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Innovation in Transportation

DETERMINING EFFECTIVENESS OF WILDLIFE-VEHICLE COLLISION MITIGATION PROJECTS: PHASE I

Final Report

Prepared by:
Arizona Game and Fish Department
Phoenix, Arizona

Prepared for:
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7500B Pan American Freeway NE
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DETERMINING EFFECTIVENESS OF WILDLIFE-VEHICLE COLLISION MITIGATION PROJECTS: PHASE ONE

by

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

PREFACE

The research reported herein evaluates a selection of New Mexico's wildlife-vehicle mitigation projects. The purpose of this work was to gather wildlife structure use data and wildlife-vehicle collision trends for pre- and post-construction time periods where appropriate and produce a preliminary report documenting wildlife structrue use and WVC trends.

NOTICE

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DISCLAIMER

ABSTRACT

Wildlife-vehicle collisions (WVC), particularly with large ungulates (deer and elk), pose a safety risk for motorists and habitat fragmentation for wildlife. Since 2004, the New Mexico Department of Transportation (NMDOT) has completed 10 WVC mitigation projects designed to increase motorist safety by excluding wildlife from the right-of-way (ROW) and reduce habitat fragmentation by allowing wildlife to safely cross over, under, or across the roadway. In 2016, NMDOT and the Arizona Game and Fish Department (AGFD) began a two phase evaluation of selected NMDOT mitigation projects (Aztec, Tijeras Canyon, Raton, Raton Pass, Cuba, and Chicorica Creek) with the Phase one objectives (detailed within this report) of gathering wildlife structure use data and WVC trends for Aztec, Tijeras, Raton, and Cuba. In addition to these objectives, four case-studies that evaluated 1) game fence gates, 2) wildlife crossing structure and crosswalk (at-grade crossing) connectivity, 3) wildlife crossing structure obstruction, and 4) the effect of cattle presence on crossing structure use by wildlife were conducted. For wildlife structure use during Phase One, 3/2/17 to 3/3/20, AGFD captured more than 1.25 million images that documented 18,034 animals comprised of 21 different species. Of these, the research team documented 14,242 use events at crossing structures, including 12,408 mule deer, 220 elk, 169 black bear, and 45 mountain lions. For WVC, mitigation projects have markedly reduced collisions with wildlife. Case studies confirmed that 1) game fence gates left open permit wildlife to enter the ROW, 2) wildlife use a crossing structure and crosswalk to connect the Sandia and Manzano mountains, 3) wildlife crossing obstructions prevent or greatly delay structure effectiveness, and 4) the presence of cattle at a wildlife crossing structure decreases wildlife use of that structure.

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- New Mexico Department of Transportation personnel (current and former): Blake Roxlau (Environmental Bureau Manager, project sponsor), Jim Hirsch (Environment Bureau/project advocate), Trent Botkin (Natural Resources Section Supervisor), and Amy Estelle (deceased) (Research Bureau)
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INTRODUCTION

Report Note: The research documented within this final report pertains to the first phase (Phase One) of a two phase project (Contract No. IG0004; Research Project Nos. R917034 and R920050).

Collisions with wildlife, particularly large ungulates such as deer and elk, pose a safety risk for motorists and are a safety challenge for Departments of Transportation. The United States (U.S.) has more than 8.8 million lane-miles of roadways, including > 6 million rural area lane-miles, and 227 million licensed drivers who drive more than 3 billion miles annually *(1)*. Each year, U.S. motorists are involved in an estimated 2 million wildlife-vehicle collisions (WVC) that result in more than 440 human deaths, 59,000 injuries *(2)*, and cost more than $8.3 billion per year *(3)*.

On the state level, New Mexico has more than 160,000 lane-miles of roadway, including > 137,000 rural area lane-miles *(1)*, and 1.4 million licensed drivers who drive more than 272 million miles annually *(4)*. Over 20,000 WVC have been reported in New Mexico between 1996 and 2018. Research has found that WVC are under-reported by at least half *(5)* and by as much as 83 percent *(3)*. Taking this research into consideration, New Mexico's actual WVC total for the time period between 1996 and 2017 could likely be between 34,000 to 115,000. Of New Mexico's reported WVC, there were 18 fatalities, 1,983 injuries, with 84 percent of all WVCs occuring on rural roadways.

Wildlife crossing structures and game fencing (8-foot high woven wire fence) can help to address both motorist safety concerns and wildlife passage issues. Properly designed wildlife crossing structures provide an opportunity for wildlife to cross over or under the road, which mitigates habitat fragmentation *(6, 7, 8, 9)*. Under appropriate circumstances, existing roadway and drainage structures can also serve as de facto cost-effective wildlife crossings *(10,11,12)*. Properly designed and maintained game fencing can limit wildlife access to roads, which addresses motorist safety concerns, and guide wildlife to safe passage at wildlife crossing structures *(13, 14, 15, 16)*.

The New Mexico Department of Transportation (NMDOT) strives to provide safe roadways for New Mexico's increasing number of motorists and was one of the first states to recognize and begin to address the specific safety issues involved in WVCs. In 2003, the New Mexico Legislature, via House Joint Memorial 3, directed NMDOT and New Mexico Department of Game and Fish (NMDGF) to collaborate and address WVC issues *(17)*. Since 2004, NMDOT has completed ten WVC mitigation projects and began an eleventh in 2020 (Table 1 and Figure 1).

TABLE 1 List of New Mexico Department of Transportation wildlife vehicle collision mitigation projects

Name	Roadway	Length (mi (km))	Year Completed
Aztec	US 550	3.3 (5.3)	2004
Chicorica Creek	US 64	0.2 (0.3)	2006
Tijeras Canyon Phase I	I-40	4.9 (7.9)	2008
Tijeras Canyon Phase II	I-40	3.3 (5.3)	2009
Tijeras Canyon Phase III	I-40	4.4 (7.1)	2010
Lumberton	US 64	2.6 (4.2)	2012
Corona	US 54	1.8 (2.9)	2013
Canoncito Interchange	I-25	0.05 (0.09)	2016
Raton	I-25	4.4 (7.1)	2017
Cuba	US 550	4.5 (7.2)	2019
Raton Pass	I-25	5.6 (9.0)	Present

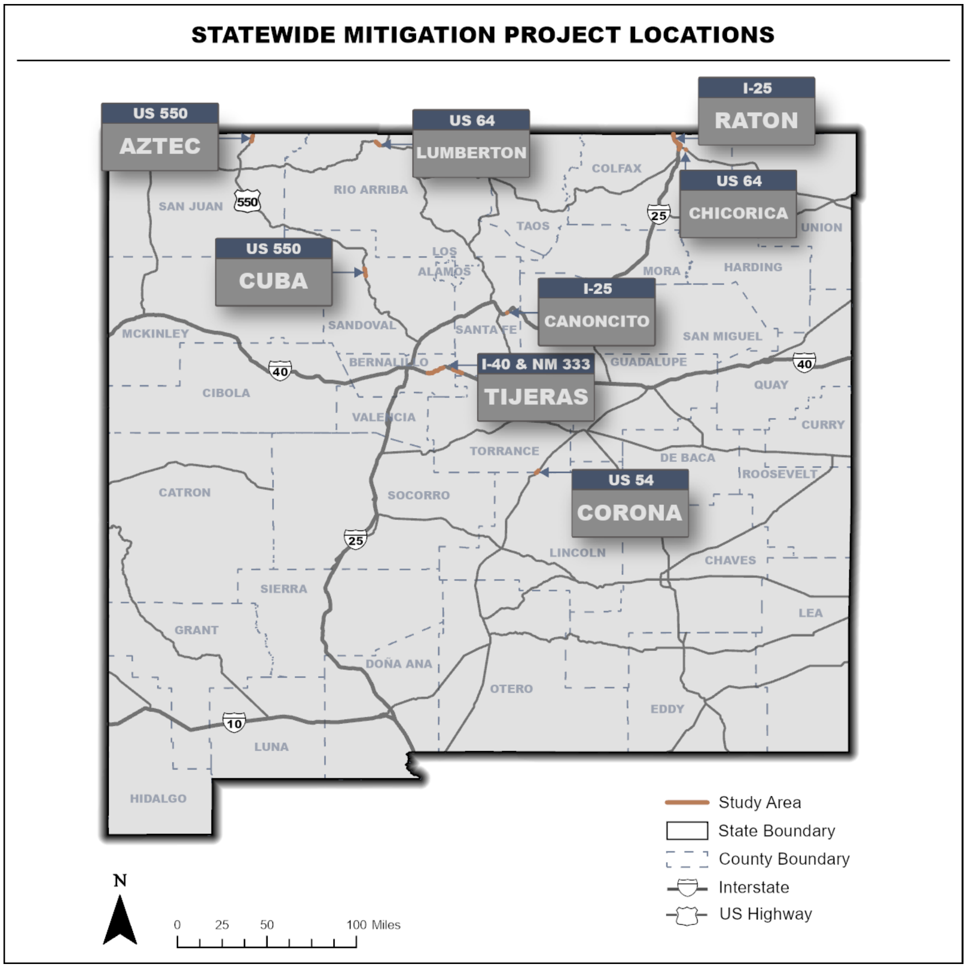

FIGURE 1 New Mexico Statewide Mitigation Project Locations

NMDOT WVC mitigation projects have two goals: 1) to increase motorist safety by excluding wildlife from the roadway and 2) to provide safe wildlife passage by allowing wildlife to safely cross over, under, or across the roadway to access life sustaining resources (e.g., food, water, mating grounds, seasonal habitat). Game fencing, escape ramps, game guards, electrified barriers, wildlife crossing structures, and Animal Detection Systems (ADS) are structures and technologies that NMDOT has used to address WVC problem areas. These structures and technologies are used in combination during a WVC mitigation project depending on roadway conditions, budget, constructability, the probability of big game species getting struck, and additional other factors.

GAME FENCING

NMDOT has used game fencing in conjunction with wildlife crossing structures to keep large animals from entering the roadway while at the same time providing safe wildlife passage.

Typical game fencing is 8-feet (ft) high and constructed of woven wire (Figure 2). In one case, 6-ft high electrobraid fence was installed but has not been used in other projects because of maintenance challenges. Game fencing typically directs wildlife to cross roadways safely through existing or constructed crossing structures (i.e. bridges, concrete box culverts (CBCs)).

In one case, game fencing directed wildlife to cross at a designated road section (at-grade). An ADS was also installed at this location to warn motorists when this crossing is being used by wildlife. However, this ADS has not been successful and replacement of this system is currently being evaluated.

FIGURE 2 Game Fencing on I-25 at Raton within Colfax County, New Mexico

ESCAPE RAMPS

Since wildlife has been documented to breach game fencing at breaks, washouts, open gates, cattle guards, or fence ends *(18)*, NMDOT has incorporated escape mechanisms to allow animals that have entered the right-of-way (ROW) an opportunity to exit or "escape" the ROW *(16, 19)*. NMDOT has implemented one-way gates to function as escape mechanisms (Figure 3). However, since implementation, research has found one-way gates to be ineffective *(20)*. NMDOT no longer uses one-way gates and has begun using escape ramps as an alternative.

Escape ramps, when viewed from within the ROW, are earthen ramps that gradually (4:1 slope) slope up from within the ROW to a designed platform, which is 3-ft wide at a 6-ft fence low point (Figure 4). Ungulates can ascend the ramp, "stage" on the flat platform at the lowered fence section, and safely jump down onto the non-ROW side of the fence. However, the 6-ft ramp, when viewed from the non-ROW side, discourages ungulates from entering the ROW via the escape ramp due to the ramp's height (Figure 5).

Escape ramps are often used as a mechanism for allowing deer to escape from fenced roadways *(21, 22)* and are implemented on NMDOT projects.

FIGURE 3 One-way gate as viewed from within the right-of-way on NM 550 near Aztec within San Juan County, New Mexico

FIGURE 4 Escape ramp as viewed from within the right-of-way on I-25 at Raton within Colfax County, New Mexico

FIGURE 5 Escape ramp as viewed from outside the right-of-way on I-25 at Raton within Colfax County, New Mexico

GAME GUARDS

At relatively high traffic volume access points (driveways, lateral access roads, and on- and off-ramps) where gates are not be feasible, NMDOT installs game guards (Figure 6) to allow vehicles to enter or exit the roadway. At these locations, game guards, which are either double the width of traditional cattle guards or electrified concrete, are placed in the roadway. The guard is difficult for ungulates to traverse or leap. These guards are typically located at motor vehicle access points that have relatively high traffic volumes and where gates are not an option. The guards have been found to vary in effectiveness at preventing wildlife from accessing the ROW *(23)*.

FIGURE 6 NMDOT game guard located on I-25 at the North Raton interchange within Colfax County, New Mexico

WILDLIFE CROSSING STRUCTURES

In conjunction with game fencing, NMDOT has either upsized or retrofitted existing structures to enable them to function as wildlife crossing structures or, as an alternative, added at-grade wildlife crosswalks. Wildlife crossing structures negate wildlife-vehicle interactions, while at-grade crossings can employ systems that inform drivers when wildlife may be present; thus, allowing drivers to increase attentiveness and decrease speeds. The upsizing of a structure typically includes replacements of an existing, smaller structure (e.g., 48-inch corrugated metal pipe) with a new, larger structure (e.g., 16-ft high x 20-ft wide CBC; Figure 7). Retrofitting an existing structure, which was originally placed for transportation, hydrological, and/or topographical reasons, adapts the structure and surrounding area (e.g., adding game fencing and removing barbed wire fences) to function as a wildlife crossing (Figure 8). When game fencing cannot logically terminate at crossing structures or other natural locations, at-grade wildlife crosswalks can be placed at those termini (Figure 9).

FIGURE 7 Upsized Concrete Box Culvert located on US 550 at milepost 171 north of Aztec within San Juan County, New Mexico

FIGURE 8 Game fencing tied to existing bridge located on I-40 at milepost 184.7 within Santa Fe County, New Mexico

FIGURE 9 At-grade wildlife crosswalk with electrified barriers (light colored concrete) located on NM 333 at milepost 4.2 within Bernalillo County, New Mexico

In 2016, NMDOT and the Arizona Game and Fish Department (AGFD) began a two phase evaluation of selected NMDOT mitigation projects: Aztec, Tijeras Canyon (Phase I, II, and III), Raton, Raton Pass, Cuba, and Chicorica Creek. The Phase One objectives were to gather wildlife structure use data and WVC trends (historical and current) for pre- and post-construction time periods, where appropriate, and produce a preliminary report documenting wildlife structure use and WVC trends. To complete these Phase One objectives, AGFD gathered 1) pre-construction data at Cuba (future project location), 2) pre-and post-construction data at Raton (began construction during Phase One), 3) post-construction data at Aztec and Tijeras (completed projects), and 4) gathered historical WVC data from the University of New Mexico. In addition to the direct Phase One objectives, AGFD also gathered pre-construction wildlife structure use data for Raton Pass (future project location scheduled for completion during Phase Two). AGFD then monitored Aztec game fence gates, which were not being closed as intended, and were thought to be allowing wildlife to enter the ROW. The Phase Two goals are to continue gathering data at all project locations and most wildlife structures, begin gathering data at Cuba's ADS and Chicorica Creek, and combine all data (Phase One and Phase Two) in order to produce a Phase Two final report that will include additional final recommentations that are not addressed in this Phase One report.

STUDY AREA

The research team gathered data at four NMDOT WVC mitigation project sites: Aztec (US 550), Tijeras Canyon (I-40 and NM 333), Raton (I-25), Raton Pass (I-25), and Cuba (US 550) (Figure 10). Each WVC mitigation site's roadway has been reconstructed (Aztec 2004 and Tijeras Canyon 2008-10), retrofitted during Phase One of this study (Raton 2017 and Cuba 2019), or scheduled to be reconstructed during Phase Two of this study (Raton Pass 2020). All sites currently have or will have wildlife crossing structures (newly constructed or retrofitted), game fencing, ROW escape mechanisms, and game guards (metal and and/or electrified concrete).

