation yielded significant spring run-off that scoured portions of these parcels, creating more open, unvegetated habitat (Figure 13). A total of 1.3 ha (3.2 acres) were scoured by the 2019 flooding (see Figure 13), and 0.3 ha (0.7 acre) was burned in a wildfire late in 2017 (Figure 14) (SWCA 2019).

Figure 12. Examples of flood-disturbed habitat at Bunkerville Parcels 2-A through 2-E.

Bunkerville Parcels 2-F and 2-G are dominated by anthropogenically disturbed lands and include large areas that have been completely bladed and cleared of native vegetation (Figure 15). Any regrowth in this area is generally patchy tamarisk and arrowweed, 2- to 4-m- (6.6- to 13.1-foot-) high, with little continuous canopy. Much of the southern portion of Bunkerville Parcel 2-F is currently being used for growing alfalfa (*Medicago sativa*) and grazing cattle. The areas of Parcels 2-F and 2-G that have not been disturbed by anthropogenic activities are dominated by 1- to 3-m- (3.3- to 9.8-foot-) tall seep willow (*Baccharis salicifolia*), tamarisk, and intermittent arrowweed (Figure 16). There is a small patch of monotypic tamarisk in Parcel 2-F and a small patch of narrowleaf willow (*Salix exigua*) in Parcel 2-G (Figure 17). The tamarisk occurs largely on a dry terrace, raised above the river, and consists of 3- to 4-m- (9.8- to 13.1-foot-) tall trees with less than 50% canopy closure. The patch of willow consists largely of narrowleaf willow, with intermittent tamarisk and seep willow, all of which ranges mostly between 3 and 4 m (9.8 and 13.1 feet) in height. This area of willow has intermittent surface water and relatively dense canopy cover (approximately 75%) but is less than 0.4 ha (1 acre) in size (SWCA 2019).

Figure 13. Evidence of the 2019 flooding at Bunkerville Parcels 2-A through 2-E.

Figure 14. Evidence of wildfire at Bunkerville Parcels 2-A through 2-E.

Figure 15. Anthropogenically disturbed habitat at Bunkerville Parcels 2-F and 2-G.

Figure 16. Examples of young seep willow and arrowweed at Bunkerville Parcels 2-F and 2-G.

Figure 17. Monotypic tamarisk at Bunkerville Parcel 2-F (left) and the narrowleaf willow patch at Bunkerville Parcel 2-G (right).

4.2.2.1 BAT HABITAT FEATURES

Acoustic detectors were deployed at two survey points within the Bunkerville North Subunit; BN-12 was located in Parcel 2F within anthropogenically disturbed habitat and adjacent to a patch of narrowleaf willow (Figure 17 and Figure 18). Survey point BN-13 was located on a sandbar near the Virgin River, on the far western end of Parcel 2A-2E; vegetation in the area is desert riparian shrubland and consists primarily of arrowweed, seep willow, narrowleaf willow, and tamarisk (see Figure 11).

Eight bat species were recorded at Bunkerville North: big brown bat, hoary bat, silver-haired bat (an MSHCP-covered bat species), Western yellow bat, California myotis, Yuma myotis, canyon bat, and Brazilian free-tailed bat (see Table 2). Given the lack of large, mature trees in the Bunkerville north Site, tree roosting species recorded within this parcel, such as big brown bat, hoary bat, silver-haired bat, and Western yellow bat, are likely foraging or passing through the area and roosting elsewhere. Several sections of the Virgin River within this parcel provide unobstructed access to water, likely serving as an attractant feature for several species of bats. Bat species occurrence and activity data recorded at survey point BN-12 were similar to those recorded at BN-13.

Figure 18. Acoustic bat survey points BN-12 (left) and BN-13 (right) in the Bunkerville North Subunit.

