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Desert Tortoise Telemetry Around Culverts
Project Number: 2015-ECOCENTRIC-1580E
Clark County, Nevada
November 1, 2020 - June 15, 2022

Final Report
June 1, 2022

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Desert Conservation Program
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Executive Summary

This project report details a study undertaken to determine whether desert tortoises use highway culverts to cross roads. Roads can serve as barriers to movement and subsequent mating by desert tortoises and other species. Because adequate gene flow is crucial for the long-term survival of the threatened desert tortoise, which faces widespread habitat disruption, understanding how to maintain connection between populations separated by anthropogenic features such as highways may contribute to the long-term survival of the species (Averill-Murray et al., 2021). This project contributed to that effort by collecting data on tortoise movement in relation to culverts along portions of US-95 north of Las Vegas, Nevada.

This study was initiated by Clark County Nevada as part of its Multiple Species Habitat Conservation Plan (MSHCP), which promotes conservation of protected species and their habitats to ensure their long-term survival. The Clark County Desert Conservation Program (DCP), representing Boulder City, Henderson, Las Vegas, North Las Vegas, the Nevada Department of Transportation, and Clark County, is tasked with maintaining compliance with the MSHCP and the associated Incidental Take Permit (ITP) granted under Section 10(a)(1)(B) of the Endangered Species Act (ESA). The Mojave Desert tortoise (*Gopherus agassizii)* is listed by the United States Fish and Wildlife Service (USFWS) as a threatened species and is designated a protected species under the MSHCP

Ecocentric, a Henderson, Nevada-based biological services company, provided field biologists, GIS staff, and data and project management to successfully complete this project. The study is part of a larger effort by the Clark County Desert Conservation Program, the United States Fish and Wildlife Service, and the Bureau of Land Management (BLM) to gain a better understanding of tortoise population connectivity throughout the Mojave Desert.

The aim of the study was to record tortoise movement and assess their utilization of box culverts along Highway 95 using GPS data loggers and radio telemetry encounters. This assessment involved 1) monitoring a population of up to 20 adult resident tortoises living near these culverts and 2) monitoring a population of up to 20 adult translocated tortoises, who were to be released in the same area. A total of 15 resident tortoises were located in the study area. Because of significant predation pressures experienced by the resident tortoises, BLM and USFWS decided not to translocate tortoises to the site. Therefore, no results were obtained for a population of translocated tortoises as they were never released for monitoring.

To collect movement data from March 2021 to May 2022, we completed radio telemetry encounters and deployed i-gotU GT-120 Global Positioning System (GPS) data loggers on 15 resident tortoises (6 female, 9 male) for a total of 311 radio telemetry encounters and 67 unique GPS logger deployments, comprising 51,259 location recordings. Of significance, we recorded one male resident tortoise (CC0477) utilizing a culvert to cross the highway twice during the project: moving to the south side of the highway in April, and returning to the north side on June 30, 2021.

Unfortunately, monitored tortoises experienced significant mortality. Only three tortoises survived to the project conclusion, all of which were female. Ten tortoises (3 female, 7 male) were found dead between June and October 2022, and all these mortality events were thought to be caused by canid predation. Two male tortoises went missing over the summer and are presumed to have been predated. Resident tortoises experienced a mortality rate of 66.67% (missing tortoises assumed alive) or 80% (missing tortoises presumed dead) over the first six months of the project (comprising most of the March-October active season). While we were able to record the movement data on the resident tortoises, the project fell short of accomplishing the intended goal due to the high resident tortoise mortality and subsequent non-release of translocated tortoises.

1.0 – Introduction

1.1 Project Background and Description

Several threats contributed to the listing of the Mojave desert tortoise (*Gopherus agassizii)* as a threatened species under the Endangered Species Act including habitat loss, predation, and disease (USFWS, 2011). Continued development throughout the range of the threatened Mojave Desert tortoise and the subsequent fragmentation of its habitat comprise two of the greatest ongoing threats to the long-term survival of the species. Roads and highways can be especially detrimental to population connectivity and gene flow as they are hazardous for tortoises to cross. In many cases, highways within the tortoise's range are fenced to keep tortoises from entering the roadway. While this measure will protect tortoises from highway fatalities, it does not address the long-term detriment of creating genetically isolated tortoise populations. Culverts, a channel, structure, or conduit for drainage under roads, and in particular box culverts, those of rectangular shape made of concrete, have been proposed as a method to allow for tortoise movement across roadways.

The *Desert Tortoise Telemetry Around Culverts* project (2015-ECOCENTRIC-1580E) was initiated to monitor a population of resident and translocated tortoises along Highway 95 (US-95) in Clark County, north of Las Vegas, Nevada. Resident tortoises were encountered during mark-recapture surveys in spring 2021 conducted by Ecocentric for the Desert *Tortoise Connectivity Across Roadways* project (2015-ECOCENT-1580B). The resident tortoises were located on plots adjacent to box culverts along Highway 95 between mileposts 121 and 132 west of Indian Springs, Nevada (Figure 1). Tortoises were monitored using VHF radio telemetry and were affixed with Global Positioning System (GPS) data loggers to record daily movement.

This work was supported by the Clark County DCP and is in coordination with a larger population connectivity study by the U.S. Fish and Wildlife Service and the Bureau of Land Management. The project is part of a larger conservation effort to further implement Clark County's Multiple Species Habitat Conservation Plan (MHSCP), permit #TE034927-0, effective February 1, 2001, and was funded in accordance with the Southern Nevada Public Land Management Act (SNPLMA) (Clark County, 2000).

1.2 Management Actions Addressed (As Identified in the MSHCP)

As outlined in Clark County, Nevada's MSHCP, the County is required to implement conservation actions within the county to mitigate take of protected species. The MSHCP was created to help the County maintain compliance with the Endangered Species Act and the county's Section 10(a)(1)(B) incidental take permit.

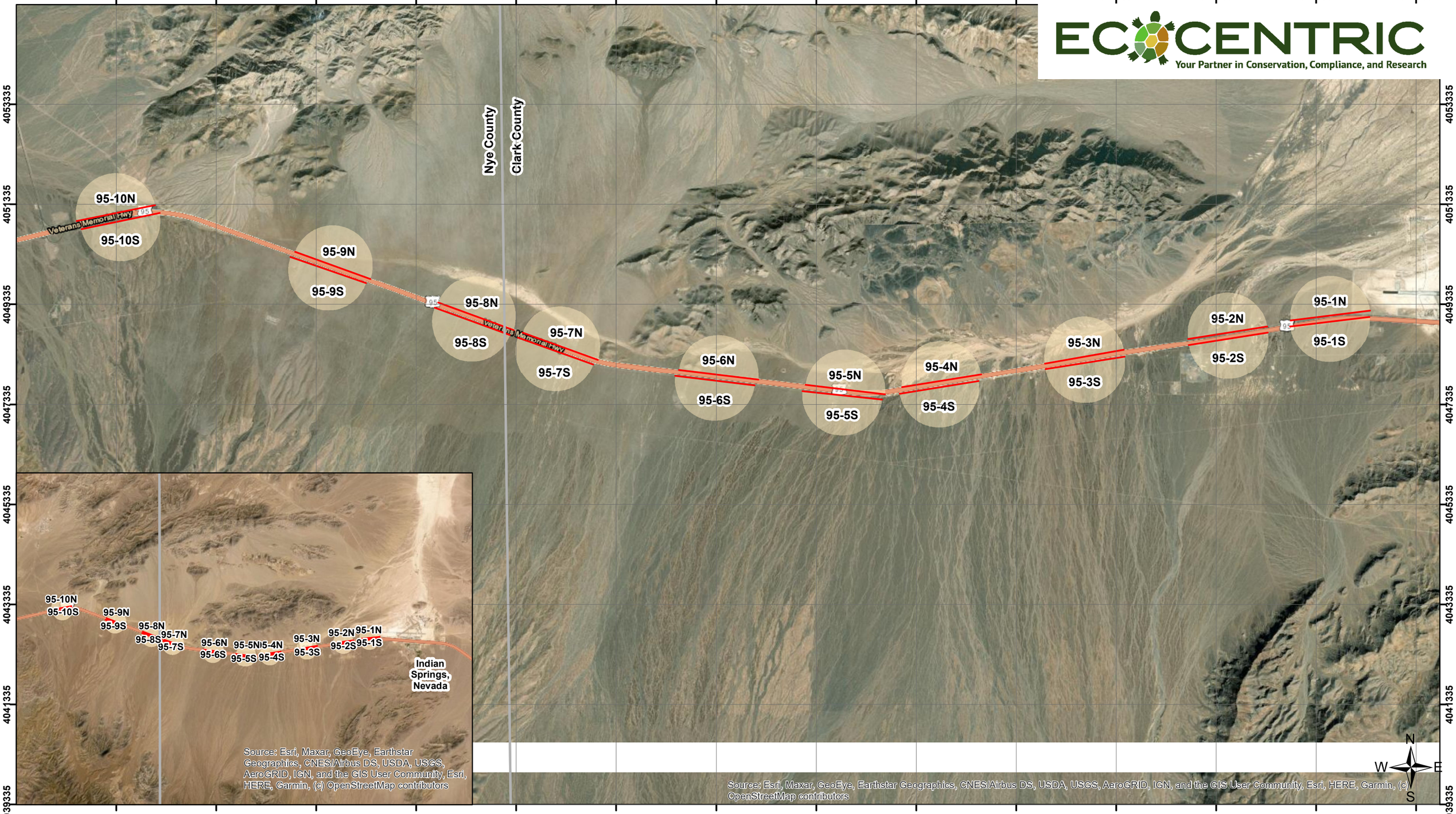
Specifically, the MSHCP identifies the following as primary goals: (a) No net unmitigated loss or fragmentation of habitat and (b) Maintain stable or increasing populations of covered species. The MSHCP seeks to maintain the long-term value of ecosystems in Clark County by providing a balance between allowing incidental take of covered species and ensuring the long-term recovery of those species and their habitat.