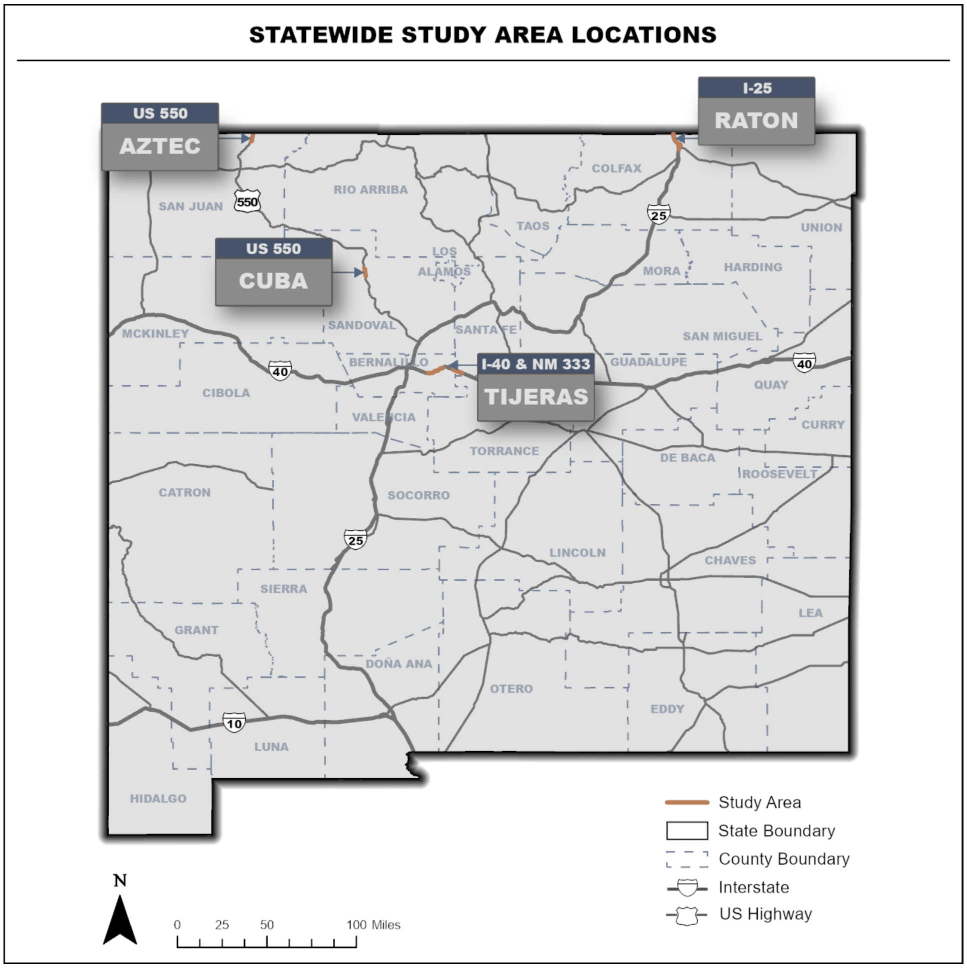

FIGURE 10 New Mexico Statewide Study Area Locations

AZTEC

Aztec, elevation 5,630 ft, is located in northwestern New Mexico on the southern edge of the Colorado Plateau and the lower end of the Animas River valley within San Juan County. The vegetation, typical of the higher elevations of the American Southwest, consists of a variety of land-covers including: sagebrush, shrubland, pinyon-juniper woodland, Fremont cottonwood, willow, irrigated field/pasture, residential, non-residential/developed, among others *(24)*. The

Animas River, which runs through Aztec, creates riparian areas and is also used to irrigate agricultural fields and create water holding ponds along US 550. Summer temperatures range from 54.7° F to 88.9° F with an average of 71.8° F, and winter temperatures range from 19.7° F to 45.7° F with an average 32.7° F *(25)*. Average precipitation for the area totals 10.9 inches (in.). and is roughly, evenly dispersed throughout the seasons: winter (2.5 in.), summer (2.8 in.), spring (2.5 in.), fall (3.1 in.) *(25)*.

The Aztec US 550 Project (Project # AC-NH-550-1(35) 23), located 8.1 miles north of Aztec between mileposts 169.5 and 172.8, was completed in 2004. The project erected 6.6 miles of ROW game fencing, and replaced three hydrological corregated metal pipe culverts with large CBCs that were intended to function as wildlife underpass crossing structures for mule deer and other species (Table 2; Figure 11, 12, 13, and 14). In order to prevent deer from entering the ROW via the numerous unfenced lateral access roads and driveways, the project installed a number of game guards (Figure 15), driveway gates (Figure 16), and pedestrian gates (Figure 17). This section of US 550 at Aztec has an Annual Average Daily Traffic (AADT) volume of 9,230.

TABLE 2 Three Concrete Box Culverts intended to function as wildlife underpassses on US 550 north of Aztec within San Juan County, New Mexico

Roadway	Milepost	Name	Height (m)	Width (m)	Length (m)	Openness Factor*
US 550	170.1	Underpass 1	16 (4.8)	20 (6.1)	120.4 (36.7)	0.80
US 550	171.1	Underpass 2	16 (4.8)	20 (6.1)	124.0 (37.8)	0.77
US 550	172.2	Underpass 3	16 (4.8)	12 (3.6)	92.0 (27.9)	0.63

**Meters used to calculate openness factor.*

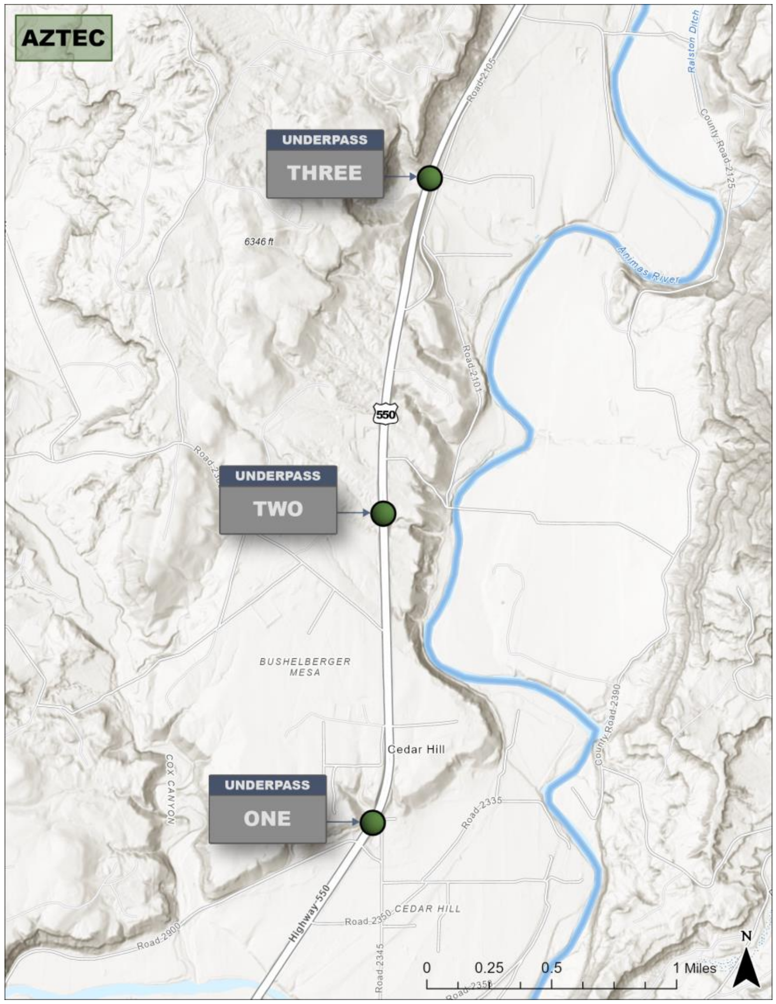

FIGURE 11 Three monitored Concrete Box Culverts locations on US 550 north of Aztec within San Juan County, New Mexico

FIGURE 12 Upsized Concrete Box Culvert located at milepost 170.1 on US 550 north of Aztec within San Juan County, New Mexico

FIGURE 13 Upsized Concrete Box Culvert located at milepost 171.1 on US 550 north of Aztec within San Juan County, New Mexico

FIGURE 14 Upsized Concrete Box Culvert located at milepost 172.2 on US 550 north of Aztec within San Juan County, New Mexico

FIGURE 15 Game guard installed on US 550 on a lateral access road at milepost 170.0 north of Aztec within San Juan County, New Mexico

FIGURE 16 Game fence gate along US 550 north of Aztec within San Juan County, New Mexico

FIGURE 17 Pedestrian gate along US 550 north of Aztec within San Juan County, New Mexico

TIJERAS

Tijeras Canyon, elevation 6,322 ft, is located in central New Mexico, five miles east of Albuquerque and 11 miles west of Edgewood. Vegetation types within the study area include: Montane Riparian Forest, Arroyo Riparian, Plains/Mesa Grassland, Desert Grassland, Juniper Savanna, Coniferous Woodland, and Montane Scrub *(26)*. Although close in proximity to Albuquerque and Edgewood, the Tijeras Canyon climate is slightly cooler than those areas. The Tijeras Ranger Station, which is within the study area, reports that Canyon temperatures range from 15.3° F in January to 88° F in July with an average annual maximum temperature of 66.4° F, and annual average precipitation of 15.31 in., 13.8 in. of which falls as snow *(17)*. Albuquerque has temperatures ranging from 27.5° F in the winter to 88.5° F in the summer with an annual precipitation of 9.5 in., 6.6 in. of which falls as snow *(25)*.

Tijeras Canyon is an east-west oriented canyon located in Bernalillo County. The canyon separates the Sandia and Manzano Mountains, which are located to the north and south respectively. The major, steep north-south drainages of these mountains provide water to Tijeras Creek, and serve as intermountain wildlife corridors that connect animals to relatively unfragmented mountain resources and water from Tijeras Creek *(17)*. This wildlife corridor, which was identified as a high priority linkage connecting the Sandia and Manzano Mountains to the larger Rocky Mountain range, is perpendicular to and bisected within Tijeras Canyon by I-40 and NM 333 *(17)*. The intersection of this wildlife corridor and these roadways has historically resulted in a number of WVC and has decreased the ability of animals to safely utilize the corridor. As a result, Tijeras Canyon was identified as a WVC “hot-spot” by NMDOT, NMDGF, and several conservation groups during a statewide WVC identification process mandated by the New Mexico State Legislature *(17)*. In 2007, a roadway reconstruction project commenced on I-40 and NM 333 that included measures to address WVC within and adjacent to Tijeras Canyon. The project, which was also known as the Tijeras Canyon Safe Passage Project (Project No.: AC-GRIP-IM-(IM)-040-3(149)174), occurred in three phases: Phase I – I-40 milepost 167.4 to 169.0 and NM 333 milepost 1.0 – 7.0; Phase II – I-40 milepost 169.0 to 174.2; and Phase III – I-40 milepost 174.2 to 187.2. The AADT for all three Phase sections of I-40 is > 50,000 (Figure 18).

All three phases were completed by 2010 and included two ADSs, electric and metal game fencing to prevent large animals from entering the ROW and guide them to an at-grade crossings and four existing bridges meant to serve as wildlife underpasses and escape ramps (Table 3). The ADS’s in-road, composite electrified barriers were replaced with electrified concrete in 2017. As of the writing of this report, the ADS needs to be replaced. The research team evaluated the effectiveness of one at-grade crossing on NM 333 (Figure 19) and four existing bridges on I-40 meant to function as wildlife crossing underpasses; three bridges (Middle, East, and Juan Tomas; Figure 20, 21, and 23) that cross “natural” terrain; and one (Public School road; Figure 24) that crosses a paved, low traffic volume road that includes wildlife “paths” outside of the guardrails.

TABLE 3 The location and dimensions of monitored Tijeras Canyon Safe Passage structure on I-40 and NM 333 within Bernalillo and Santa Fe Counties, New Mexico

Roadway	Milepost	Name	Height (m)	Width (m)	Length (m)	Openness Factor*
NM 333	4.2	Crosswalk**	-	-	-	-
I-40	170.0	Middle Bridge	24.9 (7.6)	53.8 (16.4)	186.0 (56.7)	2.2
I-40	171.0	East Bridge	29.8 (9.1)	54.1 (16.5)	196.9 (60.0)	2.5
I-40	173.8	Public School Bridge	20.7 (6.3)	53.8 (16.4)	153.2 (46.7)	2.2
I-40	184.7	Juan Tomas Bridge	13.8 (4.2)	37.7 (11.5)	117.5 (35.8)	1.3

**Meters used to calculate openness factor.*
***The wildlife crosswalk is an at-grade crossing; thus, dimensions and openness factor are not applicable.*

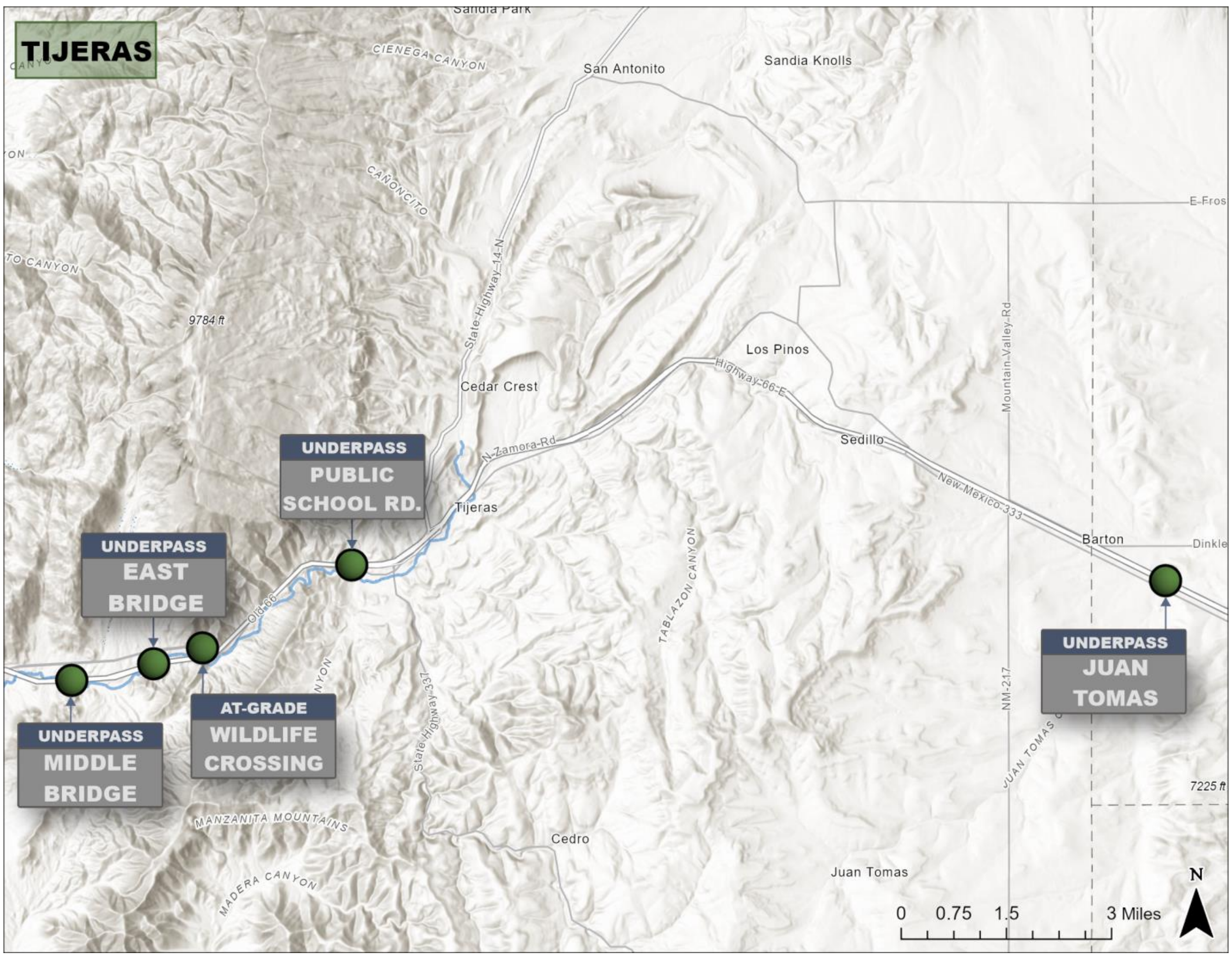

FIGURE 18 Monitored Tijeras Canyon Safe Passage structure locations on I-40 and NM 333 within Bernalillo and Santa Fe Counties, New Mexico

FIGURE 19 Tijeras wildlife crosswalk located on NM 333 at milepost 4.2 within Bernalillo County, New Mexico

FIGURE 20 Middle Bridge located on I-40 at milepost 170.0 within Bernalillo County, New Mexico

FIGURE 21 East Bridge located on I-40 at milepost 171.0 within Bernalillo County, New Mexico

FIGURE 22 Public School Bridge located on I-40 at milepost 173.8 within Bernalillo County, New Mexico

FIGURE 23 Juan Tomas Bridge located on I-40 at milepost 184.7 within Santa Fe County, New Mexico

RATON

Raton, elevation 6640 ft, is located in northcentral New Mexico, within the foothills of the Rocky Mountains, and is characterized by higher elevation (>7,874 ft) ponderosa pine-douglas fir forests (Pinus ponderosa-Pseudotsuga menziesii) and lower elevation (~6,233 ft) grasslands and pinyon-juniper woodlands *(27)*. Monitoring was focused within Raton's city limits along I-25, within the lower transition zone containing montane shrublands through mid-elevation pinyon-juniper woodlands. Summer temperatures range from 49.2° F to 81.8° F with an average of 65.5° F, and winter temperatures range from 14.8° F to 46.9° F with an average 30.9° F *(25)*. Total average precipitation for the area is 16.5 in., which is unevenly distributed throughout the seasons: winter (1.2 in.), summer (8.1 in.), spring (3.9 in.), fall (3.3 in.) *(25)*.