4.2.3 Bunkerville South

Much of Bunkerville South (Parcels 2-I and 2-J) appear to be subject to regular flooding, and some of the most abundant plants within these two Parcels are sapling arrowweed and tamarisk less than 3 m (9.8 feet) tall. Bunkerville Parcels 2-I and 2-J host very few large riparian tree species, such as Fremont cottonwood and Goodding's and narrowleaf willow, which may be utilized by tree-roosting bat species. Most of the mature riparian vegetation within these Parcels consists of tamarisk and screwbean mesquite 2 to 5 m (6.6–16.4 feet) tall, and these stands have virtually no continuous canopy cover or nearby surface water (Figure 19). Additionally, much of the tamarisk is dead or dying. Much of the area is relatively unvegetated when compared to other riparian habitat in the desert Southwest, and this is likely due, at least in part, to relatively recent flood events, including flooding in the spring of 2019. A total of 0.9 ha (2.2 acres) were scoured by spring flooding, leaving unvegetated bare ground (Figure 20). Despite a lack of many native trees, Parcels 2-I and 2-J do have flowing channels, a pond, and a wet meadow (Figure 21), all of which provide suitable bat foraging habitat. The wet meadow is located in the eastern half of Parcel 2-J and is composed largely of sedges and other wetland grasses, with relic Goodding's willow and scattered tamarisk (SWCA 2019).

Figure 19. Typical open, scrubby habitat at Bunkerville South Parcels 2-I and 2-J.

Figure 20. Evidence of the 2019 flooding at Bunkerville South Parcel 2-I.

Figure 21. Open water (left) and wet meadow (right) habitats at Bunkerville South Parcel 2-J.

4.2.3.1 BAT HABITAT FEATURES

Acoustic detectors were deployed at two survey points within the Bunkerville South Subunit. BS-10 was located in Parcel 2-I, on a sandbar, adjacent to a dense stand of tamarisk, scattered arrowweed, and areas of pooled backwater resulting from recent flood events. Survey point BS-11 was installed in Parcel 2-J within a wet meadow and near a large backwater pond (see Figure 21; Figure 22). Vegetation at BS-11 consisted of saltgrass (*Distichlis spicata*), cattail (*Typha* spp.), arrowweed, honey mesquite (*Prosopis glandulosa*), and tamarisk.

In total, ten bat species were recorded within Bunkerville South in 2019: pallid bat, big brown bat, greater bonneted bat, silver-haired bat (a MSHCP-covered bat species), Western yellow bat, California myotis, Yuma myotis, big free-tailed bat, canyon bat, and Brazilian free-tailed bat. Canyon bat and Brazilian free-tailed bat accounted for most of the echolocation files recorded at Bunkerville South that were identifiable to species. Suitable bat roosting habitat is scarce within the Bunkerville South Subunit (although scattered Goodding's willow in Parcel 2J may be utilized by tree-roosting bat species); therefore, many of the bat species recorded at Bunkerville south were likely foraging or moving through the site.

Suitable foraging habitat within the subunit includes dense riparian scrub, ponds and backwater features, and wet meadow habitat, which likely support high densities of flying insects that many detected bat species prey upon, such as flies, moths, and beetles. Bat activity levels observed at survey point BS-10, which was installed on a sandbar adjacent to a dense stand of tamarisk, were nearly twice as high (mean files per survey-night) as those recorded at BS-11, which was installed next to a large pond. Flooding in the Virgin River in 2019 resulted in the formation of multiple areas of stagnant, standing water along the floodplain; BS-10 was located next to some of these temporary pools, which are often utilized as foraging and water sources by many bat species.

Figure 22. Acoustic bat survey points BS-10 (left) and BS-11 (right) in the Bunkerville South (2I/2J) Subunit.

4.2.4 Riverside

Much like Bunkerville South, Riverside Parcels 3-A and 3-B are composed mostly of the open, scrubby habitat typically found in riparian areas that experience frequent flooding (Figure 23). The Riverside Subunit was subjected to substantial seasonal run-off associated with above average winter precipitation in the Virgin River watershed in 2019. The 2019 flooding also removed portions of a large, contiguous patch of tamarisk at the northern end of the Riverside Subunit. An irrigation ditch runs along the center of Parcel 3-A, the banks of which support tall stands of narrowleaf willow (Figure 24).

Figure 23. Scrubby, open habitat within the floodplain at Riverside Parcels 3-A and 3-B.

Figure 24. Narrowleaf willow along the irrigation ditch at Riverside Parcels 3-A and 3-B.