The desert tortoise is a federally-threatened species under the Endangered Species Act and is considered a covered species by the MSHCP. Therefore, the County is required to implement measures to ensure conservation of tortoise populations and their habitat within Clark County. This project contributes to the completion of goals outlined by the MSHCP by assessing tortoise utilization of box culverts as population connectors. This assessment can inform future conservation efforts by Clark County and its partners to protect the species.

1.3 Project Goals and Objectives

As outlined in the project Scope of Work, the goal of the project was to understand how tortoises utilize box culverts by recording their daily movement patterns using GPS data loggers. One objective was to attach transmitters and GPS loggers on up to 20 resident tortoises encountered during the previously mentioned surveys in 2021, and to record their movement patterns. A second objective was to record the movement of up to 20 translocated tortoises that were slated to be released on plots with the resident tortoises.

Data collected from this project will be analyzed to assess tortoise utilization of box culverts and to determine the culverts' effectiveness in maintaining connectivity between populations of tortoises separated by impermeable barriers such as highways with tortoise-proof fencing.



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US-95 Survey Plot

US-95 Plot Line

This map is for display purposes only.
Inset maps display plots US95 1 thru 10
& Plots in relation to Indian Springs, NV

Figure 1. US-95 Plot Names and Locations
Desert Tortoise Telemetry Around Culverts
Project 2015-ECOCENTRIC-1580E
Clark County, Nevada
March 2021 – May 2022

Section 2.0 – Methods and Materials

2.1 Tortoise Monitoring

Tortoises were monitored following USFWS guidelines in the Desert Tortoise Field Manual (USFWS, 2009) and the project Scope of Work. These guidelines required tortoises to be located once a week during the active season (March through October) and monthly during the inactive season (November through February). Tortoise monitoring consisted of the following aspects for this project: 1) radio telemetry for locating tortoises, 2) deploying GPS data loggers for movement data collection, 3) searching for missing tortoises as needed, and 4) tortoise mortality reporting.

2.1.1 Radio Telemetry Encounters

To facilitate location of tortoises during each monitoring event, biologists used a VHF receiver and antenna connected via co-axial cable to detect a signal emitted from a radio transmitter attached to the carapace of each tortoise. For this project, we used Holohil radio transmitters (RI-2B, 15.0 gram, 24-month battery life) with frequencies from 158.000 to 162.000 Hertz (Hz). Tortoises were tracked to their locations and the following information was recorded: a) tortoise identification number, b) date and time, c) fieldworker, d) the tortoise's geographic coordinates (UTM, NAD83 datum), e) the tortoise's activity (e.g., resting, feeding, digging, etc.), f) the tortoise's physical location in the landscape (e.g., burrow, shrub, in the open, etc.), g) the vegetation type (genus and species), h) interactions with other tortoises, and i) handheld GPS accuracy.

Radio transmitters were attached to the carapace of each tortoise using Devcon 5-Minute cream gel epoxy for the body and J-B Weld SteelStik steel-reinforced putty epoxy for the antenna attachments (Boarman et al., 1998). For male tortoises, we attached the transmitter to the fifth vertebral, or fourth left or right costal, and then affixed the antenna to anterior costal scutes, securing the entire transmitter to the carapace. The posterior placement of the transmitter body keeps the transmitter below the shell profile, reducing impedance to righting in the even the animal is overturned. For female tortoises, we placed the transmitter body on the first left or right costal and secured the antenna to posterior costal scutes. The anterior placement of the transmitter body on females ensured any potential mating would not be impeded. Due to the one-year duration of the project, no transmitter exchanges were required.

2.1.2 Tortoise Handling and Extraction

All desert tortoises were handled in accordance with the project contract and USFWS guidelines (USFWS, 2009, 2019) to ensure minimal risk to the animals. Tortoises were only extracted from burrows for a GPS logger exchange. In keeping with standard practice and given the severity of drought conditions within recent months, team members took measures to avoid exacerbating tortoise dehydration. If a tortoise voided its bladder during handling, non-invasive rehydration was attempted by offering clean drinking water from a sterile needless syringe. Tortoises were offered at least 40 milliliters (ml) of water per kilogram (kg) body weight with a minimum of 15 ml offered regardless of body weight (USFWS, 2019).

2.1.3 GPS Data Loggers

To record daily movements, modified Mobile Action i-gotU GT-120 GPS data loggers were deployed on each tortoise being monitored. To expand recording duration and decrease the number of handling events, we replaced the 380mAh factory batteries with 1000mAh batteries. With a slight modification, we were able to use the original case and the same brackets used for the factory units. A custom aluminum bracket was affixed to females on the third or fourth left or right costal; or on the third or fourth left or right costal, or the fifth vertebral on males; using Devcon 5-Minute cream gel epoxy under the bracket, and J-B Weld SteelStik steel reinforced putty epoxy along the front, top (dorsal), and bottom (ventral) sides. In cases where the bracket spanned more than one scute, care was taken to ensure that the gel and putty epoxy were only placed on the anterior scute. As with transmitter attachment, this is done to prevent any potential growth defects that could be caused by affixing the bracket to two scutes spanning a growth seam. The GPS logger units were then inserted into the bracket and held in place with 22-gauge aluminum wire along the back of the logger and weatherproof silicone along the front, top (dorsal), and bottom (ventral) sides. The larger battery size and secure, minimally invasive placement of the GPS loggers enhanced data collection and helped minimize stress to the tortoises.

Using the accompanying software (@TripPC), the loggers were set to record locations every 30 minutes, 24 hours a day. Loggers were exchanged every three to four weeks to ensure no lapses in data collection. Attached loggers were removed from the brackets by cutting the wire and silicone, and then freshly charged loggers were inserted into the bracket and secured with new wire and silicone. By utilizing this method, handling time is minimized (typically less than five minutes per exchange), reducing stress on the animal.

2.1.4 Missing Tortoises

Tortoises are considered missing once biologists are unable to locate them during a normal radio telemetry monitoring event. Missing adult tortoise events are sometimes caused by large displacement of the tortoise (typically 800 meters or more), due to which the radio signal is not readily received in the vicinity of the animal's last known location. Tortoises also go missing because of predator attacks leading to transmitter detachment or transmitter damage. Additional causes include battery expiration and equipment malfunction.

Tortoises missing due to large displacement have a high probability of being encountered, usually after widening the telemetry search area. Tortoises missing due to damaged or malfunctioning transmitters, where broadcast signal range is diminished, are occasionally recovered with a dedicated search effort. However, the signal of a damaged transmitter can be reduced to twenty meters or less, compared to the 200-meter or more range of a fully functional transmitter, making those animals with damaged, but still functional transmitters, difficult to encounter. In cases of transmitter detachment, complete malfunction, or suspected predator attack where the transmitter is rendered non-functional, missing tortoises are seldom recovered.