The Raton I-25 Project (Project # CN-4101090R), located within Raton's city limits between milepost 450.26 and 455.15 (Figure 24), was completed during the study (November 2017), and installed game fencing that connected four existing structures: Raton Creek CBC (Figure 25), Lincoln Avenue bridge (Figure 26), First Street bridge (Figure 27), and Unnamed CBC (Figure 28) (Table 4). In addition to the game fencing (7.6 miles; Figure 29), the project installed escape ramps (Figure 30), game guards (Figure 31), and electrified barriers (Figure 32). This section of I-25 has an AADT volume of 4,598.

TABLE 4 The four monitored Raton structures on I-25 within Colfax County, New Mexico

Roadway	Milepost	Name	Height (m)	Width (m)	Length (m)	Openness Factor*
I-25	452.5	Raton Creek CBC	13.8 (4.2)	13.8 (4.2)	149.3 (45.5)	0.39
I-25	453.8	Lincoln Ave Bridge	15.7 (4.8)	39.0 (11.9)	103.3 (31.5)	1.81
I-25	454.0	First Street Bridge**	-	29.5 (9.0)	199.8 (60.9)	-
I-25	454.2	Unnamed CBC	7.9 (2.4)	7.9 (2.4)	125.0 (38.1)	0.15

*Meters used to calculate openness factor.
**First Street bridge is an overpass; thus no height to calculate an openness factor

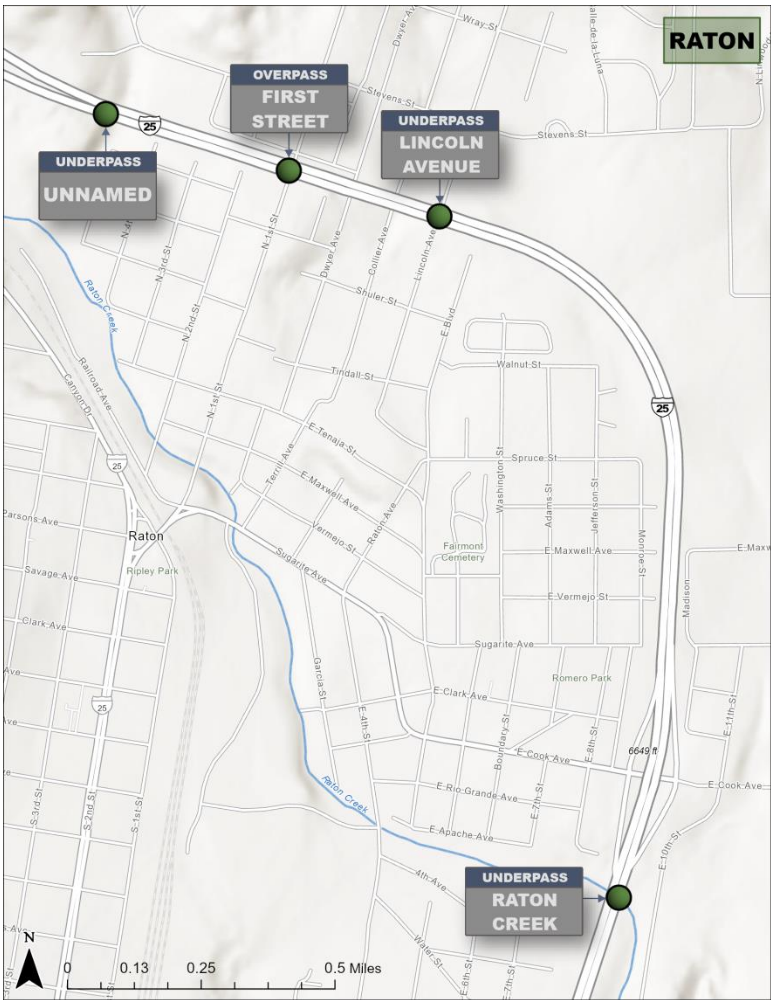

FIGURE 24 The four monitored Raton structure locations on I-25 within Colfax County, New Mexico

FIGURE 25 Raton Creek Concrete Box Culvert on I-25 at milepost 452.5 within Colfax County, New Mexico

FIGURE 26 The Lincoln Avenue Bridge on I-25 at milepost 453.8 within Colfax County, New Mexico

FIGURE 27 The First Street Bridge on I-25 at milepost 454.0 within Colfax County, New Mexico

FIGURE 28 The Unnamed Concrete Box Culvert on I-25 at milepost 454.2 within Colfax County, New Mexico

FIGURE 29 Raton game fencing on I-25 within Colfax County, New Mexico

FIGURE 30 Raton escape ramp on I-25 within Colfax County, New Mexico

FIGURE 31 Game guard located on I-25 at the North Raton interchange within Colfax County, New Mexico

FIGURE 32 Electrified barrier on the East Cook Avenue - I-25 traffic interchange in Raton within Colfax County, New Mexico

CUBA

Cuba, elevation 6,908 ft., is located in northwest New Mexico within the Colorado Plateau Ecoregion and is characterized by juniper woodland, sagebrush shrubland, and arroyo riparian scrub. Summer temperatures range from 45.8° F to 83.8° F with an average of 64.8° F, and winter temperatures range from 11.1° F to 44.5° F with an average 27.8° F *(25)*. Total average precipitation for the area is 12.9 in., which is unevenly distributed throughout the seasons: winter (2.3 in.), summer (5.1 in.), spring 2.3 in.), fall (3.2 in.) *(25)*. A dominant feature within the study area is the Rio Puerco river, which cuts a deep, incised channel, and provides vertical walls up to 35-ft high *(28)*. The river is crossed twice by US 550 via large scale bridges located at milepost 52.7 and 53.6.

The Cuba Project (Project # CN – 6101120R), located south of Cuba between milepost 51.5 and 55.9 (Figure 33), was completed during the study in July 2019, and connected two existing structures with game fencing (Table 5. Figures 34, 35, and 36). In addition to the fencing (4.5 miles; Figure 37), the project installed escape ramps (Figure 38), game guards (Figure 39), and electrified barriers across the roadway at the northern and southern fence termini as part of an ADS (Figure 40). Additionally, as part of the ADS, signage and lights were installed at the two fence termini to alert motorists of wildlife detected at the end of the fence. (Figure 41). This section of US 550 has an AADT of 9,230.

TABLE 5 The two monitored Cuba bridges located on US 550, south of Cuba within Sandoval County, New Mexico

Roadway	Milepost	Name	Height (m)	Width (m)	Length (m)	Openness Factor*
US 550	52.7	S. Rio Puerco Bridge	38.1 (11.6)	69.6 (21.2)	200.8 (61.2)	4.02
US 550	53.6	N. Rio Puerco Bridge	31.2 (9.5)	69.6 (21.2)	284.4 (86.7)	2.32

**Meters used to calculate openness factor.*

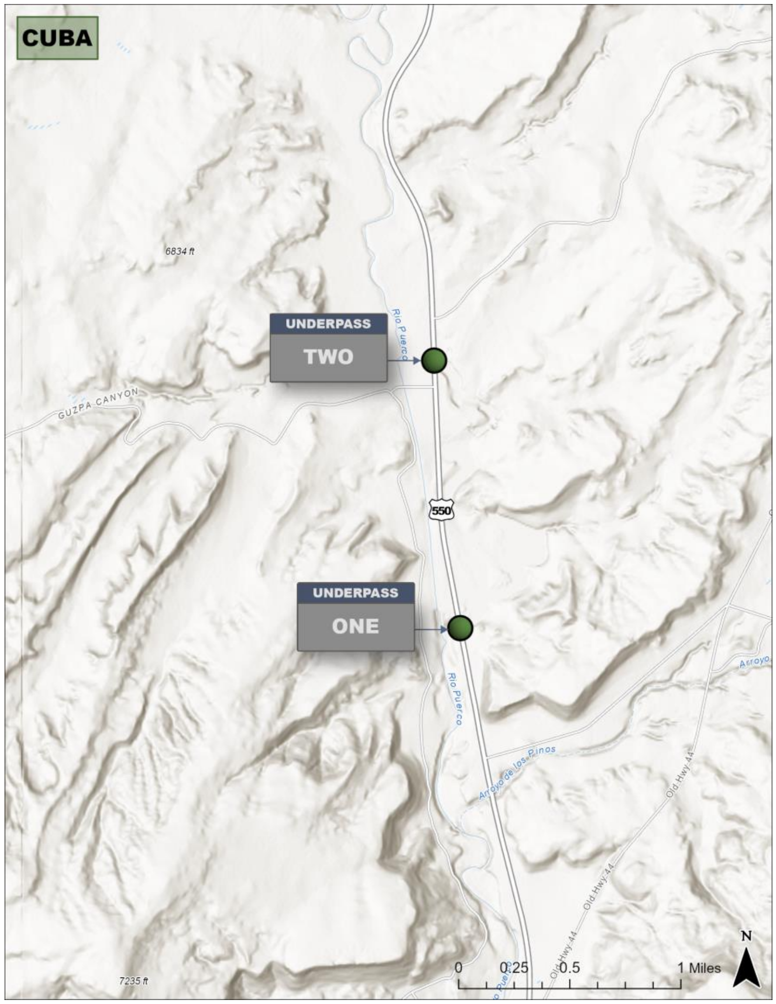

FIGURE 33 The two monitored Cuba bridge locations on US 550 south of Cuba within Sandoval County, New Mexico

FIGURE 34 North Rio Puerco Bridge located on US 550 at milepost 53.6 south of Cuba within Sandoval County, New Mexico

FIGURE 35 South Rio Puerco Bridge located on US 550 at milepost 52.7 south of Cuba within Sandoval County, New Mexico

FIGURE 36 The South Rio Puerco Bridge's scour during year two of the study

FIGURE 37 Cuba game fencing on US 550 south of Cuba within Sandoval County, New Mexico

FIGURE 38 Cuba escape ramp on US 550 south of Cuba within Sandoval County, New Mexico

FIGURE 39 Cuba game guard on US 550 at milepost 53.5 south of Cuba within Sandoval County, New Mexico

FIGURE 40 Cuba electrified barrier at game fence end on US 550 south of Cuba within Sandoval County, New Mexico

FIGURE 41 Cuba Animal Detection System on US 550 south of Cuba within Sandoval County, New Mexico

METHODS

To gather data regarding wildlife structure use, structure dimensions, and WVC, the research team used three primary sources:

- Still cameras: Data from the cameras documented whether the target species (deer, elk, black bear, and mountain lion) and other wildlife species used the structures.
- NMDOT Construction Plan Sets: Data from NMDOT plan sets and documentation provided structure dimensions for the Aztec, Tijeras, Raton, and Cuba Projects.
- NMDOT Crash Database: WVC data was provided by The University of New Mexico's NMDOT Crash Databases from 1996 to 2018.
- NMDOT Patrol Yard carcass data

WILDLIFE STRUCTURE USE

The research team placed still cameras at 16 crossing locations, three game fence gates, and one game guard. The cameras were distributed among the study areas as follows:

- Aztec US 550: six cameras at three upsized CBC
    - Four cameras redistributed May 2019 to three gates and one wildlife crossing guard
- Tijeras NM 333: four cameras at wildlife crosswalk
- Tijeras I-40: 10 cameras at four bridges
- Raton I-25: eight cameras at four CBCs, three cameras at two bridges
- Cuba US 550: eight cameras at two bridges

The research team used data gathered from the 39 motion sensitive Reconyx professional series still-frame cameras to evaluate the use of 16 crossing locations, three game fence gates, and one game guard. The cameras were installed in March 2017. The 16 crossing locations, which typically required multiple cameras, were comprised of bridges, CBCs, and one at-grade crossing. These structures had either a natural (soil) or hard (asphalt or concrete) substrate for wildlife to traverse as they crossed under, over, or onto the roadway. In May 2019 since sufficient data had been gathered and cameras were needed at other locations, NMDOT, NMDGF, and the research team decided to 1) move four Aztec cameras (CBC 1 and CBC 2) to three Aztec exculsionary fence gates and one Aztec game guard; and 2) remove the cameras from three Tijeras bridges; Middle, East (these two cameras will be reinstalled at the beginning of Phase Two), and Juan Tomas.

The cameras that monitored large bridges, gates, and the game guard were oriented to document use (crossings) by wildlife (Figure 42) and the cameras that monitored CBCs and the at-grade crossing were oriented to document passage rates (approaches and crossings) (Fgure 43). Of the 39 cameras (Table 6), 38 were operational 24-hours a day and one, which monitored a neighborhood roadway with traffic, was programed to record images between 18:00 and 07:00. This is the time period when mule deer (the target species) are most active and traffic is minimal. All cameras, when detecting motion, would record three images in rapid (~ 2 seconds) succession and were programed as follows: high sensitivity, rapid fire image interval, and no delay quiet period. Because of the limitations of battery life and image storage capacity, cameras were checked approximately every six weeks to replace batteries, collect image data, verify that camera orientation was correct, and ensure that vandalism or theft had not occurred. Images were backed up twice on external hard drives to avoid loss in the event of storage equipment failure. If a camera was stolen or vandalized, researchers replaced the camera as soon as possible to minimize disruption in data collection.

TABLE 6 Aztec, Tijeras, Raton, and Cuba camera locations, number, orientation, and structure substrate

	Roadway	Milepost	Structure	Substrate	Cameras	Orientation
Aztec	US 550	170.1	UP-1 CBC	Concrete	2	Approach/Cross
	US 550	171.1	UP-2 CBC	Natural	2	Approach/Cross
	US 550	172.2	UP-3 CBC	Concrete	2	Approach/Cross
	US 550	170.5	Gate 1	Natural	1	Approach/Cross
	US 550	170.5	Gate 2	Asphalt	1	Approach/Cross
	US 550	171.8	Gate 3	Asphalt	1	Approach/Cross
	US 550	170.0	Game Guard	Grate	1	Approach/Cross
Tijeras	NM 333	4.2	Crosswalk	Roadway	4	Approach/Cross
	I-40	170.0	Middle Bridge	Natural	4	Use
	I-40	171.0	East Bridge	Natural	2	Use
	I-40	173.3	Public School Rd	Roadway	2	Use
	I-40	184.9	Juan Tomas	Natural	2	Use
Raton	I-25	252.5	Raton Creek CBC	Natural	2	Approach/Cross
	I-25	454.0	First Street Bridge	Roadway	1	Use
	I-25	453.8	Lincoln Ave Bridge	Natural	2	Use
	I-25	454.2	Unnamed CBC	Natural	2	Approach/Cross
	I-25	458.1	458.1 CBC	Concrete	2	Approach/Cross
	I-25	458.9	458.9 CBC	Natural	2	Approach/Cross
Cuba	US 550	53.6	S. Rio Puerco	Natural	2	Use
	US 550	52.7	N. Rio Puerco	Natural	6	Use

FIGURE 42 Camera oriented to capture wildlife using the Raton I-25 Lincoln Avenue structure within Colfax County, New Mexico

FIGURE 43 Camera oriented to capture wildlife approaching and crossings the Raton I-25 Unnamed CBC within Colfax County, New Mexico

For Phase One of this research project, the data gathering period for crossing locations was from March 2, 2017 to March 3, 2020 (1125 days). More than 1.25 million images were gathered during this time period. The two exceptions to this date range are; 1) the Cuba Project, where pre-construction data gathering was from March 2, 2017 to June 30, 2019 (850 days); and the Aztec Project,where game fence gates and game guard data gathering was from May 20, 2019 to July 21, 2020 (428 days). Camera imagery data was analyzed by researchers using custom software (RABID - Rapid Analysis of Batched Imagery Data), which permits the accurate and time efficient documentation of location, date, time, species, species movement, sex, and age class. The research team used the imagery data to: 1) evaluate target wildlife (mule deer, elk, black bear, and mountain lion) use at bridges, gates, and the game guard; 2) calculate target wildlife passage rates at CBCs and the at-grade crossing; and 3) document the presence of non-target wildlife at the bridges, CBCs, and the at-grade crossing.