4.2.4.1 BAT HABITAT FEATURES

Acoustic detectors were deployed at two survey points within the Riverside Subunit; RS-08 was deployed in the northwestern corner of Parcel 3-A above cut bank and sandbar features on the Virgin River. RS-08 is situated between creosote desert scrub to the north and patches of arrowweed and dense tamarisk to the south and west. Survey point RS-09 was installed at the southern end of Parcel 3-A, along the river's edge in a wet meadow area vegetated by saltgrass, arrowweed, and scattered screwbean mesquite trees (Figure 25).

In total, twelve bat species were recorded within the Riverside Subunit in 2019: pallid bat, pale Townsend's big-eared bat (an MSHCP-proposed covered and evaluation species), big brown bat, greater bonneted bat, silver-haired bat (a MSHCP-covered bat species), Western yellow bat, California myotis, Western small-footed myotis (an MSHCP evaluation species), Yuma myotis, big free-tailed bat, canyon bat, and Brazilian free-tailed bat. Bat activity data collected at survey point RS-08, as measured by the mean files per survey-night, were nearly twice as high as the activity levels recorded at RS-09 (Figure 9; Appendix A). Dense riparian scrub and wet meadow habitat along the banks of the Virgin River likely support high densities of flying insects that bats prey upon, such as flies, moths, and mosquitoes. The irrigation channel located in Parcel 3-A, when flowing, provides a potential slow-moving water source for bats (see Figure 24). Adjacent to the floodplain, upland desert habitat may provide suitable foraging habitat for pallid bats, which forage on the desert floor or in low brush for scorpions, centipedes, and small terrestrial vertebrates, such as lizards.

As suitable bat roosting habitat within the Riverside Subunit is limited, many of the bat species recorded at Riverside were likely foraging or moving through the site. Along this stretch of the Virgin River, however, suitable bat roosting habitat is varied and widespread. Crevices located in the eroded cliff walls in the northern end of the parcel may provide suitable roosting habitat for canyon bat and California myotis. Fan palm trees (*Washingtonia* spp.), which are scattered throughout the residential areas south of the unit, are known to be utilized by the Western yellow bat as roosting substrate. Many of the bat species recorded at the Riverside Subunit are also known to roost in abandoned buildings and/or under bridges (pallid bat, pale Townsend's big-eared bat, big brown bat, western bonneted bat, California myotis, Yuma myotis, big free-tailed bat, canyon bat, and Brazilian free-tailed bat), and many of these potential roost features are located upstream and downstream of the Subunit within the Virgin River floodplain.

Figure 25. Acoustic bat survey points RS-08 (left) and RS-09 (right) in the Riverside (3A/3B) Subunit.

4.2.5 Muddy River

Vegetation at the Muddy River RRU is highly diverse. The Muddy River RRU is composed primarily of creosote bush upland and mesic forest, and the unit lacks the desert riparian habitat that occurs at the Virgin River Subunits. Parcels A through E are dominated by horticultural plantings (e.g., pine [*Pinus* spp.] and California fan palm [*Washingtonia filifera*]) (Figure 26), creosote bush (*Larrea tridentata*) scrubland, or big saltbush (*Atriplex lentiformis*). Parcel F is dominated almost completely by creosote bush scrub, with smaller patches of honey mesquite, particularly in the central and southeast portions of the Parcel (Figure 27). Parcels G through I are composed largely of very dense thickets of big saltbush and Mojave seablite (*Suaeda moquinii*) mixed with scattered honey mesquite and tamarisk (Figure 28). While the Muddy River runs near the Muddy River RRU, it does not run through any of the southern Parcels and only forms the eastern boundary of Parcels A through E. This portion of the Muddy River is also deeply incised, and true desert riparian vegetation, consisting of widely scattered tamarisk and velvet ash (*Fraxinus velutina*), is generally limited to within a couple of meters of the riverbank.

Figure 26. Horticultural trees planted at Muddy River Parcels A-E.

Figure 27. Creosote bush habitat with scattered honey mesquite at Muddy River Parcel F.

Figure 28. Varied scrub habitat at Muddy River Parcels G-I.