On this project, biologists spent at least ten hours actively searching for each missing tortoise. This included a local and widespread telemetry search, a visual search near the last known location or the location of a found transmitter, and a visual inspection of previously known burrows. In the case of a found transmitter, only visual searches and burrow inspections were able to be conducted for that animal. The searches were conducted over multiple days throughout the year to increase the likelihood of encountering an animal.

2.1.5 Tortoise Mortality

For reporting purposes, we documented each tortoise fatality by gathering a series of data for each event. These data included: date, time, location of the remains (UTM, NAD83), photos of the remains, percentage estimate of shell and soft tissue remaining, cause of death evidence, estimated time of death, and suspected cause of death. The Clark County DCP biologist was informed of each event and the suspected cause.

2.2 Data Collection and Processing

Data was collected in accordance with the parameters and guidelines outlined in the Clark County *Desert Tortoise Telemetry Around Culverts* Scope of Work and the USFWS Desert Tortoise Field Manual (USFWS, 2009). Fieldworkers recorded data for each encounter on *Tortoise Encounter* paper datasheets and corresponding digital forms. Digital records were created within the iForm application by Zerion Software on Android or iOS devices. Primary spatial data were recorded within iForm and a secondary location for verification purposes was collected on Garmin GPS handheld devices for each tortoise encounter. All location data was collected in Universal Transverse Mercator (UTM), North American Datum 1983 (NAD83), Zone 11S.

All radio telemetry encounter data were assessed for accuracy during three phases of integration into the final dataset. Prior to uploading electronic data at the end of each day, fieldworkers performed a first round of quality control by comparing the paper and electronic data forms and making any necessary corrections. During the integration process, all data were validated for thoroughness, redundancies, likelihood, spatial-temporal precision, and relational integrity. Lastly, a final round of quality control was completed comparing the paper datasheets to the uploaded electronic data. Discrepancies were recorded in a log and corrected in the final MS Access database.

Movement data recorded by the GPS data loggers was processed using @TripPC and R statistical software to 1) verify data collection, 2) remove points recorded when the logger was not attached to a tortoise, 3) remove improbable points recorded while the logger was attached based on elevation and speed (Hromada et al., 2020), and 4) analyze recording statistics for each unique logger deployment. We achieved these data analysis objectives using a four-step process. First, we completed an initial verification of the spatial data as the data loggers are downloaded in the @TripPC software, looking at points collected and the plotted data. Any obvious discrepancies were noted as they may indicate faulty logger programming or other malfunction. Any loggers suspected of malfunctioning were removed from future deployments until they could be tested to verify proper function.

Next, once all loggers had been downloaded, the raw data files were processed in R to remove points from the data file that were recorded before the logger was attached to the tortoise, or after the logger was removed. During this step, a column for tortoise identification numbers was created, and data from all deployments was combined into one dataset. The third step consisted of elevation screening (Laver et al., 2015) based on a United States Geological Survey (USGS) Digital Elevation Model and the recorded altitude. Using elevation screening, any recordings with absolute value differences between the DEM altitude and the recorded altitude greater than 25 meters are removed. Points were also removed when movement speed between any two points exceeded what is realistic for a tortoise (300 m/hour; Nussear and Esque, unpublished data). For the fourth and final step, we used R to analyze each unique deployment for the mean position fix rate, the number of hours the logger was on the tortoise, the number of points recorded, the number of points expected to be recorded if the logger recorded a point every 30 minutes, and the number of points that were removed due to high elevation error or unrealistic speed.

Section 3.0 – Results and Evidence of the Results

Tortoise Populations

One project objective was to monitor up to 20 resident tortoises located along US-95. In April and May of 2021, surveyors located 14 adult desert tortoises during mark-recapture surveys along US-95 culverts in Clark County (Figures 2 and 3). An additional tortoise was encountered incidentally in August 2021 and incorporated into the study. Demographic details for the resident tortoises can be found in Table 1. The second project objective, monitoring up to 20 translocated tortoises, was not completed since these animals were never released to the study site.

604433 606433 608433 610433 612433 614433 616433 618433

4050637 4048637 4046637 4044637 4042637

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95-1N
95-1S
95-2N
95-2S
95-3N
95-3S
95-4N
95-4S
95-5N
95-5S

Veterans Memorial Hwy
95

CC0675
5/10/2021

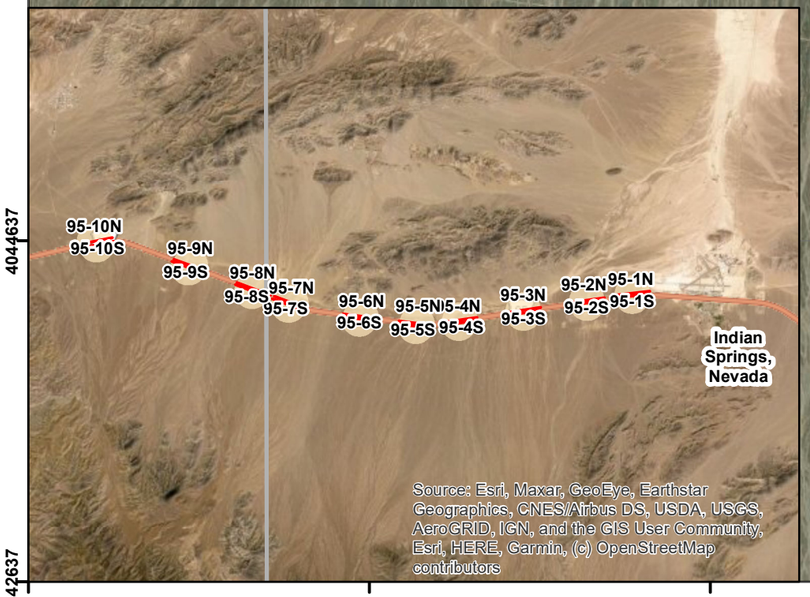
CC0724
5/10/2021

CC0726
8/19/2021

CC0677
5/13/2021

CC0461
4/9/2021

CC0462
4/10/2021



Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Esri, HERE, Garmin, (c) OpenStreetMap contributors

N
W E
S

Desert Tortoise Sex

▲ ***Female***

✚ ***Male***

US-95 Survey Plot

US-95 Plot Line

0 1,000 2,000 Meters

This map is for display purposes only.
Inset maps display plots US95 1 thru 10 & Plots in relation to Indian Springs, NV

Figure 2. Resident Tortoise Initial Encounter Locations, US-95 Plots 1-5
Desert Tortoise Telemetry Around Culverts
Project 2015-ECOCENTRIC-1580E
Clark County, Nevada
March 2021 – May 2022

589918 591918 593918 595918 597918 599918 601918 603918

4052931 4050931 4048931 4046931 4044931

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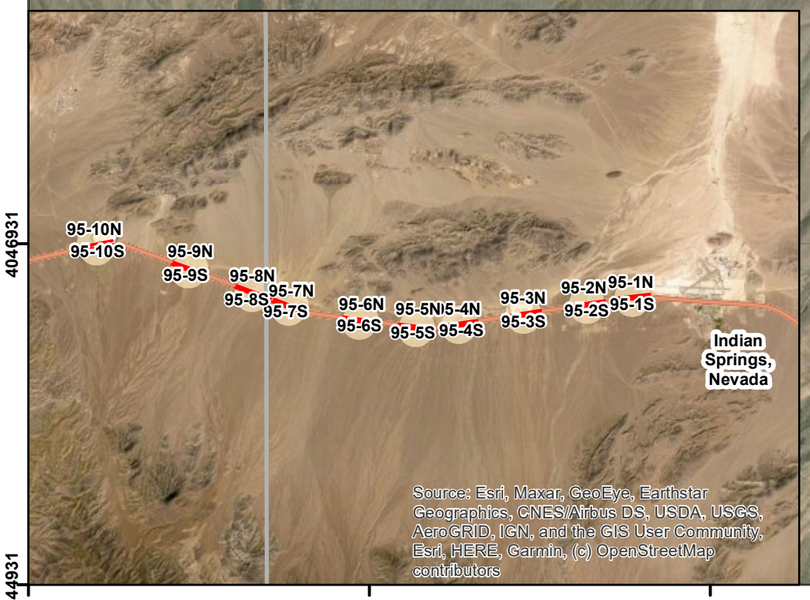
Nye County
Clark County