The team defined "use" as wildlife using the crossing structure to safely cross under the roadway, or using the open gates or game guard to enter the ROW. As in other research, given the large expanse of monitored bridges (average length approximately 180-ft), the research team determined it was not logically feasible to derive passage rates at these structures *(29)*. While passage rates, a quantitative metric of relative wildlife crossing structure effectiveness that is independent of species distribution variation, provide a means for assessing functionality among structures, the primary objective for bridges was to establish wildlife use *(30, 31)*. Therefore, given the reasonable assumption that species distributions remained constant within study sites, direct crossing rates are a valid measure of use over time *(29)*. For CBCs, the research team calculated passage rates because it was possible wildlife are more likely to be repelled by smaller structures (such as the monitored CBCs), and calculating passage rates allows researchers to better understand how structure size impacts use.

To calculate passage rates, the team determined the ratio of target wildlife that crossed (i.e., used a CBC to safely cross under the roadway) to those that approached the CBC. For example, if 25 mule deer crossed CBC A and 100 mule deer approached CBC A, the passage rate for mule deer at CBC A is 25 percent (i.e., 25 mule deer crossings ÷ 100 mule deer approaches = 0.25 or a 25 percent passage rate). Conversely, from the same example, the repel rate or did not cross rate is 75 percent. Comparing passage rates for various smaller structures throughout time verifies the effectiveness or ineffectiveness of the structure and can inform future structure design.

WILDLIFE-VEHICLE COLLISIONS

To provide a consistent evaluation of WVC trends, the team calculated rates based on 2002 through 2018 data within the NMDOT Crash Database, which is maintained by the University of New Mexico Geospatial and Population Studies Traffic Research Unit *(32)*. The crash database is the consolidation of the Uniform Crash Reports filed by law enforcement agencies to report public roadway collisions that involve one or more vehicles and results in at least $500 in property damage, personal injury, or death. Since WVC, especially concerning deer and other smaller animals often result in less than $500 property damage, rarely result in injury or death, and often go unreported, the research team worked with NMDOT to develop WVC reporting forms and procedures for the NMDOT Patrol Yards located within the project areas. In the future, the WVC data collected by Patrol Yards in conjunction with the Uniform Crash Report data will more accurately document the total number of WVC that occur on New Mexico roadways.

To evaluate the effectiveness of the mitigation measures discussed above on WVC, the team used the Crash Database to compare pre- and post-construction WVCs. For projects completed more than a decade ago (Aztec and Tijeras), the Crash Database was used to compare historical project area WVC trends. For all sites, the Database was used to evaluate each project area on a mile-by-mile basis.

For Phase One, the research team did not analyze Cuba WVC since the project was completed after the data collection period for this report. The researchers defined the project's WVC effect as occurring within the project area (Beginning of Project (BOP) to End of Project (EOP)), plus one mile on either end of the project (e.g., For BOP = 167.4, EOP = 169.0, the team looked at WVC between 166.4 to 170.0). The additional mile at either end of the project area allowed the research team to determine if wildlife were crossing the roadway near the fence termini (often referred to as an "end-of-the-fence run"). Thus, resulting in an increase in WVC at the fence ends *(33)*. This additional mile, however, was not added to Aztec's southern project boundary since the project terminates at the Animas river and precludes an "end-of-the-fence run".

SELECT CASE STUDIES

Within the long-term Phase One project, the research team conducted four short-term (2 years) case studies that focused on specific wildlife mitigation issues to provide NMDOT with recommendations prior to completion of the long-term study. These four case studies involved: 1) open game fence gates; 2) wildlife crossing structure and nearby wildlife crosswalk connectivity; 3) wildlife crossing structure access obstructions; and 4) wildlife structures with considerable cattle presence. All case studies were identified by NMDOT, NMDGF, and the research team as opportunities to provide valuable information and preliminary guidance prior to the issuance of final results and recommendations at the completion of Phase Two. Below is a discussion of these case studies.

Case Study 1: Game fence gates

The US 550 Aztec Project included 6.6 miles of game fencing and contained both gates and game guards. Both of which were placed on lateral access roads and driveways. The gates were to remain closed when not in operation. However, the gates were unlocked and could be temporarily opened by motorists to either enter or exit US 550. After entering or exiting US 550, motorists were to close the gate.

In 2016, 12 years after the Aztec Project had been completed, the research team noted that a number of gates were opened and precluded from closing by established vegetation (Figure 44). Some appeared to be recently locked and unofficially signed (Figure 45). One gate was open and closed by local residents, who also monitored the gate's entrance with a closed-circuit video camera (Figure 46). NMDOT, NMDGF, and the research team suspected that deer were using the open gates to enter the US 550 ROW.

FIGURE 44 Vegetation precluded an Aztec game fence gate from closing north of Aztec on US 550 within San *Juan County, New Mexico*

FIGURE 45 Game fence gate locked and unofficially signed north of Aztec on US 550 within San Juan County, New Mexico

FIGURE 46 Game fence gate opened and closed by local residence north of Aztec on US 550 within San Juan County, New Mexico

The research team installed still cameras at two gates that were opened and precluded from closing by established vegetation, as well as the one gate opened and closed by local residents. In addition, one game guard (Figure 47) was monitored within the project area to determine if wildlife were entering the US 550 ROW at these locations.

FIGURE 47 Monitored game guard north of Aztec on US 550 within San Juan County, New Mexico

Case Study 2: Wildlife Crossing Structure and Crosswalk Connectivity

The I-40/NM 333 Project includes a wildlife crossing structure and an at-grade wildlife crosswalk that are connected by an approximately 0.6 mile section of the vegetated Tijeras Creek (Figure 48). The proximity of the structure and the crosswalk has led NMDOT and NMDGF personnel to speculation that wildlife, specifically deer, use the wildlife crossing structure and wildlife crosswalk in succession to safely access habitat on either side of the I-40/NM 333 roadway corridor. The research team monitored the two mitigation structures to determine if deer were using them to safely cross under I-40 and over NM 333 in succession, which would provide habitat connectivity between the Manzano Mountains to the south and the Sandia Mountains to the north.

FIGURE 48 The NM 333 wildlife crosswalk and I-40 East Bridge are 0.6 miles apart within Bernalillo County, New Mexico

Case Study 3: Wildlife Crossing Structure Obstruction

At the beginning of Phase One, the research team noted that two project areas, Raton and Aztec, each had a CBC wildlife crossing structure obstructed. Raton's Unnamed CBC, located at milepost 454.2 on I-25, had a steel corral panel spanning its eastern opening (Figure 49). The panel appeared to be recently placed and intended to prevent horses from leaving the horse owner's property located adjacent to the structure. Aztec's obstructed CBC, located at milepost 172.2 on US 550, had a four-strand barbed wire fence attached to its eastern opening (Figure 50). The fence's aged barbed wire, rusted angle iron CBC attachment points, and information from NMDGF indicated that the fence had been in place for a number of years, possibly since the completion of the project in 2004.

The Raton and Aztec CBC obstructions were removed by NMDOT at the beginning of Phase One. However, the obstructions were reinstalled by unknown parties during the project, and once again removed by NMDOT. After the obstructions were removed for the second time, to prevent reinstallation, NMDOT erected wildlife friendly fences away from the CBCs' openings along the ROW boundary. The obstructions were not reinstalled for the remainder of Phase One.

The research team used still camera data and the obstructions temporal presence and absence to evaluate the short-term (Raton) and the long-term (Aztec) effects that obstructions may have on wildlife crossing structure function.

FIGURE 49 A steel corral panel obstructing a Concrete Box Culvert opening in Raton on I-25 within Colfax County, New Mexico

FIGURE 50 A barbed wire fence obstructing a Concrete Box Culvert opening north of Aztec on US 550 within San Juan County, New Mexico

Case Study 4: Wildlife Crossing Structure Cattle Presence

The US 550 Cuba Project's wildlife crossing structures are bordered by two cattle grazing allotments: Cold Creek (west of US 550) and La Ventana (east of US 550) (Figure 51). During Phase One, Cold Creek was not actively grazed and La Ventana was permitted to graze 58 cattle for 294 days (80 percent of the year) during two periods: March 1st to August 1st (153 days) and October 10th to February 28th (141 days). The research team monitored cattle structure use to determine if cattle presence impacted wildlife use.

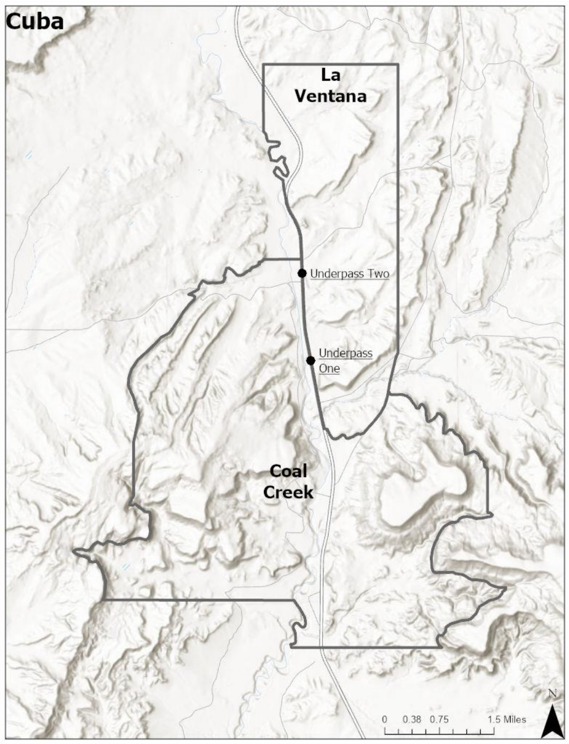

FIGURE 51 Grazing allotments south of Cuba within Sandoval County, New Mexico

RESULTS

This section contains two result types: preliminary and final. Preliminary results with little to no interpretation will be presented detailing the effectiveness of the project area's wildlife crossing structures and project mitigation, which are still being monitored as part of Phase Two. Final results and interpretations will be presented for the four case studies.

For both the preliminary and final results, the research team: 1) documented the use of 16 wildlife crossing locations, three game fence gates, one game guard; and 2) analyzed WVC data.

WILDLIFE CROSSING STRUCTURE USE

Still camera images documented 18,034 animals comprised of 21 different species at wildlife crossing structures. Of these, the research team documented 14,242 use events, including 12,408 mule deer, 220 elk, 169 black bear, and 45 mountain lions (Table 7). The still camera data results in this section are presented first for the wildlife crossing structures and the case studies second.

TABLE 7 All wildlife documented using monitored New Mexico Department of Transportation crossing structures

	At-Grade	Bridge	CBC	Total
Beaver	0	4	0	**4**
Black Bear	0	21	148	**169**
Black-tailed Jackrabbit	0	16	7	**23**
Bobcat	0	77	109	**186**
Coyote	22	331	97	**450**
Desert Cottontail	0	2	0	**2**
Elk	0	219	1	**220**
Gray Fox	18	57	90	**165**
Mountain Lion	5	26	14	**45**
Mule Deer	219	4662	7527	**12408**
Raccoon	1	40	415	**456**
Red Fox	0	0	20	**20**
Ringtail	1	0	0	**1**
Rock Squirrel	9	25	1	**35**
Striped Skunk	0	2	15	**17**
White-tailed Deer	0	33	8	**41**
Total	**275**	**5515**	**8452**	**14242**

Wildlife Crossing Structures

At four NMDOT mitigation project sites (Aztec, Tijeras, Raton, and Cuba), the research team monitored 16 wildlife crossing structures that encompassed eight bridges, seven CBCs, and one at-grade wildlife crosswalk. The research team documented a combined 12,842 target wildlife species (12,408 deer, 220 elk, 169 black bear, and 45 mountain lion) using these 16 crossing locations. The results from Phase One (November 16, 2016- November 16, 2020) and Phase Two (November 16, 2020 – October 31, 2024) will be combined to provide species specific recommendations on structure design and mitigation options in the Phase Two final report; thus, the Phase One results reported here are considered preliminary.

Aztec - Preliminary Results

The Aztec mitigation project was completed in 2004, and even though the structures have been in place for 16 years, the research team continues to gather data at the smaller CBC that was obstructred prior to, and during, the Phase One time period (see Case Study 3). Thus, the results presented here are considered preliminary and pertain to a post-construction time period.

The research team documented a total of 6,479 occurrences of wildlife using the three monitored CBCs: Underpass One (UP-1), Underpass Two (UP-2), and Underpass Three (UP-3). Of those 6,479 wildlife occurrences, 95 percent (6,134) was linked to deer use that was unevenly distributed amongst the CBCs (Table 8). Deer use varied by month (Figure 52), and time of day (Figure 53). In general, deer use peaked in the spring and late summer/early fall, and at dawn and dusk. Mule deer passage rates at all three CBCs averaged 86 percent (Table 9). In addition, elk (Table 10), black bear (Table 11), mountain lion (Table 12), and nine other wildlife species were also documented using the CBCs (Table 13).

TABLE 8 Deer documented using monitored Concrete Box Culverts to cross under US 550 north of Aztec within San Juan County, New Mexico

	Deer Structure Use
UP1	3075
UP2	2272
UP3*	787
Total	**6134**

**Prior to and during portions of this study, a fence was across this CBC. Details are provided in Case Study 3.*

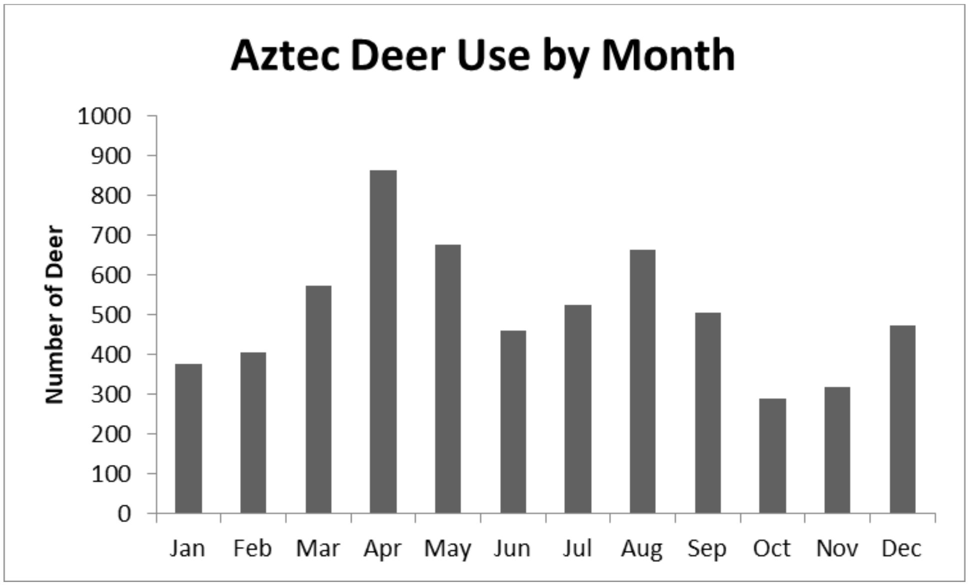

FIGURE 52 By month, deer documented using monitored Concrete Box Culverts to cross under US 550 north of Aztec within San Juan County, New Mexico