4.2.5.1 BAT HABITAT FEATURES

Acoustic detectors were deployed at five survey points within the Muddy River Unit. MR-01 and MR-02 were deployed directly adjacent to the Muddy River; dominant vegetation near MR-01 consisted of velvet ash, tamarisk, quailbush (*Atriplex lentiformis*), and scattered palm trees. Dominant vegetation near MR-02 consisted of arrowweed and giant reed (*Arundo donax*); this area was recently restored with native species plantings, including Fremont cottonwood, willow, mesquite (*Prosopis* spp.), seep willow (*Baccharis* spp.), and alkali sacaton (*Sporobolus airoides*) (Figure 29). MR-03 and MR-04 were deployed in rocky, upland areas near rock crevices; dominant vegetation near MR-03 consisted of creosote-white bursage desert scrub. Dominant vegetation near MR-04 consisted of a large patch of honey mesquite adjacent to mixed salt desert scrub dominated by quailbush and Mojave seablite (*Suaeda moquinii*). MR-05 was located in mixed salt desert scrub; noted vegetation in the vicinity included alkali sacaton, tamarisk, Mojave seablite, quailbush, and scattered honey mesquite (Figure 30 and Figure 31).

In total, twelve bat species were recorded within the Muddy River parcel in 2019: pallid bat, pale Townsend's big-eared bat (an MSHCP-proposed covered and evaluation species), big brown bat, hoary bat, silver-haired bat (a MSHCP-covered bat species), Western yellow bat, California myotis, Yuma myotis, big free-tailed bat, canyon bat, and Brazilian free-tailed bat. A variety of potential bat roosting

and foraging habitat is located near or adjacent to the Muddy River Unit, which is reflected in the high bat species diversity observed at this location.

Based on acoustic analysis, bat activity within the project area was highest at survey point MR-02, which was located along the banks of the Muddy River within mixed invasive and native desert riparian habitat. Surface water in the active channel of the Muddy River likely provides water to multiple bat species, and dense riparian and upland vegetation within and adjacent to the Muddy River channel likely supports high densities of flying insect populations that various bat species prey upon.

Many bat species detected within the unit are known to roost in trees, and include, big brown bat, hoary bat, silver-haired bat (a MSHCP-covered bat species), and Western yellow bat (and, to a lesser extent, pallid bat, greater bonneted bat, California myotis, and big free-tailed bat will also roost in trees). Bats likely roost in large, deciduous riparian trees located within and near the unit, such as Fremont cottonwood, velvet ash, and Goodding's willow. Western yellow bat, in particular, has been documented utilizing the Warm Springs Natural Area just north of the Muddy River unit (Williams et al. 2006; Southern Nevada Water Authority 2011), and likely roosts in the dead fronds of palm trees (*Washingtonia* spp.) that are scattered within and adjacent to the unit.

Large crevices are located in the eroded cliff walls in the southeastern portion of the unit (see Figure 31), which may provide suitable roosting habitat for various observed species such as California myotis, Yuma myotis, and canyon bat. Many of the bat species detected in the Muddy River unit may also be roosting in buildings, bridges, and other man-made structures that are located in the vicinity, such as pallid bat, pale Townsend's big-eared bat, big brown bat, western bonneted bat, California myotis, Yuma myotis, big free-tailed bat, canyon bat, and Brazilian free-tailed bat. Adjacent to the unit, large areas of upland desert scrub may provide suitable terrestrial foraging habitat for pallid bats, which are known to glean prey items from the desert floor or low brush, including beetles, scorpions, centipedes, and occasionally lizards (Wilson et al. 1999; Reid 2006).

Figure 29. Acoustic bat survey points MR-01 (left) and MR-02 (right) in the Muddy River RRU.

Figure 30. Acoustic bat survey points MR-03 (left) and MR-04 (right) in the Muddy River RRU.

Figure 31. Potential bat roosting habitat near acoustic bat survey point MR-04 (left); acoustic bat survey point MR-05 (right) in the Muddy River RRU.