95-10N
95-10S
95-9N
95-9S
95-8N
95-8S
95-7N
95-7S
95-6N
95-6S

Veterans Memorial Hwy 95

CC0477
4/5/2021
CC0430
4/7/2021
CC0480
4/6/2021
CC0365
4/25/2021
CC0719
5/6/2021
CC0431
4/10/2021
CC0375
3/29/2021
CC0359
4/15/2021
CC0360
4/16/2021



Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Esri, HERE, Garmin, (c) OpenStreetMap contributors

N
W E
S

Desert Tortoise Sex

▲ *Female*

✚ *Male*

US-95 Survey Plot

US-95 Plot Line

0 1,000 2,000 Meters

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Inset maps display plots US95 1 thru 10 & Plots in relation to Indian Springs, NV

Figure 3. Resident Tortoise Initial Encounter Locations, US-95 Plots 6-10
Desert Tortoise Telemetry Around Culverts
Project 2015-ECOCENTRIC-1580E
Clark County, Nevada
March 2021 – May 2022

Table 1. Resident Tortoise Status Table

Table detailing demographics and encounter details for each of the 15 resident tortoises. Sorted by *Project-End Status* and *Tortoise ID*.

Tortoise ID	Project-End Status	Initial Encounter Plot	Initial Detection Date	Final Encounter Date	Carcass Detection Date	Sex	Initial MCL	Initial Mass	Number of Encounters During Monitoring	Number of GPS Logger Missions Recovered
CC0461	Alive	95-05S	9/Apr/2021	5/May/2022	---	Female	222	1500	44	9
CC0675	Alive	95-01S	10/May/2021	5/May/2022	---	Female	238	2400	38	7
CC0724	Alive	95-03S	10/May/2021	5/May/2022	---	Female	238	1750	40	8
CC0719	Missing	95-07S	6/May/2021	24/Jul/2021	---	Male	197	1400	14	2
CC0726	Missing	---	19/Aug/2021	25/Sep/2021	---	Male	263	3500	6	1
CC0359	Dead	95-06S	15/Apr/2021	24/Jul/2021	29/Jul/2021	Female	183	975	19	5
CC0360	Dead	95-06S	16/Apr/2021	16/Oct/2021	7/Sep/2021	Male	238	2100	24	6
CC0365	Dead	95-07S	25/Apr/2021	29/Jul/2021	6/Aug/2021	Female	235	2400	15	3
CC0375	Dead	95-06S	29/Mar/2021	16/Jun/2021	26/Jun/2021	Male	269	3150	16	4
CC0430	Dead	95-07S	7/Apr/2021	27/May/2021	1/Jun/2021	Male	237	1900	10	3
CC0431	Dead	95-06N	10/Apr/2021	29/Jul/2021	6/Aug/2021	Male	212	1400	19	4
CC0462	Dead	95-05S	10/Apr/2021	29/Jul/2021	16/Oct/2021	Male	232	1700	18	5
CC0477	Dead	95-07N	5/Apr/2021	13/Aug/2021	19/Aug/2021	Male	222	1830	21	6
CC0480	Dead	95-07S	6/Apr/2021	27/May/2021	1/Jun/2021	Female	264	2073	14	3
CC0677	Dead	95-04S	13/May/2021	7/Oct/2021	16/Oct/2021	Male	205	1700	24	8

Tortoise Movement Using Culverts

During the project, 311 radio telemetry encounters were completed from March 29, 2021, to May 5, 2022. Only one tortoise was recorded moving from one side of the highway to the other on two separate occasions. CC0477 (male, 222mm midline carapace length [MCL]), initially encountered on the north side of US-95 in April 2021, was located a week later on the south side of the highway, 1.3 kilometers from its previous location. On June 30, this tortoise crossed back to the north side of the highway, where it was monitored until its carcass was located on August 19, 2021 (Figure 4). The movement of CC0477 suggests that tortoises use culverts, at least upon occasion, to cross highways. Unfortunately, likely due to the small sample size and significant mortality of this population, no other highway crossings were recorded.