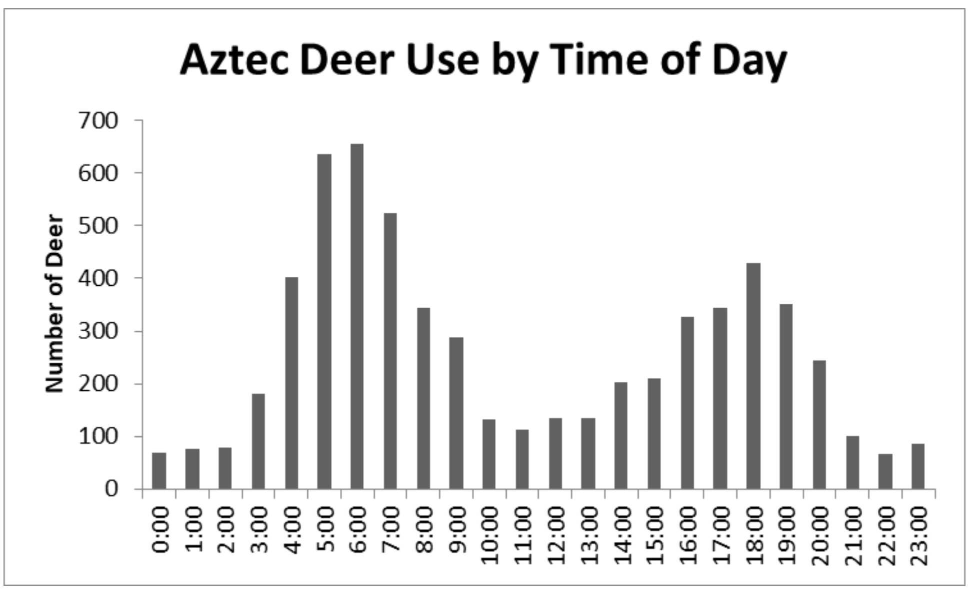

FIGURE 53 By time of day, deer documented using monitored Concrete Box Culverts to cross under US 550 north of Aztec within San Juan County, New Mexico

TABLE 9 Deer passage rates for monitored Concrete Box Culverts on US 550 north of Aztec within San Juan County, New Mexico

	Deer Approaches	Deer Crosses	Passage Rate
UP-1	3708	3075	**0.83**
UP-2	2505	2272	**0.91**
UP-3	891	787	**0.88**
Total	**7104**	**6134**	**0.86**

**Prior to and during portions of this study, a fence was across this CBC. See Case Study 3.*

TABLE 10 Elk passage rates for monitored Concrete Box Culverts on US 550 north of Aztec within San Juan County, New Mexico

	Elk Approaches	Elk Crosses	Passage Rate
UP-1	0	0	0.00
UP-2	2	1	0.50
UP-3*	0	0	0.00
Total	**2**	**1**	**0.50**

**Prior to and during portions of this study, a fence was across this CBC. See Case Study 3.*

TABLE 11 Black bear passage rates for monitored Concrete Box Culverts on US 550 north of Aztec within San Juan County, New Mexico

	Bear Approaches	Bear Crosses	Passage Rate
UP-1	0	0	0.00
UP-2	0	0	0.00
UP-3*	2	2	1.00
Total	**2**	**2**	**1.00**

**Prior to and during portions of this study, a fence was across this CBC. See Case Study 3.*

TABLE 12 Mountain lion passage rates for monitored Concrete Box Culverts on US 550 north of Aztec within San Juan County, New Mexico

	Mt. Lion Approaches	Mt. Lion Crosses	Passage Rate
UP-1	7	6	0.86
UP-2	5	4	0.80
UP-3*	2	1	0.50
Total	**14**	**11**	**0.79**

**Prior to and during portions of this study, a fence was across this CBC. See Case Study 3.*

TABLE 13 All wildlife documented using monitored Concrete Box Culverts to cross under US 550 north of Aztec iwthin San Juan County, New Mexico

	UP-1	UP-2	UP-3*	Total
Black Bear	0	0	2	**2**
Black-tailed Jackrabbit	5	0	0	**5**
Bobcat	0	1	1	**2**
Coyote	5	50	35	**90**
Elk	0	1	0	**1**
Gray Fox	4	7	24	**35**
Mountain Lion	6	4	1	**11**
Mule Deer	3075	2272	787	**6134**
Raccoon	15	3	163	**181**
Red Fox	2	1	6	**9**
Striped Skunk	6	0	3	**9**
Total	**3118**	**2339**	**1022**	**6479**

**Prior to and during portions of this study, a fence was across this CBC. See Case Study 3.*

Tijeras - Preliminary Results

The Tijeras Projects were completed in 2008, 2009, and 2010; thus, the preliminary results presented here pertain to a post-construction time period. The research team documented 2,241 occurrences of wildlife using Tijeras's five monitored structures: an at-grade wildlife crossing, Middle Bridge, East Bridge, Public School Road Bridge, and Juan Tomas Arroyo Bridge. Of those 2,241 wildlife occurrences, 79 percent (1,774) was linked to deer use and unevenly distributed amongst the structures (Table 14). To note, no deer were documented using the Public School structure. This nonuse may be related to unhabituated deer's reluctance to pass under a heavily trafficed interstate via a paved roadway. Deer use varied by month (Figure 54) and time of day (Figure 55). In general, deer use peaked in the summer and fall and at dawn and dusk. In addition, bobcat, mountain lion, and nine other wildlife species were also documented using the CBCs (Table 15).

TABLE 14 Deer documented using monitored Tijeras Canyon Safe Passage structure on I-40 and NM 333 within Bernalillo and Santa Fe Counties, New Mexico

	Mule Deer
At-grade Crossing	219
Middle Bridge	563
East Bridge	484
Public School	0
Juan Tomas	508
Total	**1774**

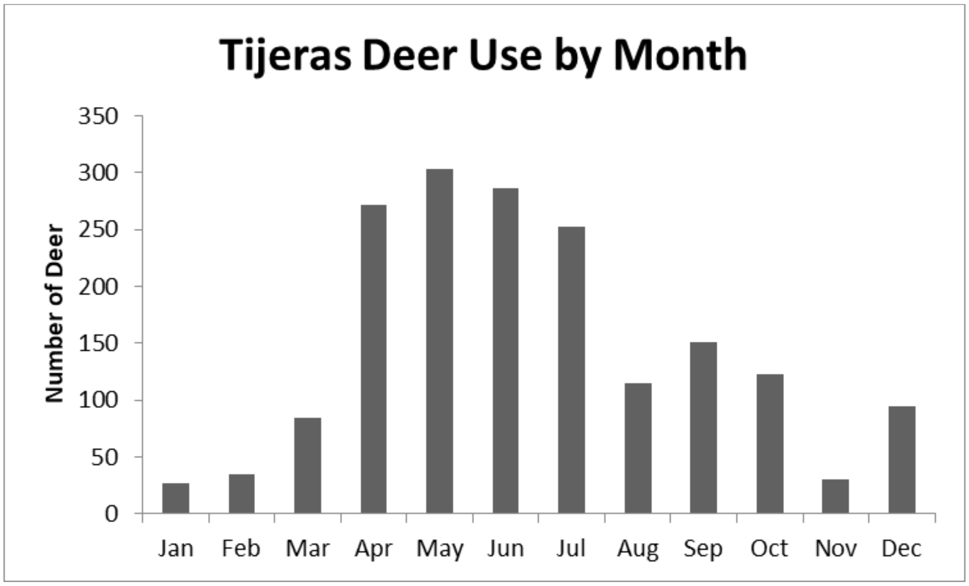

FIGURE 54 By month, deer documented using monitored Tijeras Canyon Safe Passage structure on I-40 and NM 333 within Bernalillo and Santa Fe Counties, New Mexico

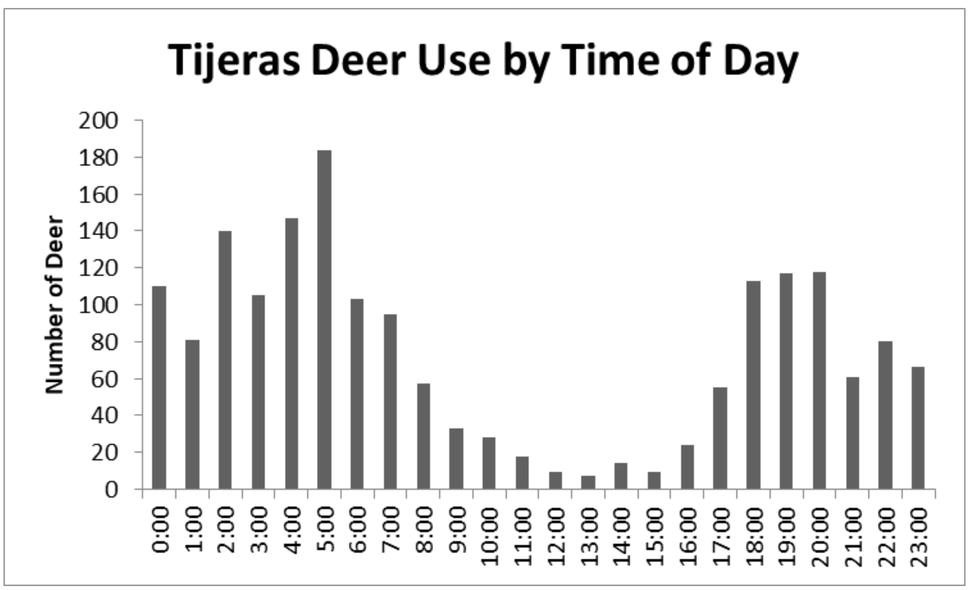

FIGURE 55 By time of day, deer documented using monitored Tijeras Canyon Safe Passage structure on I-40 and NM 333 within Bernalillo and Santa Fe Counties, New Mexico

TABLE 15 All wildlife documented using monitored Tijeras Canyon Safe Passage structure on I-40 and NM 333 within Bernalillo and Santa Fe Counties, New Mexico

	At-grade Crossing	Middle	East	Public Sch.	Juan Tomas	Total
Black Bear	0	1	0	0	0	**1**
Bobcat	0	41	15	5	0	**61**
Coyote	22	62	175	4	1	**264**
Gray Fox	18	0	1	1	0	**20**
Mountain Lion	5	0	21	0	0	**26**
Mule Deer	219	563	484	0	508	**1774**
Raccoon	1	12	15	2	0	**30**
Ringtail	1	0	0	0	0	**1**
Rock Squirrel	9	2	0	19	0	**30**
Striped Skunk	0	1	0	1	0	**2**
White-tailed Deer	0	0	0	0	32	**32**
Total	**275**	**682**	**711**	**32**	**541**	**2241**

Raton - Preliminary Results

The Raton Project was completed in November 2017, shortly after the beginning of Phase One. Thus, the preliminary results presented here pertain primarily to the post-construction time period. In addition, pre-construction results for Raton Pass, which is scheduled to be completed during Phase Two, are reported. The research team documented 3,699 occurrences of wildlife using the four monitored CBCs (Raton Creek, Unnamed, Milepost 458.1, and Milepost 458.9), and two bridges (First Street and Lincoln Avenue). While the research team expected deer to use the two, relatively large Raton CBCs, deer use at the two trafficed bridges was unexpected and likely the result of deer having been urbanized or habituated to the neighborhood, traffic, and residence.

Of those 3,699 wildlife occurrences, 87 percent (3,237) was linked to deer and unevenly distributed amongst the structures (Table 16). Deer use varied by month (Figure 56), and time of day (Figure 57). In general, deer use peaked in late spring and early summer and at dawn and dusk. Mule deer passage rates at CBCs within the Raton project area totaled 61 percent at Raton Creek and 76 percent at unnamed locations (Table 17). Mule deer passage rates for CBCs within the future Raton Pass project area totaled zero percent at Milepost 458.1 and 10 percent at Milepost 458.9 (Table 17). Whitetail deer passage rates for CBCs within the Raton project area totaled 73 percent at unnamed locations (Table 18). In addition, black bear (Table 19), mountain lion (Table 20), and elk (Table 21) were also documented at the Raton CBCs. Black bear had an average passage rate of 69 percent; mountain lion 17 percent; and elk zero percent. Seven other wildlife species were also documented using the structures (Table 22).

TABLE 16 Mule deer documented using monitored Raton structure on I-25 within Colfax County, New Mexico

	Deer Structure Use
Raton Creek	457
Lincoln Ave	2412
First Street	373
Unnamed*	928
Milepost 458.1**	0
Milepost 458.9**	8
Total	**4178**

**Prior to and during portions of this study, a fence was across this CBC. See Case Study 3.*
*** Milepost 458.1 and 458.9 are part of the future Raton Pass Project.*

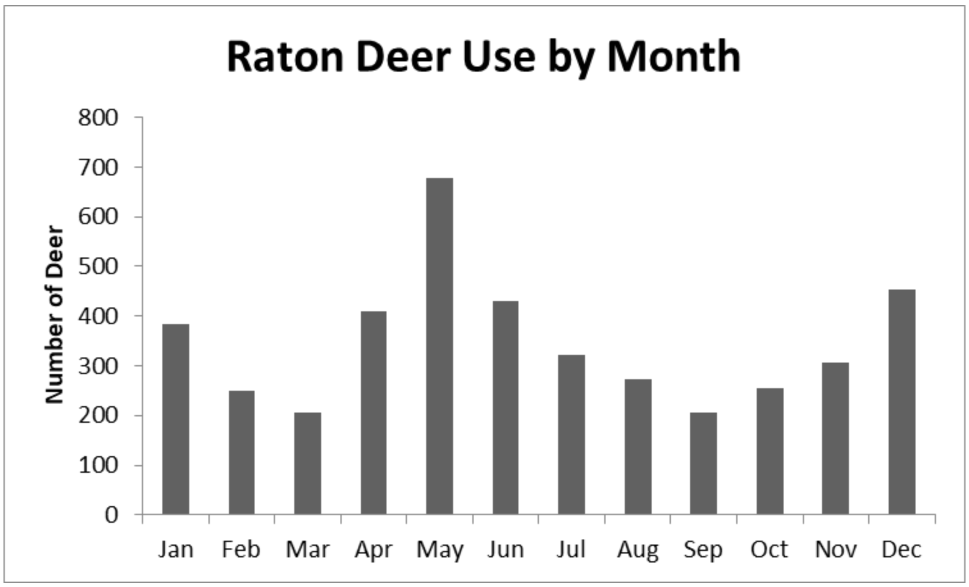

FIGURE 56 By month, deer documented using monitored Raton structure on I-25 within Colfax County, New Mexico

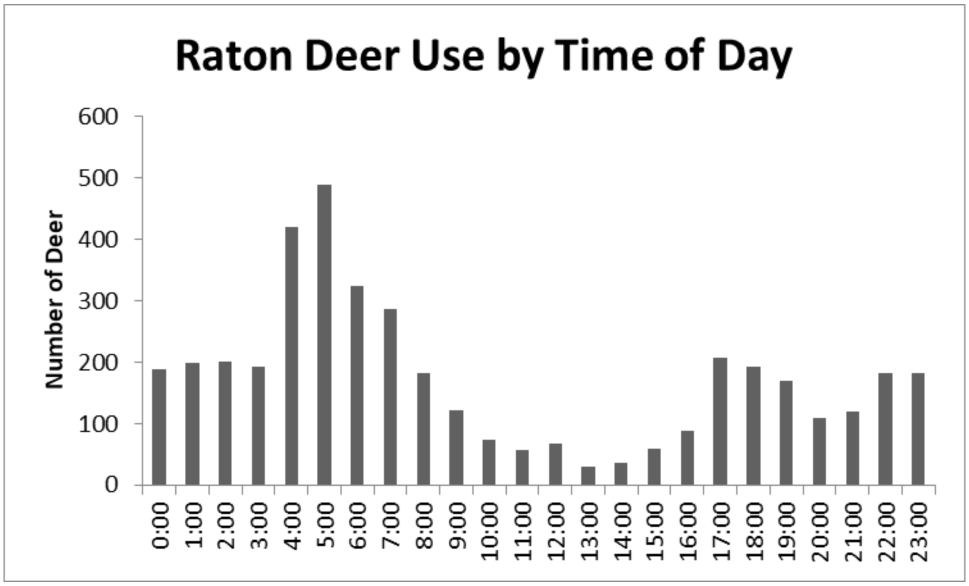

FIGURE 57 By time of day, deer documented using monitored Raton structure on I-25 within Colfax County, New Mexico

TABLE 17 Mule deer passage rates for monitored structures on I-25 in Raton within Colfax County, New Mexico

	Mule Deer Approaches	Mule Deer Crossings	Passage Rate
Raton Creek	760	457	0.60
Unnamed*	1144	928	0.81
Milepost 458.1**	95	0	0.00
Milepost 458.9**	87	8	0.09
Total	**2086**	**1393**	**0.67**