4.2.6 BCCE

Mojave Desert scrub, which is co-dominated by creosote bush and burrobush (*Ambrosia dumosa*), is the dominant vegetation community across the Mojave Desert, and this community covers over 97% of the BCCE (Clark County 2019b). All of the acoustic bat survey locations are situated within this habitat type (Figure 32). The remainder of the BCCE is composed of salt desert scrub (1.5%), mesquite/acacia habitat (less than 1%), and previously disturbed habitat (Clark County 2019b). There are also scattered, dense populations of silver cholla along the foothills of the BCCE. Mesquite/acacia habitat is present along ephemeral washes within the BCCE (Figure 33). A small spring, Forlorn Hope Spring, is located near survey point BCCE-07 (see Figure 11); vegetation at the spring consists mostly of honey mesquite and lacks species typical of desert riparian habitat, such as willow and cottonwood (Figure 34).

Figure 32. Examples of Mojave Desert scrub habitat within the BCCE.

Figure 33. Examples of dense cholla (left) and mesquite-acacia desert wash habitat within the BCCE (right).

Figure 34. Mesquite-acacia habitat at Forlorn Hope Spring, near survey point BCCE-07.

4.2.6.1 BAT HABITAT FEATURES

Acoustic detectors were deployed at 16 survey points within the BCCE (see Figure 7). Based on SWReGAP land cover data (U.S. Geological Survey, 2004), all 16 survey points are located within creosote bush-white bursage scrub. Photographs of each survey point were not collected; however, Figure 32 through Figure 34 provide examples of the various habitat features within the BCCE.

In total, seven bat species were recorded within the BCCE in 2018: silver-haired bat (a MSHCP-covered bat species), Western yellow bat, California myotis, Western small-footed myotis (an MSHCP evaluation species), Yuma myotis, canyon bat, and Brazilian free-tailed bat. A majority of the bat echolocation files documented within the BCCE were identified as canyon bat or Brazilian free-tailed bat.

Relative to the RRU acoustic data, bat species diversity and activity data collected within the BCCE were much lower. These differences may be explained by the paucity of bat attractant features and roosting habitat within the BCCE. However, the timing and duration of acoustic bat surveys varied considerably between each location, which precludes a statistically robust analysis of differences in bat habitat selection and activity across all the County-managed properties.

Numerous cliffs, crevices, and rockpiles located in the mountains and foothills that surround the BCCE may provide suitable roosting habitat for such saxicolous bat species as California myotis, Western small-footed myotis, Yuma myotis, and canyon bat, which are known to utilize the area. Most of the bat species detected in the BCCE are those that are known to occur in desert scrub habitat, namely California myotis, Western small-footed myotis, Yuma myotis, canyon bat, and Brazilian free-tailed bat. A notable exception is Western yellow bat, which was recorded in the northeastern end of the BCCE at Survey Site BCCE-01. This species is usually restricted to desert riparian habitat, although it has also been documented roosting in trees (particularly fan palms) in urban areas, which are located within three miles north of this point in Boulder City, Nevada. In addition, potential bat attractant features located within several miles of this survey point to the north and west include a desert riparian corridor along Quail Wash, and wastewater treatment ponds at the Boulder City Lagoon (see Figure 7).

5 CONCLUSION

One MSHCP-covered bat species, and two MSHCP evaluation bat species, were recorded within the project area. Some notable conclusions about MSHCP bat species and their habitats at the County's properties include:

- Thirteen species of bats were acoustically detected within the project area. In particular, high bat species diversity was observed at the Muddy River Unit and the Riverside Subunit (12 species at each location), which is likely associated with an abundance of attractant features and roosting sites within and near these locations.
- Acoustic bat surveys detected one species covered by the Clark County MSHCP, silver-haired bat (*Lasionycteris noctivagans*). This species was detected at the BCCE and at all of the RRUs. The silver-haired bat is a tree specialist; they will utilize hollow trees, bark, and woodpecker holes as maternity and day/night roost sites. There is no suitable roosting habitat for this species within the BCCE, however, and recordings of this species at the BCCE are likely from individuals moving through, or foraging within, the area.
- Acoustic surveys also detected pale Townsend's big-eared bat (*Corynorhinus townsendii*), an MSHCP-proposed covered and evaluation bat species, and Western small-footed myotis (*Myotis ciliolabrum*), an evaluation bat species. Pale Townsend's big eared bat is often referred to as a "quiet bat," as it will often produce low-amplitude vocalizations, and can also hunt

by sight alone; as a result, it is rarely detected acoustically and so may be under-represented. This species was detected at the Muddy River (MR-02, MR-03, and MR-04) Unit and Riverside (RS-08) Subunit.