597646 598646 599646 600646 601646 602646

4049845 4048845 4047845 4046845

Nye County

Clark County

95-8N

95-8S

95-7N

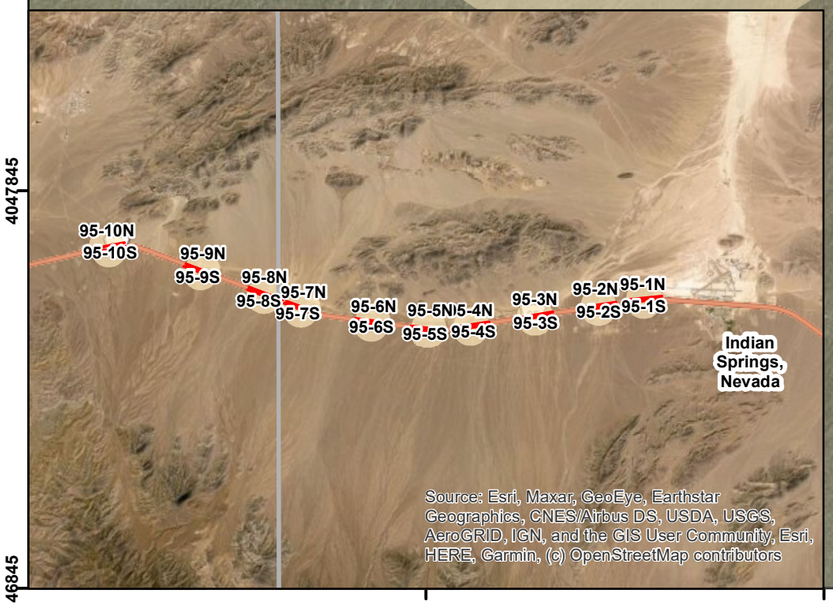
95-7S

95-6S

Veterans Memorial Hwy

95

Nuckles Rd



N W E S

Source: Esri, Maxar, GeoEye,

Tracking Points by Month

- *April 2021*
- *May 2021*
- *June 2021*
- *July 2021*
- *Aug 2021*

- *Initial Location*
- *Mortality Location*
- *Final Tracking Location*

- *Tracking Path*
- *US-95 Survey Plot*
- *US-95 Plot Line*

0 500 1,000 Meters

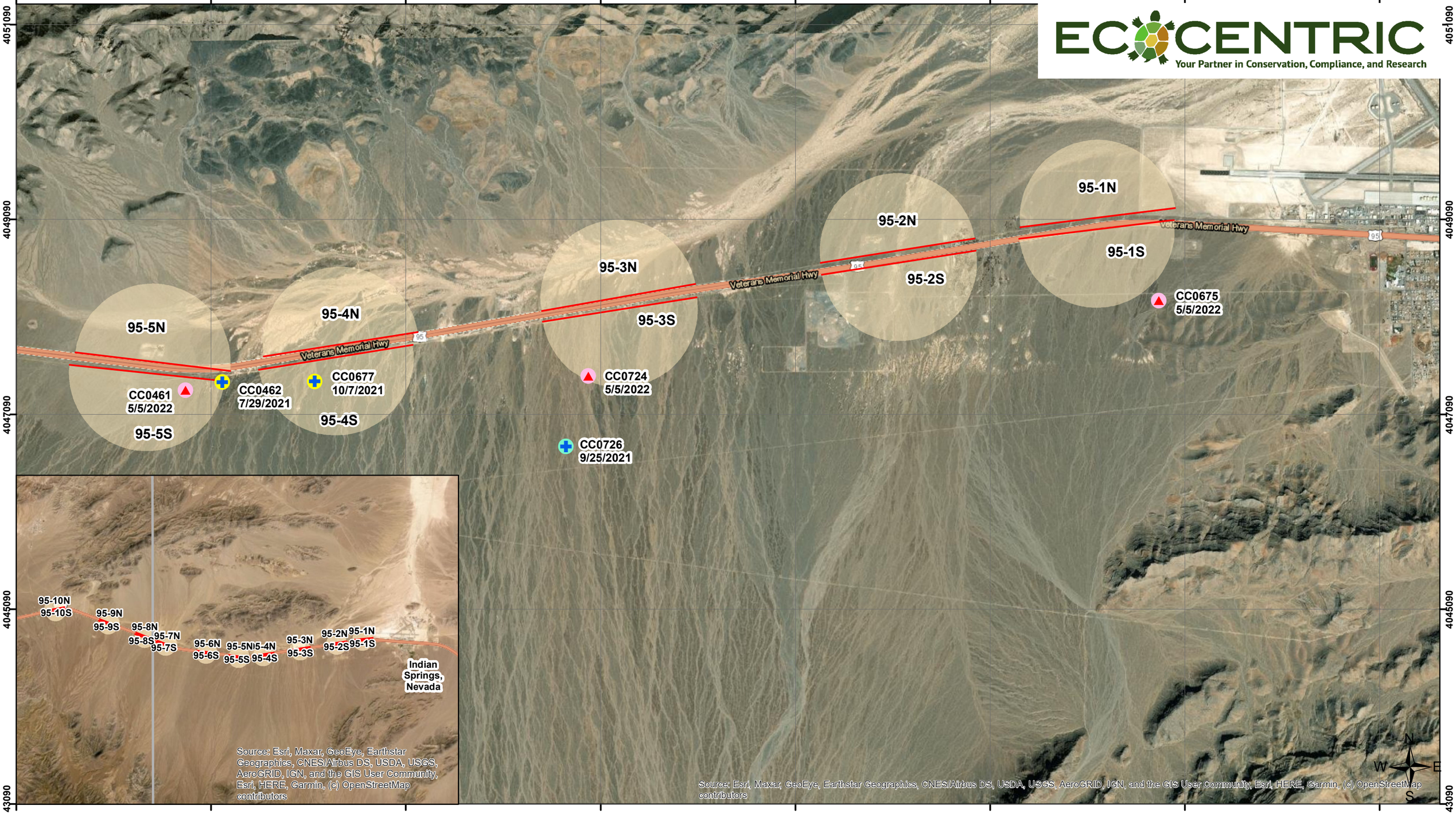
This map is for display purposes only.
Inset maps display plots US95 1 thru 10
& Plots in relation to Indian Springs, NV

Figure 4. CC0477 Highway Crossing
(Male Desert Tortoise)
Desert Tortoise Telemetry Around Culverts
Project 2015-ECOCENTRIC-1580E
Clark County, Nevada
March 2021 – May 2022

High Tortoise Mortality

Of the six female and nine male resident tortoises, only three females survived until the project conclusion in May 2022. Figures 5 and 6 show the final encounter location for each of the 15 resident tortoises. Locations displayed are either the final location at project conclusion (n = 3), the last known location before a tortoise was considered missing (n = 2), or the last encounter before a carcass was located (n = 10).

Three male tortoises went missing between July and September (Table 2, Figure 7). CC0462 was found predated with a non-functional transmitter. CC0719 and CC0726 were not recovered by project end. Given the high mortality of the study group and the extensive effort made to recover the tortoises by experienced fieldworkers, we suspect the transmitters were damaged by predators. However, since no carcasses or damaged equipment were recovered the cause remains unknown. Ten tortoises (3 female, 7 male) were predated between June and October 2021 (Table 3, Figure 8). If the missing tortoises are considered alive, the mortality of the resident population is 66.67%. If the missing tortoises are considered deceased, the mortality rate increases to 80.0%. This level of mortality was unexpected and much higher than what we anticipated.



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Desert Tortoise Sex

- ***Female***
- ***Male***

Final Live Encounter Type

- ***Pre-Fatality***
- ***Pre-Missing***
- ***Project-Wrap***

- ***US-95 Survey Plot***
- ***US-95 Plot Line***

This map is for display purposes only.
Inset maps display plots US95 1 thru 10 & Plots in relation to Indian Springs, NV

Figure 5. Resident Tortoise Final Encounter Locations, US-95 Plots 1-5
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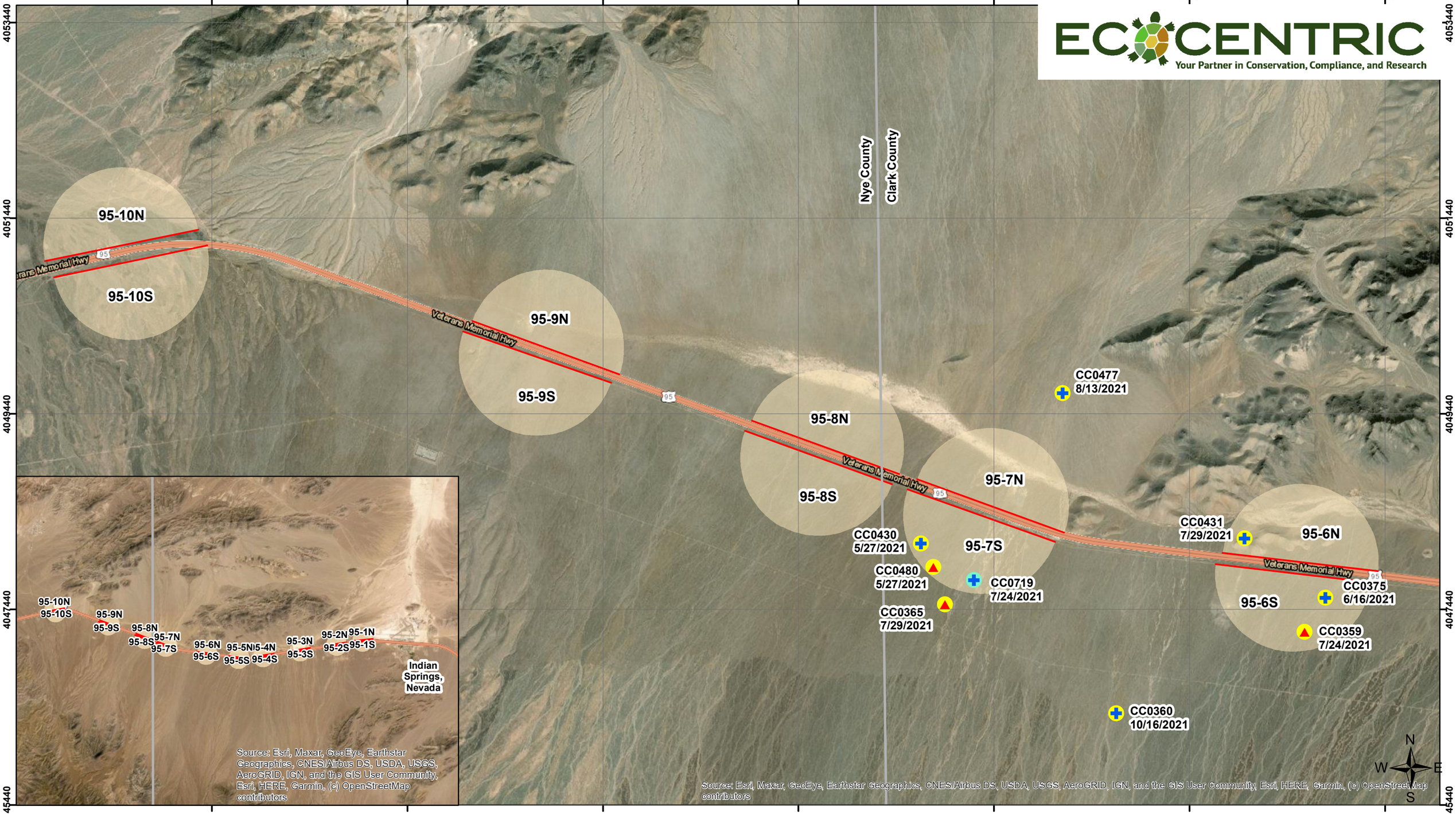

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Desert Tortoise Sex

- ▲ *Female*
- ✚ *Male*

Final Live Encounter Type

- *Pre-Fatality*
- *Pre-Missing*
- *Project-Wrap*

- *US-95 Survey Plot*
- *US-95 Plot Line*

0 1,000 2,000 Meters

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Figure 6. Resident Tortoise Final Encounter Locations, US-95 Plots 6-10
Desert Tortoise Telemetry Around Culverts
Project 2015-ECOCENTRIC-1580E
Clark County, Nevada
March 2021 – May 2022