**Prior to and during portions of this study, a fence was across this CBC. See Case Study 3.*
***Milepost 458.1 and 458.9 are part of the future Raton Pass Project.*

TABLE 18 Whitetail deer passage rates for monitored structures on I-25 in Raton within Colfax County, New Mexico

	Whitetail Deer Approaches	Whitetail Deer Crossings	Passage Rate
Unnamed*	11	8	0.73
Total	**11**	**8**	**0.73**

**Prior to and during portions of this study, a fence was across this CBC. See Case Study 3.*

TABLE 19 Black Bear passage rates for monitored structures on I-25 in Raton within Colfax County, New Mexico

	Bear Approaches	Bear Crosses	Passage Rate
Raton Creek	70	43	0.61
Unnamed*	10	10	1.00
Milepost 458.1**	145	67	0.46
Milepost 458.9**	44	26	0.59
Total	**269**	**146**	**0.54**

**Prior to and during portions of this study, a fence was across this CBC. See Case Study 3.*
***Milepost 458.1 and 458.9 are part of the future Raton Pass Project.*

TABLE 20 Mountain lion passage rates for monitored structures on I-25 in Raton within Colfax County, New Mexico

	Mt. Lion Approaches	Mt. Lion Crosses	Passage Rate
Raton Creek	0	0	0.00
Unnamed*	2	2	1.00
Milepost 458.1**	6	0	0.00
Milepost 458.9**	1	1	1.00
Total	**9**	**3**	**0.33**

**Prior to and during portions of this study, a fence was across this CBC. See Case Study 3.*
***Milepost 458.1 and 458.9 are part of the future Raton Pass Project.*

TABLE 21 Elk passage rates for monitored structures on I-25 in Raton within Colfax County, New Mexico

	Elk Approaches	Elk Crosses	Passage Rate
Raton Creek	0	0	0.00
Unnamed*	0	0	0.00
Milepost 458.1**	16	0	0.00
Milepost 458.9**	33	0	0.00
Total	**49**	**0**	**0.00**

**Prior to and during portions of this study, a fence was across this CBC. See Case Study 3.*
***Milepost 458.1 and 458.9 are part of the future Raton Pass Project.*

TABLE 22 All wildlife documented using monitored Raton structure on I-25 within Colfax County, New Mexico

	Raton Creek	Lincoln Ave.	First St.	Unnamed*	458.1**	458.9**	Total
Black Bear	43	12	7	10	67	26	**165**
Black-tailed Jackrabbit	0	0	0	2	0	0	**2**
Bobcat	1	0	0	0	63	43	**107**
Coyote	2	2	0	2	0	3	**9**
Gray Fox	0	51	1	50	5	0	**107**
Mountain Lion	0	0	0	2	0	1	**3**
Mule Deer	457	2412	373	928	0	8	**4178**
Raccoon	196	4	0	16	2	20	**238**
Red Fox	0	0	0	11	0	0	**11**
Striped Skunk	4	0	0	2	0	0	**6**
Whitetail Deer	0	1	0	8	0	0	**9**
Total	**703**	**2482**	**381**	**1031**	**137**	**101**	**4835**

**Prior to and during portions of this study, a fence was across this CBC. See Case Study 3.*
***Milepost 458.1 and 458.9 are part of the future Raton Pass Project.*

Cuba - Preliminary Results

The Cuba Project was completed in July 2019. Thus, the preliminary results presented here pertain to the pre-construction time period (3/2/17 to 6/30/19). The research team documented 571 wildlife using the two monitored bridges: North Rio Puerco and South Rio Puerco. Of those 571 wildlife documented uses, 42 percent (239) was linked to mule deer and 37 percent (212) was linked to elk. Deer were documented more often at the South Rio Puerco bridge, and elk were documented more often at the North Rio Puerco bridge (Table 23). Deer and elk use varied by month (Figure 58 and 60) and time of day (Figure 59 and 61). In general, deer use peaked in the spring and fall and at dawn and dusk. In general, elk use peaked in the summer, early morning (2:00) and later at night (20:00). In addition, black bear, mountain lion, and eight other wildlife species were also documented using the bridges (Table 24).

TABLE 23 Deer and elk documented using monitored structure south of Cuba on US 550 within Sandoval County, New Mexico

	Deer Use	Elk Use
N. Rio Puerco	61	127
S. Rio Puerco	178	85
Total	**239**	**212**

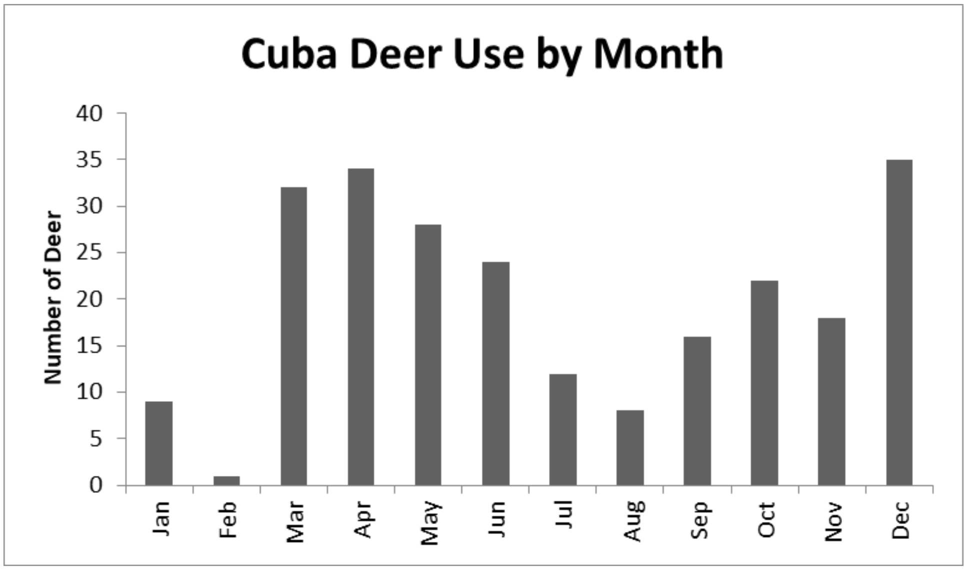

FIGURE 58 By month, deer documented using monitored structures south of Cuba on US 550 within Sandoval County, New Mexico

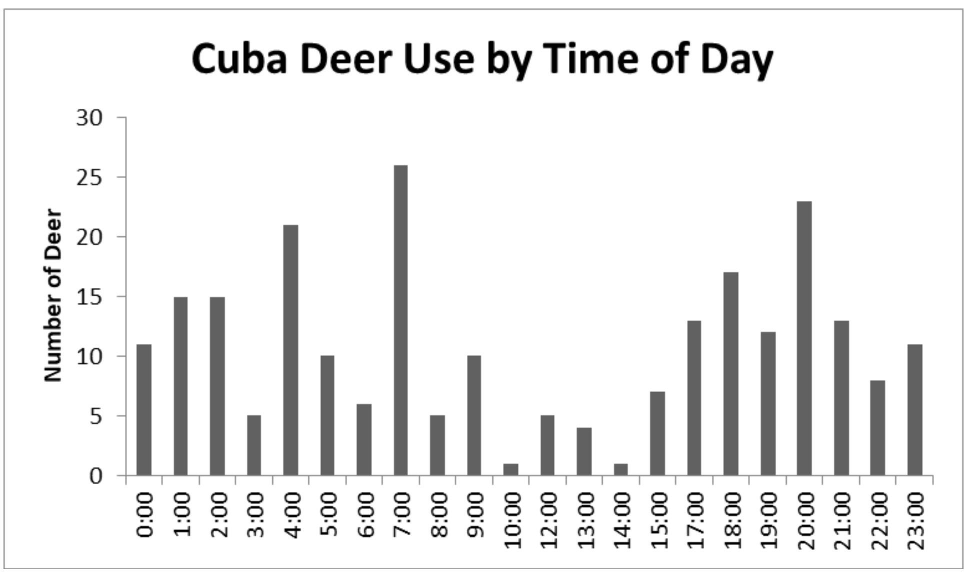

FIGURE 59 By time of day, deer documented using monitored structures south of Cuba on US 550 within Sandoval County, New Mexico

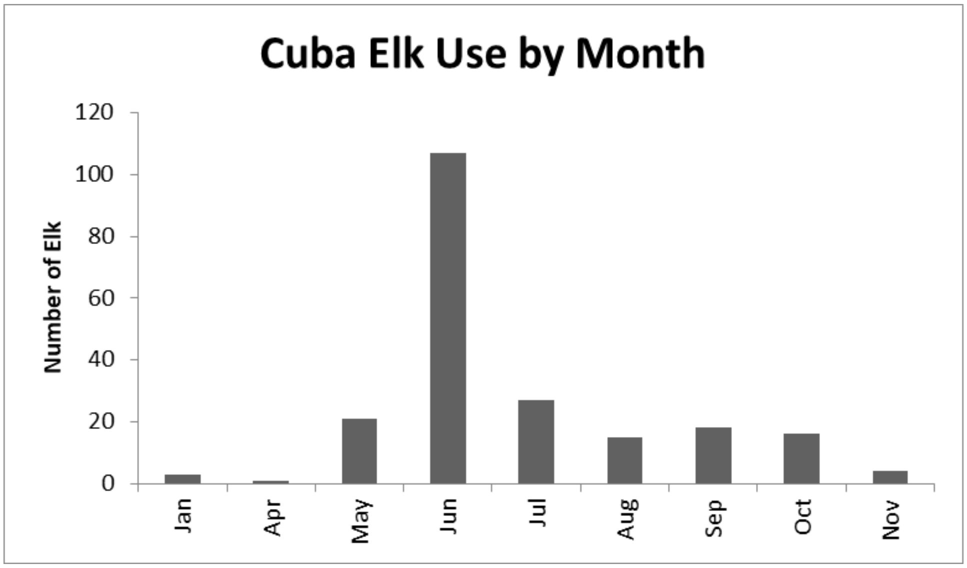

FIGURE 60 By month, elk documented using monitored structures south of Cuba on US 550 within Sandoval County, New Mexico

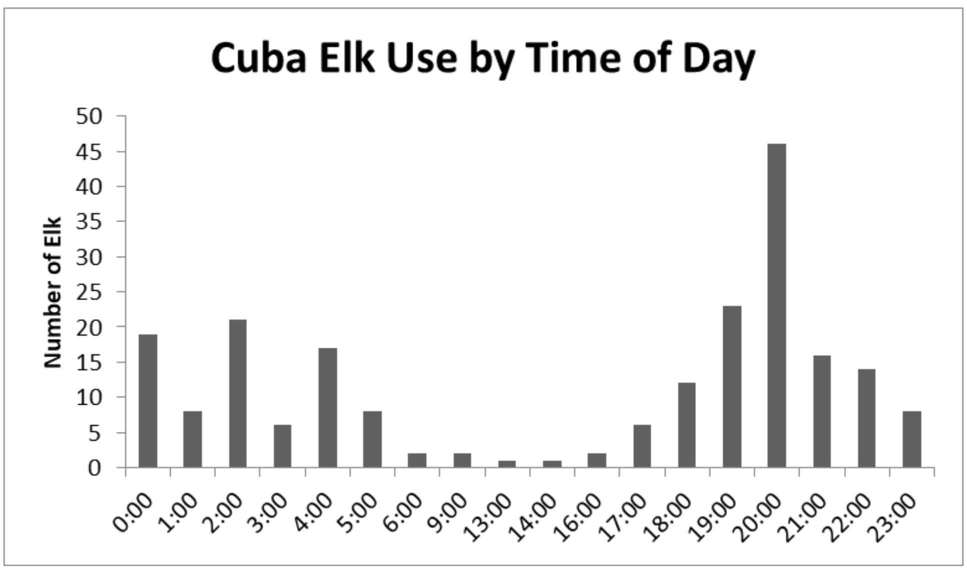

FIGURE 61 By time of day, elk documented using monitored structure south of Cuba on US 550 within Sandoval County, New Mexico

TABLE 24 All wildlife documented using monitored structure south of Cuba on US 550 within Colfax County, New Mexico

	N. Rio Puerco	S. Rio Puerco	Total
Beaver	0	4	**4**
Black Bear	1	0	**1**
Black-tailed Jackrabbit	16	0	**16**
Bobcat	6	5	**11**
Coyote	36	37	**73**
Desert Cottontail	1	0	**1**
Elk	127	85	**212**
Gray Fox	0	2	**2**
Mountain Lion	4	1	**5**
Mule Deer	61	178	**239**
Raccoon	0	3	**3**
Rock Squirrel	0	4	**4**
Total	**252**	**319**	**571**

WILDLIFE-VEHICLE COLLISIONS

The research team evaluated WVC for the state of New Mexico in general and mitigation sites specifically. For New Mexico and mitigation sites, the research team analyzed the NMDOT Transportation Crash Database for 2002 through 2018 and Annual Reports. For two project areas with sufficient carcass collection data, Aztec and Raton, the team also used Patrol Yard carcass collection data from 2016 through 2019. Since Aztec and Raton WVCs are primarily comprised of collisions with deer, which are underreported within the Crash Database, Patrol Yard data more completely documents the number of WVCs within these study sites. The team presents the Patrol Yard data results at the end of the Aztec and Raton sections so they are not confused with those from the Crash Database and Annual Reports.

For New Mexico, the Crash Database documented 15,419 WVC, which totals to an average of 907 collisions per year. Of those 15,419 WVC, 11,359 (74 percent) of the collisions were with deer for an average of 631 deer-vehicle collisions (DVC) each year. The 2018 Annual Report noted that New Mexico WVCs have consistently increased within recent years; 2018 had 1,377 WVC, a 51 percent increase over the state’s 16 year average (907); and 991 DVC, a 36.3 percent increase over the state’s 16 year average (631) (Figure 62) (NMDOT – New Mexico Traffic Crash Annual Report 2018).

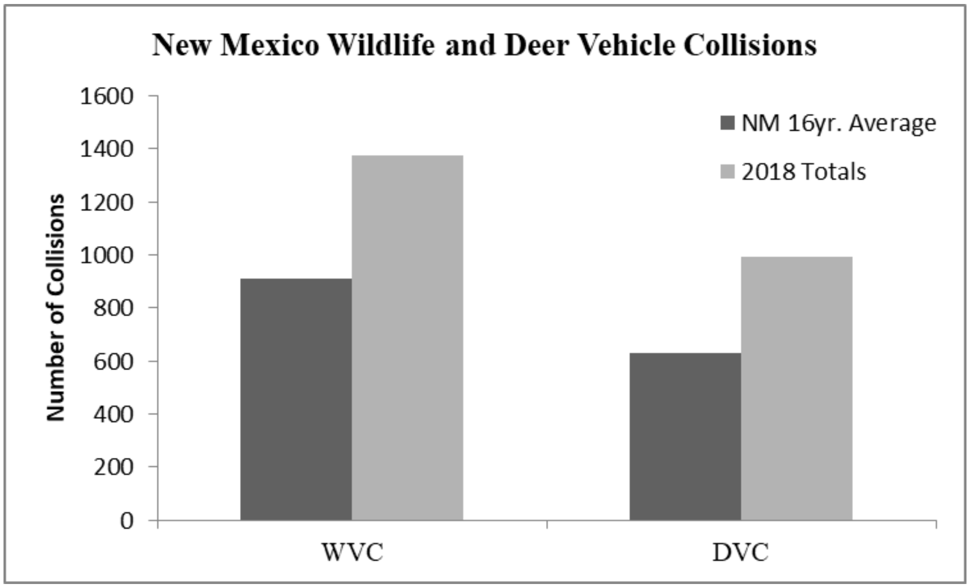

FIGURE 62 New Mexico historic average and 2018 wildlife and deer vehicle collisions. Data from NMDOT Crash Database

The research team looked at site specific WVC trend data to determine the effectivenss of longterm mitigation projects (Aztec and Tijeras) when compared to New Mexico as a whole. While the Crash Database and Annual Reports indicate that New Mexico's DVCs trends have markedly increased in recent years (2016 – 2018), Aztec and Tijeras Canyon projects, which have been completed for more than a decade, have decreased and remained the same respecitvely (Figure 63).