- Of note are several recordings of two Molossid bats, greater bonneted bat (*Eumops perotis*) and big free-tailed bat (*Nyctinomops macrotis*), collected within the project area. There are relatively few confirmed acoustic records for either of these species in Nevada (Williams et al. 2006; Bradley et al. 2006; Las Vegas Wash Coordination Committee 2011). Both species were recorded at the Bunkerville South, Muddy River, and Riverside properties in 2019. Greater bonneted bats, in particular, are known to fly up to 15 miles (25 kilometers) nightly to foraging areas (Reid 2006). These are fast, high-flying bat species that are known to roost in elevated features with high exposure, such as rock crevices, buildings, and hollow trees.
- Most (70%) of the bat echolocation files that were documented within the project area, and identified to species, were identified as canyon bat (*Parastrellus hesperus*) or Brazilian free-tailed bat (*Tadarida brasiliensis*). These are both widespread and abundant species that roost and forage in a variety of habitat types.

6 RECOMMENDATIONS

Based on observations from the 2018 and 2019 acoustic bat surveys and factors discussed in this report, there are several recommendations provided here that would support the County's long-term goals for the RRUs and the BCCE:

- Acoustic bat data collected for this project indicate that multiple bat species, including MSHCP-covered species, are foraging, and likely roosting, within County-managed lands. As directed by the *Clark County Desert Conservation Program Riparian Reserve Units Management Plan* (Clark County 2015), the County should continue to purchase parcels along the Virgin and Muddy Rivers, particularly available parcels adjacent to the existing RRUs (if possible), and attempt to purchase parcels along the Meadow Valley Wash.
- Acoustic bat surveys should be continued for subsequent years to help build on baseline data and to track changes in species occurrence and activity throughout the acquisition, restoration, and monitoring stages. These surveys should use the protocols established for this project to ensure datasets are standardized and comparable.
- Future acoustic survey design should consider sampling at multiple sites simultaneously to control for temporal variation and facilitate robust comparative analysis of bat activity and habitat use between sites.
- To manage for the benefit of the MSHCP-covered silver-haired bat, future restoration efforts should be focused on the protection of existing stands, and the establishment of new stands, of large, deciduous riparian tree species such as Fremont cottonwood, velvet ash, and Goodding's willow. Any dead, hollow trees that are located within the project area should also be protected, as they can provide valuable roosting substrate to silver-haired bat and other bat species that occur within the project area, and provide nesting, perching, and foraging habitat for many avian species as well.
- Bats will often drink from man-made water structures such as cattle tanks and troughs, and bat mortalities resulting from drowning in these structures have been frequently observed. It is recommended that the County either disable, or install escape ramps on, any of these structures that may exist on County-managed lands.

7 LITERATURE CITED

Clark County. 2000. *Final Clark County Multiple Species Habitat Conservation Plan and Environmental Impact Statement for Issuance of a Permit to Allow Incidental Take of 79 Species in Clark County, Nevada*. Prepared by RECON, San Diego, California. Las Vegas, Nevada: Clark County Department of Comprehensive Planning, and Reno, Nevada: U.S. Fish and Wildlife Service.

———. 2015. *Clark County Desert Conservation Program Riparian Reserve Units Management Plan*. February 2015.

———. 2019a. Clark County MSHCP Proposed Covered Species List. Available at: http://www.clarkcountynv.gov/airquality/dcp/Documents/Library/dcp%20reports/2019/Proposed%20Covered%20Species%20List.pdf.

———. 2019b. *Clark County Desert Conservation Program Boulder City Conservation Easement Management Plan*. Version 3.4, February 2019. Available at: http://www.clarkcountynv.gov/airquality/dcp/Documents/mitigation/bcce/BCCE%20Management%20Plan%20%20Version%203.4%20Final.pdf. Accessed September 2019.