Table 2. Resident Tortoise Missing Events

Tortoise ID	Missing Tortoise Event Outcome	Initial Encounter Plot	Date Last Encountered	Date Recovered	Weeks Missing	Transmitter Status	Suspected Cause of Missing
CC0462	Found Dead	95-05S	29/Jul/2021	16/Oct/2021	11	Attached, but damaged	Predation
CC0719	Not Found	95-07S	24/Jul/2021	---	41	---	Predation
CC0726	Not Found	---	25/Sep/2021	---	32	---	Predation

Table 3. Resident Tortoise Mortality Events

Tortoise ID	Suspected Cause of Death	Initial Encounter Plot	Carcass Detection Date	Weeks Monitored	Sex	Initial MCL
CC0359	Canid-Badger Predation	95-06S	29/Jul/2021	15	Female	183
CC0360	Canid-Badger Predation	95-06S	7/Sep/2021	21	Male	238
CC0365	Canid-Badger Predation	95-07S	6/Aug/2021	15	Female	235
CC0375	Canid-Badger Predation	95-06S	26/Jun/2021	12	Male	269
CC0430	Canid-Badger Predation	95-07S	1/Jun/2021	8	Male	237
CC0431	Canid-Badger Predation	95-06N	6/Aug/2021	17	Male	212
CC0462	Canid-Badger Predation	95-05S	16/Oct/2021	27	Male	232
CC0477	Canid-Badger Predation	95-07N	19/Aug/2021	19	Male	222
CC0480	Canid-Badger Predation	95-07S	1/Jun/2021	8	Female	264
CC0677	Canid-Badger Predation	95-04S	16/Oct/2021	22	Male	205

600995 602995 604995 606995 608995

4050055 4048055 4046055 4044055

95-7N
95-7S
95-6N
95-6S
95-5N
95-5S
95-4N
95-4S
95-3N
95-3S

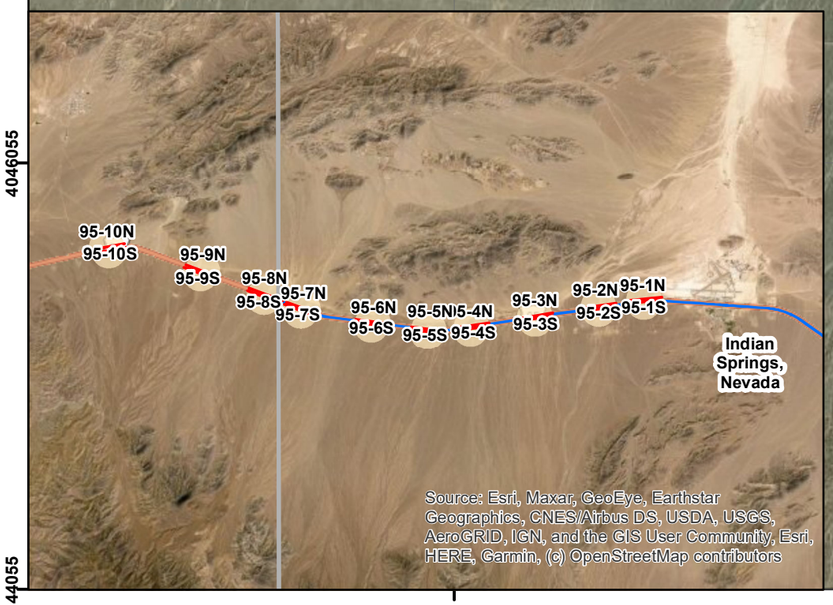
Veterans Memorial Hwy 95

CC0719
7/24/2021

CC0462
7/29/2021

CC0462
10/16/2021

CC0726
9/25/2021



Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the

N W E S

Desert Tortoise Sex
- ***Female***
- ***Male***

Carcass Recovery Location
Final Tracking Location
US-95 Survey Plot
US-95 Plot Line

0 1,000 2,000 Meters

This map is for display purposes only.
Inset maps display plots US95 1 thru 10
& Plots in relation to Indian Springs, NV

Figure 7. Resident Tortoise Missing Events
Desert Tortoise Telemetry Around Culverts
Project 2015-ECOCENTRIC-1580E
Clark County, Nevada
March 2021 – May 2022

596905 598905 600905 602905 604905 606905 608905

4050058 4048058 4046058 4044058

Nye County

Clark County

95-8N

95-8S

95-7N

95-7S

95-6N

95-6S

95-5N

95-5S

95-4N

95-4S

CC0477
8/19/2021

CC0431
8/6/2021

CC0430
6/1/2021

CC0480
6/1/2021

CC0365
8/6/2021

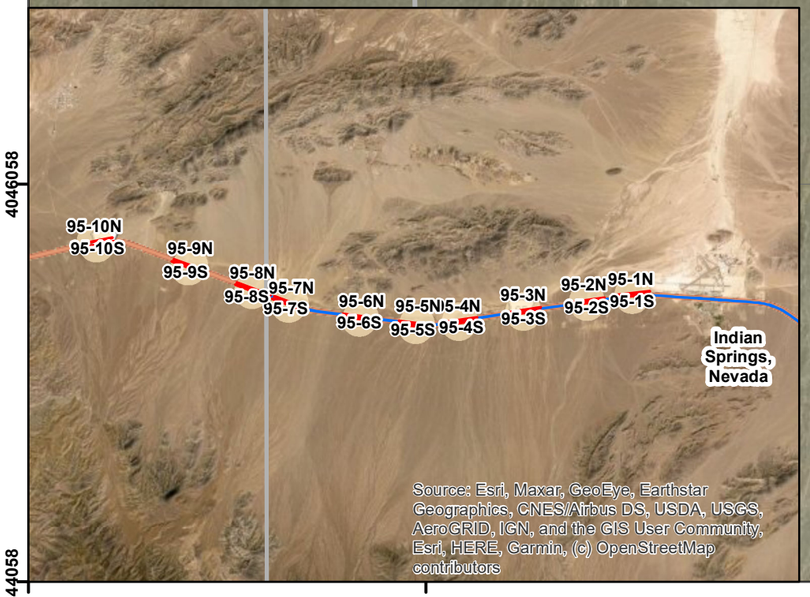
CC0375
6/26/2021

CC0359
7/29/2021

CC0462
10/16/2021

CC0677
10/16/2021

CC0360
9/7/2021



N
W E
S

Desert Tortoise Sex

Female

Male

US 95 Plots

US 95 Plot Line

0 1,000 2,000 Meters

This map is for display purposes only.
Inset maps display plots US95 1 thru 10
& Plots in relation to Indian Springs, NV

Figure 8. Resident Tortoise Carcass Locations
Desert Tortoise Telemetry Around Culverts
Project 2015-ECOCENTRIC-1580E
Clark County, Nevada
March 2021 – May 2022

GPS Logger Deployments

Tortoise encounter and GPS logger data was collected to investigate the possible role of culverts in facilitating safe passage across roadways. Of the 67 unique logger deployments, we discovered that three loggers failed (4.48% of total deployments) to record any data. Upon discovery, these loggers were removed from project inventory to avoid potential data loss from future malfunction. For unknown reasons, another logger only recorded 7.96% of expected points. The remaining loggers performed well and adequately recorded tortoise movement: 63 loggers recorded between 24.89% and 92.89% of expected points, with 55 loggers (82.09% of total deployments) recording over 60% of expected points (Table 4). Spatial-temporal data collected by the data loggers have been processed to remove improbable points and will be provided to the DCP for additional analysis. Details for each deployment can be found in Table 5.

Table 4. GPS Logger Recording Summary

Percentage of Expected Points Recorded	Number of Deployments	Percentage of Total Deployments
0	3	4.48%
1-10	1	1.49%
11-20	0	0.00%
21-30	3	4.48%
31-40	1	1.49%
41-50	1	1.49%
51-60	3	4.48%
61-70	17	25.37%
71-80	26	38.81%
81-90	11	16.42%
91-100	1	1.49%
Total:	67	

Table 5. GPS Logger Recording Details

Unique deployment of a GPS logger for each tortoise, sorted by tortoise ID and timestamp when the logger was attached. *Mean Fix Rate* is the average recording interval in minutes (loggers were programmed to record every 30 minutes), D*eployment Hours* is the number of hours the logger was on the tortoise, *Recorded* Points is the number of points that the logger actually recorded during deployment, *Expected Points* is the number of points that would have been recorded if the logger actually took a point every 30 minutes during deployment, *%Expected Points* is the percentage of recorded points compared to the total expected points, *Removed Points* is the number of points that were removed from that deployment due to high elevation error (DEM-altitude) or the point attainment had an unrealistic speed, *%Removed Points* is the percentage of erroneous points compared to the total number of points recorded.