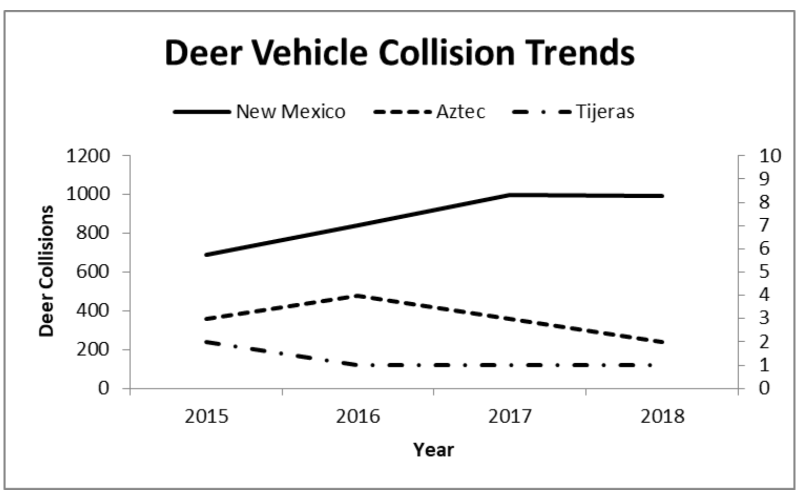

FIGURE 63 New Mexico, Aztec, and Tijeras Canyon 2015 - 2018 wildlife-vehicle collision trends. Data from NMDOT Crash Database

For each individual project area, the team considered each site to be comprised of the miles between the projects' BOP and EOP plus one additional mile on either end of the project to capture

WVCs that were likely the result of wildlife crossing the road at the end of the project's game fence. The Crash Database reports WVC to the nearest milepost.

Aztec

The Aztec project was completed in 2004 and has a BOP of 169.5 and an EOP of 172.8. Prior to project completion, 2002-2004, a total of 15 WVCs were documented (Table 25). The reletively few docuemnted WVC during this time period is likley the result of construction activities detering wildlife from entering the roadway and/or the reduction of vehicle speeds within the construction zone allowing wildlife to cross the roadway safely. However, another significant compounding factor is the WVC data itself. The Aztec project was part of a roadway reconstruction project. This project resulted in the roadway name changing from NM 44 to US 550. In addition, milepost numbering also changed. Retrieving WVC data that has the old roadway name (NM 44) and old milepost numbers has been problematic. It is very likely that the 15 WVC documented between 2002 and 2004 is an extremely inaccurate and underrepresented figure.

Since completion, 2005-2018, a total of 123 WVCs have been documented (Table 25), 96 percent (118) of which have been deer and 33 percent (40) occuring at or near the projects northern terminous. These collisions are likely the result of deer entering the roadway via open gates (see Case Study 1) and also being struck as they cross the road at the game fence's northern terminous. To address the issue of wildlife entering the roadway via open gates, NMDOT will replace most gates with game guards during an upcoming Highway Safety Improvement Program (HSIP) funded project that is scheduled for construction in 2022.

It is important to emphasize that despite the continued number of WVCs within the Aztec project area, the number of mule deer (6,134) documented using the three (3) CBCs is the highest of any project site. This suggests that if the Aztec mitigation project was not completed, WVCs would be significantly higher in this area. The Patrol Yard carcass collection data results support this assertion.

Patrol Yard data from 2017 to 2019 (data was not collected in 2016) shows that the three mile Aztec project area had relatively few DVCs (13) when compared to the adjacent two miles of roadway on either end of the project (64) (Figure 64). The adjacent two miles of roadway on either end of the project had 64 DVC, which averages to 16 DVC per mile compared to 13 DVC per mile within the project area, an average of approximatley 5 DVC per mile. Thus, when using the documented DVCs on the adjacent two miles of roadway as a predictor for the number of DVCs that would be expected to occur within the project area, the project area had an 80 percent reduction in expected DVCs.

TABLE 25 Wildlife-Vehicle Collisions documented within the Aztec mitigation project area, which was completed in 2004. Shaded area shows the milepost location of the project and post-construction years. Data from NMDOT Crash Database

	Milepost					
	169	**170**	**171**	**172**	**173**	**Total**
2002	0	1	0	2	0	**3**
2003	1	0	0	1	1	**3**
2004	0	0	2	1	6	**9**
2005	3	0	1	2	4	**10**
2006	2	5	1	2	0	**10**
2007	3	0	1	0	4	**8**
2008	1	1	2	0	3	**7**
2009	4	2	0	0	2	**8**
2010	4	6	2	0	0	**12**
2011	1	0	1	2	0	**4**
2012	0	1	0	1	1	**3**
2013	0	0	0	0	0	**0**
2014	6	3	2	1	3	**15**
2015	4	2	0	1	3	**10**
2016	6	2	2	0	5	**15**
2017	6	1	1	1	4	**13**
2018	6	1	0	1	0	**8**
Total	**47**	**25**	**15**	**15**	**36**	**138**

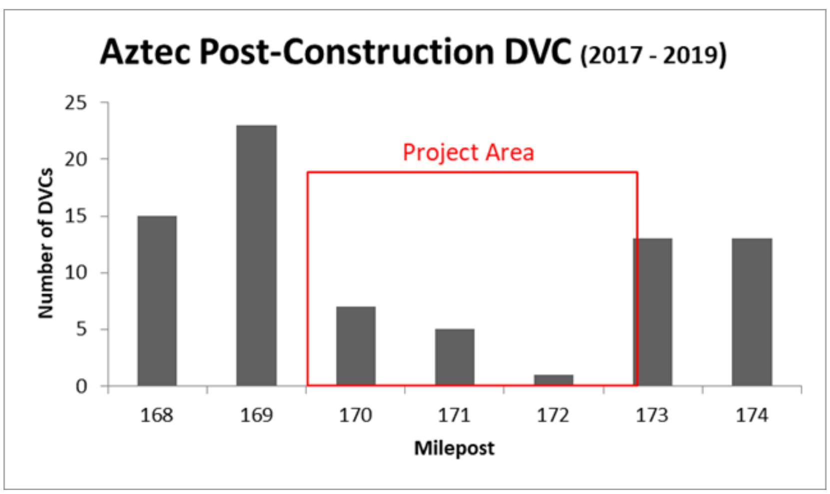

FIGURE 64 The US 550 project area north of Aztec has fewer deer-vehicle collisions than roadway outside the project. Data from Patrol Yard carcass collection

Tijeras

The Tijeras projects were completed in three phases: Phase One - NM 333 (BOP 3.8, EOP 4.3) and I-40 (BOP 169.5 – EOP 174.2) completed in 2008; Phase Two – I-40 (BOP 174.5 – EOP

177.5) completed in 2009; and Phase Three – I-40 Edgewood BOP 182.8 – EOP 187.0 completed in 2010. Prior to completion of Phase One (Table 26 and 27), Phase Two (Table 28), and Phase Three (Table 29), a total of 20 WVC were documented. The relatively few documented WVC within these project areas is likely because of the large volume of commercial truck traffic on I-40. This interstate is a major east west route heavily utilized for the transportation of goods and materials across the US. The roadway has a large volume of commercial truck traffic throughout the day and night. Wildlife-vehicle collisions involving commercial trucks are frequently unreported because truck damage is limited or non-existent. The low number of reported WVC makes it difficult to evaluate pre and post mitigation impacts on WVCs.

Since completion, a total of 28 WVCs have been documented (Table 26, 27, 28, and 29). NMDOT is already aware of two issues related to these project areas: 1) the inconsistently functioning electrified fence originally intended to exclude animals from the roadway and 2) the NM 333 ADS, which does not function properly. Both of these issues are being addressed by NMDOT and NMDGF. A pavement rehabilitation project on I-40 that is scheduled for construction in 2024 will replace the electric fence with a conventional 8-foot high woven wire game fence. The replacement of the NM 333 ADS is in the early planning stages.

The Phase Three I-40 Edgewood Project showed a reduction in WVC at MP 185 (Table 29). The Juan Tomas Bridge is near this location and the drainage it spans is likely a crossing area historically used by wildlife. Prior to the installation of game fencing, some wildlife likely crossed I-40 at grade rather than using the bridge to safely cross under the roadway. Prior to the fence being installed, six (6) WVCs were documented at this location over a 9-year period. After fence construction, only two (2) WVCs were documented at this same location over an 8-year period (Table 29).

TABLE 26 Wildlife-Vehicle Collisions documented within the Tijeras Phase One NM 333 (milepost 3.8 – 4.3) mitigation project area. Shaded area shows the milepost location of the project and post-construction years. Data from NMDOT Crash Database

	2	**3**	**4**	**5**	**Total**
2002 - 2008	0	0	0	0	**0**
2009	0	0	0	0	**0**
2010	1	0	0	0	**1**
2011	0	0	1	0	**1**
2012	0	0	0	0	**0**
2013	0	0	0	0	**0**
2014	0	0	1	1	**2**
2015	1	0	0	0	**1**
2016	1	0	0	0	**1**
2017	1	0	0	0	**1**
2018	1	0	1	0	**2**
Total	**5**	**0**	**3**	**1**	**9**

TABLE 27 Wildlife-Vehicle Collisions documented within the Tijeras Phase One I-40 (milepost 169.5 – 174.2) mitigation project area. Shaded area shows milepost location of project and post-construction years. Data from NMDOT Crash Database

	Milepost								
	168	**169**	**170**	**171**	**172**	**173**	**174**	**175**	**Total**
2002	0	0	0	0	0	0	0	1	**1**
2003	0	0	0	0	0	0	1	0	**1**
2004	0	0	0	0	0	1	1	0	**2**
2005	0	0	0	0	0	0	1	0	**1**
2006	0	0	0	0	0	0	0	0	**0**
2007	0	0	0	0	0	0	0	0	**0**
2008	0	0	0	0	0	0	0	0	**0**
2009	0	0	0	0	0	0	0	0	**0**
2010	0	0	0	0	0	0	0	0	**0**
2011	0	0	0	0	0	0	0	0	**0**
2012	0	0	0	0	0	0	0	0	**0**
2013	0	0	0	0	0	0	1	0	**1**
2014	0	0	0	0	0	0	0	0	**0**
2015	1	0	0	0	0	0	0	0	**1**
2016	0	0	0	0	0	0	0	0	**0**
2017	0	0	2	1	1	0	1	0	**5**
2018	0	0	0	0	0	0	0	0	**0**
Total	**1**	**0**	**2**	**1**	**1**	**1**	**5**	**1**	**12**

TABLE 28 Wildlife-Vehicle Collisions documented within the Tijeras Phase Two I-40 (milepost 169.5 – 174.2) mitigation project area. Shaded area shows milepost location of project and post-construction years. Data from NMDOT Crash Database

	Milepost						
	173	**174**	**175**	**176**	**177**	**178**	**Total**
2002	0	0	1	0	0	0	**1**
2003	0	1	0	0	0	0	**1**
2004	1	1	0	0	1	0	**3**
2005	0	1	0	0	0	0	**1**
2006	0	0	0	0	0	0	**0**
2007	0	0	0	0	0	0	**0**
2008	0	0	0	0	0	0	**0**
2009	0	0	0	0	0	0	**0**
2010	0	0	0	0	0	0	**0**
2011	0	0	0	0	0	1	**1**
2012	0	0	0	0	0	0	**0**
2013	0	1	0	0	0	0	**1**
2014	0	0	0	0	0	0	**0**
2015	0	0	0	0	0	0	**0**
2016	0	0	0	0	0	1	**1**
2017	0	1	0	0	0	0	**1**
2018	0	0	0	0	0	1	**1**
Total	**1**	**5**	**1**	**0**	**1**	**3**	**11**

TABLE 29 Wildlife-Vehicle Collisions documented within the Tijeras Phase Three I-40 (182.8 – 187.0) mitigation project area. Shaded area shows milepost location of project and post-construction years. Data from NMDOT Crash Database

	Milepost								
	181	182	183	184	185	186	187	188	Total
2002	0	0	0	0	1	1	0	0	2
2003	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	2	0	0	0	2
2005	0	0	0	0	1	0	0	0	1
2006	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	1	0	0	0	1
2008	0	0	0	0	1	0	0	0	1
2009	0	0	0	0	0	0	0	1	1
2010	1	0	0	0	0	0	0	0	1
2011	0	0	0	0	1	0	0	0	1
2012	0	0	0	0	0	0	0	0	0
2013	0	0	0	1	0	0	0	0	1
2014	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	1	0	0	0	1
2017	0	2	1	0	0	0	0	1	4
2018	0	0	0	0	0	0	0	0	0
Total	1	2	1	1	8	1	0	2	16

Raton

The Raton project was completed in late 2017 and has a BOP of 450.5 and an EOP of 454.7. Prior to project completion, based on reported WVCs from 2002 to 2018, a total of 154 WVCs were documented (Table 30), 84 percent (130) of which had been with deer. Since completion in November 2017, a total of 12 WVC have been documented (Table 30), 83 percent (10) of which have been with deer and 58 percent (7) occuring between mileposts 451 and 452. These collisions are likely the result of deer entering the roadway via the game fence's southern terminous (milepost 450.2). This is only 1-year of post-construction WVC data. Additional years of data are necessary to completely evaluate the effectiveness of this project. This evaluation will continue in Phase 2 of this study. In addition, NMDOT is evaluating extending the game fence southward to eleviate the impacts of end-run events.

The Raton Patrol Yard carcass collection data (2016 to 2019) indicated that, prior to completion, the project area had 102 DVCs. After project completion, 35 DVCs were recorded, which equates to approximately a 66 percent reduction in DVCs (Figure 65). These preliminary findings, based on carcass collection data, suggest that the Raton mitigation project is effectively reducing WVCs.

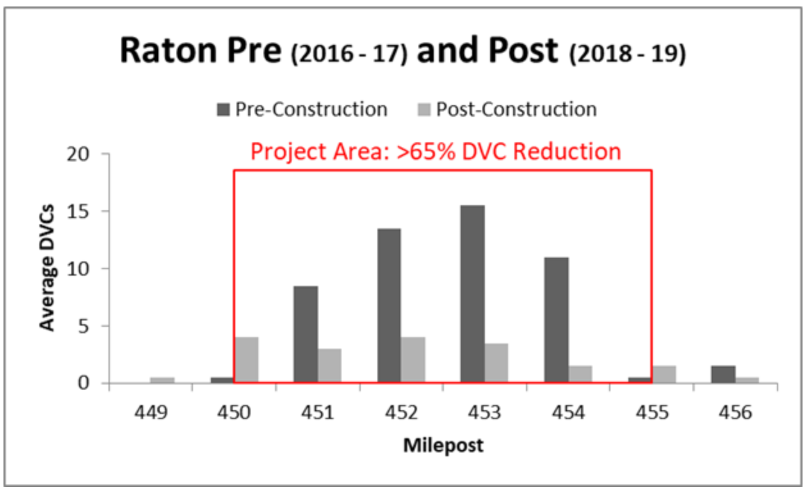

FIGURE 65 The Raton Project within Colfax County, New Mexico reduced deer-vehicle collisions by more than 65 percent. Data from Patrol Yard carcass collection

TABLE 30 Wildlife-Vehicle Collisions documented within the Raton (450.5 – 454.7) mitigation project area. Shaded area shows milepost location of project and post-construction years. Data from NMDOT Crash Database

	Milepost								
	449	450	451	452	453	454	455	456	Total
2002	0	0	0	1	0	4	0	1	6
2003	0	0	1	3	1	2	0	2	9
2004	0	0	0	2	3	1	0	0	6
2005	0	0	0	1	1	0	0	1	3
2006	0	0	1	3	0	4	0	0	8
2007	0	1	0	0	2	1	0	0	4
2008	0	1	0	2	1	1	0	1	6
2009	0	2	2	3	2	1	2	1	13
2010	0	2	3	2	3	3	0	2	15
2011	2	2	3	3	1	2	1	0	14
2012	1	0	1	3	1	3	1	0	10
2013	0	0	0	0	0	0	0	0	0
2014	0	0	0	4	1	9	0	2	16
2015	0	0	1	6	2	4	1	1	15
2016	0	1	4	3	5	2	0	0	15
2017	0	2	3	3	1	3	0	2	14
2018	0	0	3	4	1	2	1	1	12
Total	3	11	22	43	25	42	6	14	166

Cuba

The Cuba project was completed in 2019 and has a BOP of 51.7 and an EOP of 55.8. Prior to completion of the project, 2002 – 2018, a total of 30 WVCs were documented (Table 31). Deer accounted for 60 percent (18) of these collisions and elk accounted for 40 percent (12). Post-construction WVC data has yet to be analyzed and will be the focus of Phase 2 of this study.