Las Vegas Wash Coordinating Committee. 2011. Las Vegas Wash Bat Survey, 2004-2009. March. Available at: https://www.lvwash.org/assets/pdf/resources_wildlife_bats.pdf. Accessed February 16, 2020.

Reid, Fiona. 2006. A field guide to mammals of North America. 4th edition. Peterson Field Guide Series.

Southern Nevada Water Authority (SNWA). 2011. Warm Springs Natural Area Stewardship Plan. June. Available at: http://water.nv.gov/hearings/past/Spring%20-%20Cave%20-%20Dry%20Lake%20and%20Delamar%20Valleys%202011/Exhibits/SNWA%20Exhibits/SNWA_Exh_416_WSNA%20Stewardship%20Plan.pdf. Accessed on March 1, 2020.

SWCA Environmental Consultants (SWCA). 2019. Avian Surveys on MSHCP Properties: 2019 Final Project Report. September.

Szewczak, Joe. 2017. Echolocation Call Characteristics of Southwestern US Bats. Sonobat Version 4.x.

———. 2018. Echolocation Call Characteristics of Western US Bats. June.

Tyburec, Janet. 2019. Echolocation Call Spectrograms: A Primer for Acoustic ID.

U.S. Fish and Wildlife Service (USFWS). 2000. *Intra-Service Biological and Conference Opinion on Issuance of an Incidental Take Permit to Clark County, Nevada for a Multiple Species Habitat Conservation Plan*. Available at: http://www.clarkcountynv.gov/airquality/dcp/Documents/Library/Guiding%20Docs/current/MSHCP_BioOpin.pdf. Accessed March 1, 2020.

———. 2001. Clark County Desert Conservation Plan Permit TE-034927-0.

U.S. Geological Survey. 2004. Provisional digital land cover map for the Southwestern United States. Version 1.0. National Gap Analysis Program. Logan, Utah: RS/GIS Laboratory, College of Natural Resources, Utah State University.

Wildlife Action Plan Team. 2012. *Nevada Wildlife Action Plan*. Nevada Department of Wildlife, Reno.

Williams, Jason A., Michael J. O'Farrell, and Brett R. Riddle. 2006. Habit Use by Bats in a Riparian Corridor of the Mojave Desert in Southern Nevada. Journal of Mammalogy, Volume 87, Issue 6, 29 December. Available at: https://academic.oup.com/jmammal/article/87/6/1145/885979. Accessed on February 16, 2020.

Wilson, D. E., Ruff, S., American Society of Mammalogists, & Smithsonian Institution. (1999). The Smithsonian book of North American mammals. Vancouver: UBC Press.

APPENDIX A

Species Occurrence Matrix

Appendix A. Average of Mean Files Per Survey Night by Species and Location.