Tortoise ID	GPS Serial Number	Timestamp Attached	Timestamp Removed	Mean Fix Rate (min)	Deployment Hours	Recorded Points	Expected Points	% Expected Points	Removed Points	% Removed Points
CC0359	1100487972	4/17/2021 17:14	5/8/2021 16:57	43.19	504	699	1008	69.35%	4	0.57%
CC0359	1100488461	5/8/2021 16:57	5/27/2021 12:17	37.46	451	722	902	80.04%	4	0.55%
CC0359	1100487376	5/27/2021 12:17	7/2/2021 5:01	45.22	857	1136	1714	66.28%	16	1.41%
CC0359	1100458289	7/2/2021 5:01	7/18/2021 8:26	36.64	387	633	774	81.78%	19	3.00%
CC0359	1100451221	7/18/2021 8:26	7/29/2021 9:58	44.16	266	359	532	67.48%	18	5.01%
CC0360	1100488480	4/17/2021 17:59	5/8/2021 16:33	38.99	503	773	1006	76.84%	7	0.91%
CC0360	1100487660	5/8/2021 16:33	5/27/2021 11:25	40.21	451	672	902	74.50%	6	0.89%
CC0360	1100451881	5/27/2021 11:25	7/18/2021 7:45	32.27	1244	2311	2488	92.89%	80	3.46%
CC0360	1100458253	7/18/2021 7:45	8/6/2021 6:48	38.89	455	701	910	77.03%	15	2.14%
CC0360	1100457231	8/6/2021 6:48	9/2/2021 8:25	43.30	650	899	1300	69.15%	4	0.44%
CC0360	1100451374	9/2/2021 8:25	10/16/2021 12:11	46.23	1060	1148	2120	54.15%	133	11.59%
CC0365	1100488445	4/28/2021 11:56	5/21/2021 15:32	42.55	556	783	1112	70.41%	36	4.60%

Tortoise ID	GPS Serial Number	Timestamp Attached	Timestamp Removed	Mean Fix Rate (min)	Deployment Hours	Recorded Points	Expected Points	% Expected Points	Removed Points	% Removed Points
CC0365	1100452014	5/21/2021 15:32	6/26/2021 5:56	43.80	854	1170	1708	68.50%	9	0.77%
CC0365	1100451374	6/26/2021 5:56	7/17/2021 7:36	44.01	506	688	1012	67.98%	7	1.02%
CC0375	1100488439	4/3/2021 14:28	4/24/2021 13:52	49.26	503	612	1006	60.83%	14	2.29%
CC0375	1100487684	4/24/2021 13:52	5/21/2021 16:08	NA	650	0	1300	0.00%	N/A	N/A
CC0375	1100458253	5/21/2021 16:08	6/16/2021 7:55	37.42	616	987	1232	80.11%	57	5.78%
CC0375	1100457391	6/16/2021 7:55	6/26/2021 7:00	34.98	239	408	478	85.36%	14	3.43%
CC0430	1100488136	4/7/2021 13:08	4/28/2021 11:37	42.65	502	492	1004	49.00%	6	1.22%
CC0430	1100488011	4/28/2021 11:37	5/21/2021 15:18	NA	556	0	1112	0.00%	N/A	N/A
CC0430	1100457391	5/21/2021 15:18	6/1/2021 13:47	40.04	262	392	524	74.81%	12	3.06%
CC0431	1100487376	4/10/2021 16:26	4/28/2021 10:01	41.59	426	563	852	66.08%	6	1.07%
CC0431	1100487810	4/28/2021 10:01	5/21/2021 13:50	45.99	556	723	1112	65.02%	60	8.30%
CC0431	1100451691	5/21/2021 13:50	6/16/2021 5:22	NA	616	0	1232	0.00%	N/A	N/A
CC0431	1100457778	6/16/2021 5:22	8/6/2021 4:04	40.22	1223	1432	2446	58.54%	125	8.73%
CC0461	1100488570	4/11/2021 14:35	4/28/2021 14:49	44.39	408	551	816	67.52%	4	0.73%
CC0461	1100487945	4/28/2021 14:49	5/21/2021 17:46	45.08	555	738	1110	66.49%	22	2.98%
CC0461	1100452193	5/21/2021 17:46	6/11/2021 9:00	40.80	495	728	990	73.54%	2	0.27%
CC0461	1100451597	6/11/2021 9:00	6/26/2021 9:24	42.01	360	514	720	71.39%	18	3.50%
CC0461	1100457197	6/26/2021 9:24	7/24/2021 5:42	39.79	668	1007	1336	75.37%	59	5.86%
CC0461	1100451597	7/24/2021 5:42	8/19/2021 8:08	41.60	626	902	1252	72.04%	7	0.78%

Tortoise ID	GPS Serial Number	Timestamp Attached	Timestamp Removed	Mean Fix Rate (min)	Deployment Hours	Recorded Points	Expected Points	% Expected Points	Removed Points	% Removed Points
CC0461	1100451221	8/19/2021 8:08	9/14/2021 7:24	36.76	623	1016	1246	81.54%	1	0.10%
CC0462	1100487572	4/11/2021 15:35	4/28/2021 15:19	40.58	408	602	816	73.77%	6	1.00%
CC0462	1100487605	4/28/2021 15:19	5/27/2021 9:24	39.92	690	978	1380	70.87%	13	1.33%
CC0462	1100458607	5/27/2021 9:24	7/2/2021 7:26	34.86	862	1483	1724	86.02%	60	4.05%
CC0462	1100457579	7/2/2021 7:26	7/24/2021 6:30	40.57	527	770	1054	73.06%	148	19.22%
CC0477	1100489019	4/7/2021 9:10	4/28/2021 13:19	38.21	508	797	1016	78.44%	7	0.88%
CC0477	1100487603	4/28/2021 13:19	5/21/2021 14:28	40.34	553	822	1106	74.32%	42	5.11%
CC0477	1100451608	5/21/2021 14:28	6/16/2021 6:02	43.29	616	852	1232	69.16%	29	3.40%
CC0477	1100452366	6/16/2021 6:02	7/17/2021 8:51	37.29	747	1201	1494	80.39%	36	3.00%
CC0477	1100451608	7/17/2021 8:51	7/29/2021 8:14	41.41	287	415	574	72.30%	5	1.20%
CC0477	1100452193	7/29/2021 8:14	8/19/2021 14:06	40.97	510	746	1020	73.14%	33	4.42%
CC0480	1100488125	4/7/2021 11:02	4/28/2021 11:21	40.39	504	659	1008	65.38%	11	1.67%
CC0480	1100488565	4/28/2021 11:21	5/21/2021 15:04	47.49	556	701	1112	63.04%	22	3.14%
CC0480	1100457594	5/21/2021 15:04	6/1/2021 13:03	36.67	262	428	524	81.68%	3	0.70%
CC0675	1100488136	5/14/2021 9:08	6/1/2021 11:51	41.64	435	625	870	71.84%	18	2.88%
CC0675	1100452472	7/17/2021 3:53	8/6/2021 3:09	37.82	479	760	958	79.33%	10	1.32%
CC0675	1100452311	8/6/2021 3:09	8/25/2021 7:22	37.28	460	740	920	80.43%	5	0.68%
CC0675	1100457197	8/25/2021 7:22	9/14/2021 10:35	38.25	483	757	966	78.36%	1	0.13%
CC0675	1100487605	9/14/2021 10:35	10/1/2021 14:05	39.45	412	625	824	75.85%	9	1.44%