Location	Survey Point	Bat Species (4-letter Code) Detection Rate (bats per survey night) within the Project Area*															Total per Survey Point	Percent of Project Total
		ANPA	COTO	EPFU	EUPE	HIF	LACI	LANO	LAXA	LOF	MYCA	MYCI	MYYU	NYMA	PAHE	TABR	NoID		
RRU	MR_01	0.17	-	0.50	-	0.50	0.33	2.17	-	1.33	13.83	-	0.33	-	0.17	8.67	144.00	172.00	7.34
	MR_02	-	0.17	7.33	-	2.33	0.33	6.50	3.67	1.67	14.50	-	6.00	-	2.17	36.00	569.83	650.50	27.76
	MR_03	0.17	0.33	-	-	-	-	1.67	0.17	0.33	23.67	-	-	-	4.50	8.67	12.50	52.00	2.22
	MR_04	0.14	0.14	4.00	0.14	0.29	1.14	9.14	1.86	1.29	19.00	-	0.29	0.29	15.14	54.29	92.00	199.14	8.50
	MR_05	-	-	0.14	-	-	0.14	3.29	-	0.86	0.43	-	0.14	-	1.57	24.86	16.71	48.14	2.05
	MM_06	0.33	-	-	-	0.56	-	0.67	0.11	0.22	85.22	-	1.00	-	23.11	16.00	36.78	164.00	7.00
	MM_07	0.11	-	-	-	0.11	-	1.33	-	0.22	6.11	-	0.33	-	31.67	14.33	18.78	73.00	3.12
	RS_08	0.63	0.13	2.63	-	0.38	-	0.75	0.13	1.38	17.25	-	0.25	0.13	66.88	16.75	104.00	211.25	9.01
	RS_09	2.63	-	0.50	0.13	0.13	-	0.63	-	0.38	6.75	0.13	0.13	0.13	18.13	19.00	39.63	88.25	3.77
	BS_10	0.13	-	1.00	-	-	-	10.38	0.13	2.00	2.88	-	0.25	0.13	42.38	64.38	99.75	223.38	9.53
	BS_11	-	-	1.50	0.13	0.50	-	4.88	0.13	0.88	1.25	-	1.75	-	12.00	28.88	59.50	111.38	4.75
	BN_12	-	-	-	-	0.14	0.43	2.29	0.14	0.57	4.57	-	2.57	-	24.57	16.86	55.43	107.57	4.59
	BN_13	-	-	0.57	-	-	0.29	1.57	0.57	0.43	4.57	-	1.00	-	23.86	18.14	30.43	81.43	3.47
BCCE	BCCE_01	-	-	-	-	0.14	-	-	0.14	0.29	0.57	-	-	-	2.57	2.14	2.29	8.14	0.35
	BCCE_02	-	-	-	-	-	-	0.14	-	-	0.43	-	-	-	0.86	2.14	1.14	4.71	0.20
	BCCE_03	-	-	-	-	-	-	-	-	-	0.14	-	-	-	0.43	2.86	1.43	4.86	0.21
	BCCE_04	-	-	-	-	-	-	-	-	-	-	-	-	-	0.57	6.14	3.00	9.71	0.41
	BCCE_05	-	-	-	-	-	-	-	-	-	0.29	-	-	-	0.14	3.29	1.57	5.29	0.23
	BCCE_06	-	-	-	-	-	-	-	-	-	0.33	-	-	-	0.17	1.00	0.83	2.33	0.10
	BCCE_07	-	-	-	-	-	-	-	-	-	-	-	-	-	0.71	1.86	0.43	3.00	0.13
	BCCE_08	-	-	-	-	-	-	0.14	-	0.14	0.29	-	-	-	24.43	15.14	15.43	55.57	2.37
	BCCE_09	-	-	-	-	-	-	0.43	-	-	0.29	-	-	-	1.57	16.57	7.29	26.14	1.12
	BCCE_10	-	-	-	-	-	-	-	-	-	1.43	0.14	-	-	2.71	3.29	1.57	9.14	0.39
	BCCE_11	-	-	-	-	-	-	-	-	-	0.17	-	-	-	0.33	0.33	0.50	1.33	0.06
	BCCE_12	-	-	-	-	-	-	0.14	-	-	0.29	0.29	-	-	0.57	7.14	4.00	12.43	0.53
	BCCE_13	-	-	-	-	-	-	0.14	-	-	0.14	-	0.14	-	0.29	3.43	1.29	5.43	0.23
	BCCE_14	-	-	-	-	-	-	-	-	0.14	-	-	-	-	1.00	0.29	1.43	2.86	0.12
	BCCE_15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.50	0.17	0.67	0.03
	BCCE_16	-	-	-	-	-	-	0.14	-	0.14	0.29	-	0.14	-	1.29	5.57	2.14	9.71	0.41
Total		4.30	0.77	18.17	0.39	5.07	2.67	46.39	7.03	12.26	204.67	0.55	14.33	0.66	303.77	398.50	1,323.84	2,343.37	-
Percent Total		0.18	0.03	0.78	0.02	0.22	0.11	1.98	0.30	0.52	8.73	0.02	0.61	0.03	12.96	17.01	56.49	-	-
Percent Total by Species		0.43	0.08	1.81	0.04	-	0.27	4.63	0.70	-	20.42	0.06	1.43	0.07	30.31	39.76	-	-	-

* Refer to Table 3 in the main document for full species names.