Tortoise ID	GPS Serial Number	Timestamp Attached	Timestamp Removed	Mean Fix Rate (min)	Deployment Hours	Recorded Points	Expected Points	% Expected Points	Removed Points	% Removed Points
CC0675	1100441255	10/1/2021 14:05	3/31/2022 8:39	37.08	4339	2168	8678	24.98%	36	1.66%
CC0677	1100487972	5/14/2021 6:26	6/11/2021 7:57	43.92	674	356	1348	26.41%	8	2.25%
CC0677	1100487572	6/11/2021 7:57	7/2/2021 8:14	50.26	504	601	1008	59.62%	8	1.33%
CC0677	1100452317	7/2/2021 8:14	7/18/2021 6:02	41.51	382	551	764	72.12%	153	27.77%
CC0677	1100452014	7/18/2021 6:02	8/13/2021 8:13	38.61	626	972	1252	77.64%	12	1.23%
CC0677	1100452671	8/13/2021 8:13	9/2/2021 9:52	37.87	482	761	964	78.94%	8	1.05%
CC0677	1100457525	9/2/2021 9:52	9/14/2021 13:07	37.41	291	467	582	80.24%	8	1.71%
CC0677	1100457211	9/14/2021 13:07	10/1/2021 8:39	47.31	404	511	808	63.24%	3	0.59%
CC0677	1100488136	10/1/2021 8:39	10/16/2021 15:33	37.62	367	275	734	37.47%	1	0.36%
CC0719	1100488151	5/8/2021 14:04	5/27/2021 10:15	41.36	452	655	904	72.46%	2	0.31%
CC0719	1100488125	5/27/2021 10:15	6/16/2021 6:30	40.14	476	711	952	74.68%	3	0.42%
CC0724	1100488570	6/1/2021 11:07	7/9/2021 3:13	41.49	904	144	1808	7.96%	16	11.11%
CC0724	1100457525	7/9/2021 3:13	7/29/2021 3:48	42.92	481	652	962	67.78%	10	1.53%
CC0724	1100452366	8/19/2021 9:39	9/14/2021 8:59	39.57	623	944	1246	75.76%	7	0.74%
CC0724	1100451580	9/14/2021 8:59	10/1/2021 10:34	47.77	410	513	820	62.56%	3	0.58%
CC0724	1100452448	10/1/2021 10:34	3/31/2022 7:37	48.94	4341	2161	8682	24.89%	39	1.80%
CC0726	1100452317	8/19/2021 10:59	9/14/2021 9:51	34.05	623	1097	1246	88.04%	20	1.82%

Section 4.0 – Evaluation and Discussion of Results

We do not feel that this project thoroughly addressed the goal of determining how tortoises utilize box culverts in the landscape for two reasons pertaining to sampling of resident tortoises. First, although we completed the objective of monitoring resident tortoises in the area, there were fewer animals than expected. After completing a mark-recapture survey in spring of 2021, surveyors found 14 adult tortoises on plots near the seven culverts located along Highway 95 in Clark County. An additional tortoise was encountered incidentally during radio telemetry monitoring and was incorporated into the group of residents bringing the total to 15, five fewer than the desired number of 20. More tortoises were encountered along culverts in Nye County on plots 8N/S through 10N/S. However, those animals were not included in the study due to project funding requirements. The second and more impactful reason was that although 15 animals would have been sufficient for analysis, there was significant mortality of the resident population: only three of the 15 tortoises survived to project completion. The mortality of this population (66.67% if missing tortoises are considered alive, or 80.0% if missing tortoises are considered deceased) is significantly higher than that documented in other studies of adult desert tortoises. For comparison, one group found annual mortality estimates of adult tortoises, over a five-year period in the Ivanpah Valley, San Bernardino County, California to be between 0% and 11% (Dickson et al., 2017). Another analysis of adult tortoises at the Large-Scale Translocation Study (LSTS) site in southern Nevada found that 21.4% of 28 translocated tortoises died during the 18-month study (Field et al. 2007). In 2010, 20.71% mortality (29 of 140) of resident adult tortoises was noted during the first year of a study at the Ft. Irwin National Training Center near Barstow, California (Esque et al., 2010). Given the high mortality of our study group, which dramatically reduced the initial sample size, we were unable to draw significant conclusions regarding resident tortoise utilization of culverts.

High mortality among resident tortoises led to a third issue preventing successful completion of the project goal: the fact that we were not able to complete the second project objective of monitoring up to 20 translocated tortoises that were to be released near the Clark County culverts. Due to the extensive mortality of the residents, USFWS and BLM decided to postpone the translocation until spring 2022, at which time it was decided the tortoises would not be translocated at all for inclusion in this study. While it was unfortunate for the study, we support the decision given the high likelihood of excessive predation of the translocated tortoises.

Section 5.0 – Conclusion

Although the project did not collect sufficient data to address the goal, we feel the design and intention of the project made it a worthwhile endeavor. While unfortunate, the extensive mortality observed on this project was unpredictable and, based on anecdotal observations, like that of other tortoise monitoring projects throughout the Mojave Desert during the same period. It is possible that due to drought conditions and diminished availability of other food sources (i.e., black-tailed jackrabbits, *Lepus californicus*), predators like the coyote (*Canis latrans*) turned to tortoises to subsidize their diet. Although not fully tested, this hypothesis (Esque et al., 2010) is currently being evaluated by the Clark County DCP.

The two observed crossings by adult male CC0477 suggest tortoises are utilizing the culverts to cross the highway. Given the importance of maintaining genetic diversity through population connectivity, we feel that it would be worthwhile replicating this study in another location. Ideally, long-term data collected from further telemetry encounters and GPS data loggers, in addition to observations of tortoise movement made by wildlife cameras in culverts, will serve to expand our limited understanding of tortoise movement in relation to the culverts. Additional data could be used to better inform management decisions regarding culvert use as a method of maintaining connectivity.

Section 6.0 – Recommendations

The methodology for this project was fundamentally sound and would be worth repeating with a larger population of resident and translocated animals to increase the likelihood of achieving significant results. Compared to the US-95 corridor addressed in this study, a higher population of tortoises was encountered during spring 2021 mark-recapture surveys (project 2015-ECOCENT-1580B) near the culverts along US-93 north of Las Vegas. However, it is unknown whether the corrugated metal drainage pipe culverts along US-93 influence tortoise utilization compared to the larger concrete box culverts along the US-95 study site. Therefore, future studies might also investigate variables that influence tortoise movement through or near culverts such as culvert type, vegetation cover near culverts, or ease of accessing culvert entrances. These data could inform design and placement of culverts in tortoise habitat and increase safety for animals utilizing the crossings.

Since mortality in a population is unpredictable, it might be worthwhile for Clark County and its partners to investigate wildlife management options for future projects. More specifically, although public opinion varies on the subject (Slagle et al., 2017), there is precedent for predator control to protect sensitive, threatened, or endangered species (Boarman, 1992; Butchko, 1990). The United States Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS) undertakes such endeavors throughout the Mojave, but were unable to assist with this project due to administrative complications allowing funding sources for this project being used for federal agency services. Future county-federal collaborations might be able to facilitate this process allowing for expanded collaboration between agencies.

Studies focusing on juvenile/immature/sub-adult tortoise movement in relationship to culverts would also be informative since these size classes are also vital to the long-term survival of a healthy tortoise population. Due to the limitations of currently available GPS tracking devices, this project focused on adult tortoises. Commercial GPS data loggers currently available are too large for placement on sub-180mm MCL tortoises. As technology improves and logger size decreases, it may be possible to place units on sub-adult or immature tortoises to gain more detailed information on their movement in relation to culverts.

After significant field testing, we feel deployment of GPS loggers modified to increase battery life is recommended for several reasons. First, the increased recording time will allow for an extended exchange interval, thereby minimizing handling events and reducing animal stress. Although projects will still likely be required to complete radio telemetry encounters at least once a month, loggers with increased battery capacities could be exchanged every 4-6 weeks or potentially longer, reducing tortoise handling events over the course of a project, without sacrificing data collection continuity. Second, they increase the likelihood of continued data collection when a scheduled exchange cannot be performed, such as when a tortoise cannot be extracted from a burrow or when a tortoise is missing. Lastly, given that the lifespan of lithium-ion batteries degrades over time, a larger-capacity battery allows for an increased number of deployments over the life of a project without requiring replacement and refurbishment to ensure data collection continuity.

In summary, we feel it would be worthwhile to repeat this study with a larger study population and/or predator control/deterrence to preserve the sample size. Another recommendation would be to evaluate utilization of different types of culverts (e.g., corrugated pipe vs. box culverts) and factors promoting or detracting from access to culverts. It would also be interesting to expand the methodology to include smaller size classes of tortoises. Lastly, we suggest modifying commercially available GPS data loggers to expand battery life.

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