TABLE 31 Wildlife-Vehicle Collisions documented within the Cuba (51.7 – 55.8) mitigation project area. Data from NMDOT Crash Database

	Milepost							
	50	**51**	**52**	**53**	**54**	**55**	**56**	**Total**
2002	0	0	0	0	1	0	1	2
2003	0	0	0	0	0	0	1	1
2004	0	0	1	1	0	1	0	3
2005	0	1	2	0	1	0	0	4
2006	0	0	1	0	0	0	1	2
2007	1	0	0	0	0	0	0	1
2008	0	0	0	0	1	0	0	1
2009	0	0	0	1	0	1	0	2
2010	1	0	0	1	1	0	0	3
2011	0	0	0	1	0	0	0	1
2012	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0
2016	1	0	1	0	0	0	0	2
2017	1	2	1	0	0	0	1	5
2018	1	1	1	0	0	0	0	3
Total	5	4	7	4	4	2	4	30

SELECT CASE STUDIES

As mentioned, the research team used still camera data for the analysis of the four case studies: 1) open game fence gates; 2) wildlife crossing structures with nearby wildlife crosswalk connectivity; 3) wildlife crossing structure access obstruction; and 4) wildlife crossing structures with considerable cattle presence.

The research team used data gathered from already existing Phase One cameras for case studies two, three, and four. Four additional cameras were added on May 20, 2019 for the first case study. The four additional cameras gathered more than 338,000 images. Overall, case study cameras were deployed for a total of 850 days (for studies two, three, and four) and 428 days (for study one).

Case Study 1: Game fence gates

The research team monitored two types of game fence gates: “always open” gates that were precluded from closing by vegetation; and “mostly closed” gates that were opened and closed by local residents that monitored the gate’s entrance with a closed-circuit video camera.

As mentioned previously, over a period of 428 days (14 months), the research team gathered and analyzed more than 338,000 images at the three game fence gates and one game guard. The majority of the images documented vehicles entering or exiting US 550. 912 images documented wildlife present at the monitored gates and game guard. Of the 912 wildlife documented within the images, a total of 831 were deer, which is the species involved in the majority of Aztec’s WVCs.

Overall, the research team documented a total of 457 deer approaching the gates and 374 approaching the game guard. Of the 457 deer that approached the “always open” and “mostly closed” gates, 382 entered the US 550 ROW, for a total passage rate of 84 percent (Table 25). The researchers also documented that more deer (450) approached “always open” gates than deer (7) approached “mostly closed” gates. For the game guard, the research team documented 374 deer approaches and 15 crosses, a passage rate of four percent (Table 26). The deer crossed via the guards’ 6-in. vault beams, which connected the ROW to the non-ROW.

TABLE 32 Deer passage rates for monitored game fence gates north of Aztec within San Juan County, New Mexico

	Approach	Cross	Passage Rate
Mostly Open Gates	450	379	0.84
Mostly Closed Gates	7	3	0.43
All Gates	**457**	**382**	**0.84**

TABLE 33 Deer passage rates for monitored game guard north of Aztec within San Juan County, New Mexico

	Approach	Cross	Passage Rate
Wildlife crossing Guard	374	15	0.04

Case Study 2: Wildlife Crossing Structure and Crosswalk Connectivity

NM 333's Wildlife Crosswalk and I-40's East Bridge are 0.6 miles apart (Figure 66). During the still camera data review process, the research team documented a pair of male deer using the Wildlife Crosswalk (Figure 67) and East Bridge (Figure 68) in succession. The pair, which traveled together, had individually distinct antler configurations that permitted the researchers to positively identify the individuals as they passed from the Wildlife Crosswalk to and under East Bridge. NMDOT and NMDGF have often asserted that these two structures are allowing wildlife to safely travel between the Sandia and Manzano mountains and this documentation supports that conclusion. Thus, the team will continue to monitor the Crosswalk and East Bridge throughout Phase Two in order to evaluate the data and determine how often these complete movements across NM 333 and I-40 occur.

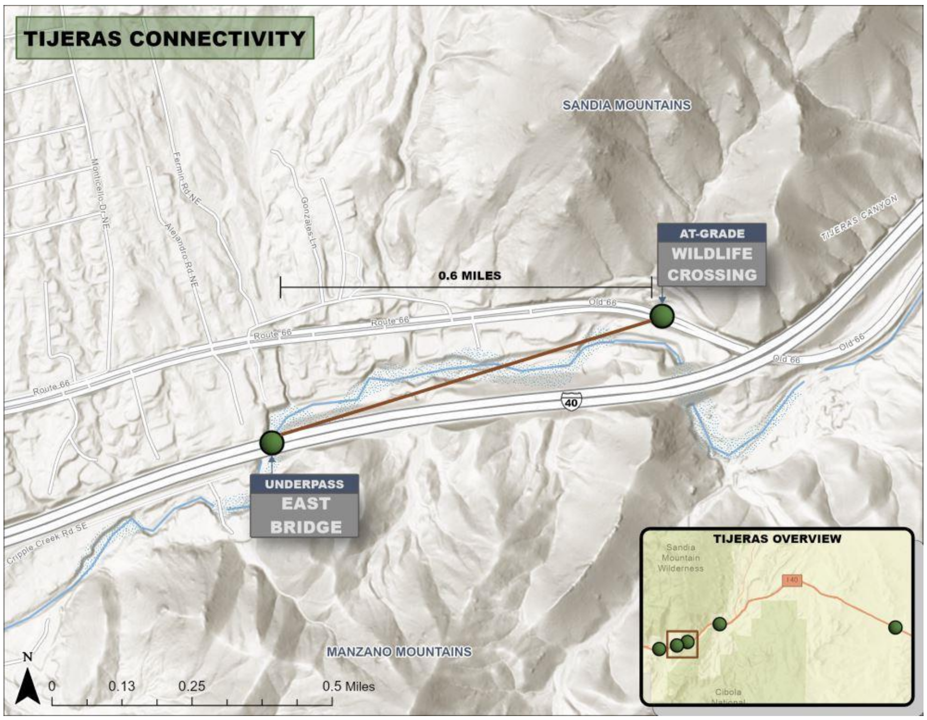

FIGURE 66 The Wildlife Crossing (NM 333) and East bridge (I-40) connect Sandia and Manzano mountains within Bernalillo County, New Mexico

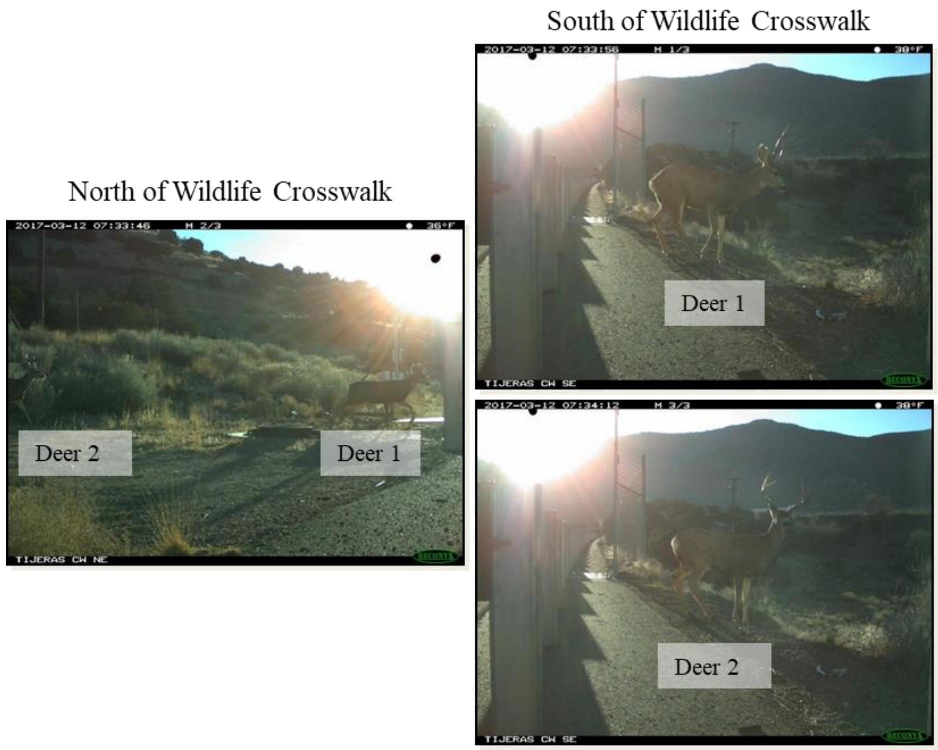

FIGURE 67 Two male deer, Deer 1 and Deer2, use the NM 333 Wildlife Crosswalk within Bernalillo County, New Mexico

FIGURE 68 Two male deer, Deer 1 and Deer 2, use I-40's East Bridge within Bernalillo County, New Mexico

Case Study 3: Wildlife Crossing Structure Obstructions

At the beginning of Phase One, the Raton and Aztec project areas each had a CBC wildlife crossing structure obstruction, which was removed by NMDOT and eventually replaced with a wildlife friendly ROW fence. Raton's CBC obstruction, after initial removal by NMDOT, was reinstalled by unknown parties and remained in place from July 16, 2017 to October 18, 2017. The research team considered this second installation to be a "short-term" obstruction placed on a functioning wildlife crossing structure. Aztec's CBC obstruction, which was in place at the beginning of Phase One, was reported by NMDGF to have likely been in place since the CBC was constructed. The research team considered this obstruction to be a "long-term" obstruction placed on a newly constructed wildlife crossing structure that had yet to be habituated to by wildlife.

The research team evaluated the effects that short-term (Raton CBC) and long-term (Aztec CBC) obstructions have on crossing structure function using monitoring data from a 1,125 day period: 110 present fencing days and 1,015 absent fencing days. During the short-term obstruction, the team documented that no deer used the CBC while the obstruction was present, and 928 deer (0.9 deer per day) used the CBC while the obstruction was abscent (Figure 69 and 70). For the short term, the obstruction reduced deer crossing by 100 percent.

In order to evaluate the long-term effect of a crossing structure obstruction being in place for a prolonged period of time, and then later removed, the team evaluated the first two years of deer use for the previously obstructed Aztec CBC. This was then compared to deer use from Aztec's two other CBC crossing structures. The previously obstructed CBC required 16 months to accumulate 100 total deer crossings (Figure 69), which is an average of 6.25 deer crossings per month. The other two CBCs each accumulated 100 deer crossings during the first month of monitoring. The previously obstructed CBC required 19 months without an obstruction to have 100 deer crossings in a single month (Figure 71).

FIGURE 69 An obstruction (steel corral panel) preventing a Raton deer from using the Unnamed Concrete Box Culvert on I-25 within Colfax County, New Mexico

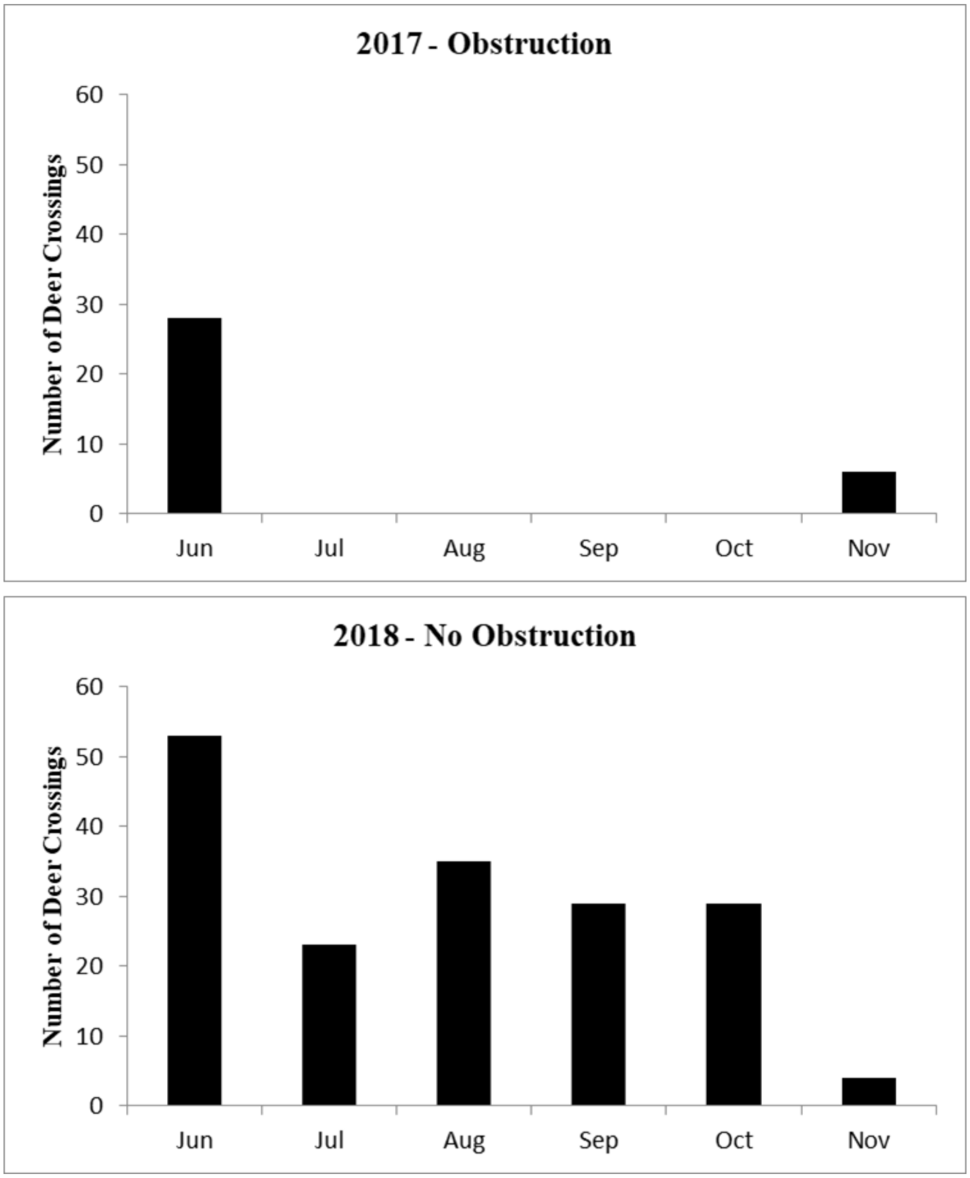

FIGURE 70 Documented deer use at the Raton Unnamed Concrete Box Culvert with obstruction (top) and without obstruction (bottom) on I-25 within Colfax County, NM

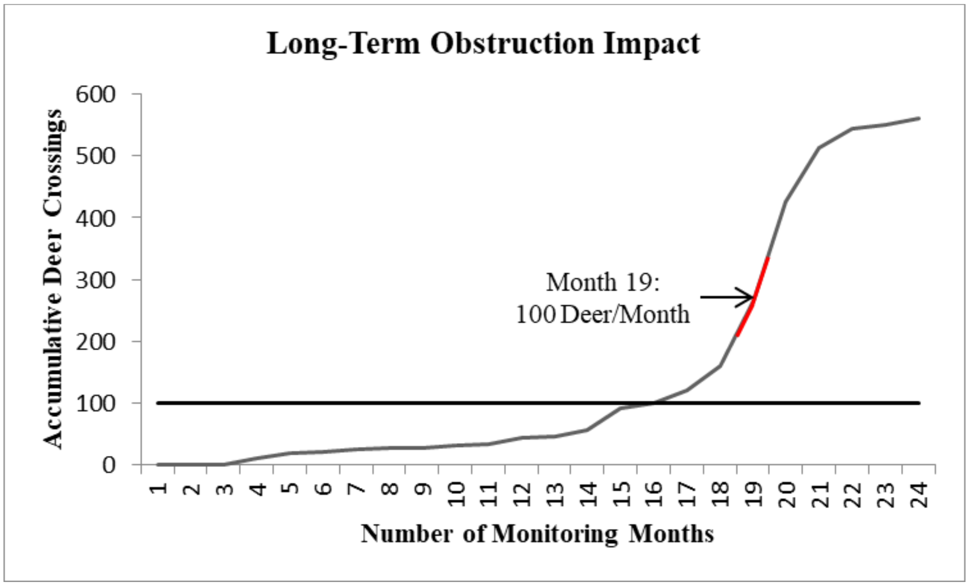

FIGURE 71 Accumulated deer use after an obstruction was removed from an Aztec Concrete Box Culvert north of Aztec on US 550 within San Juan County, New Mexico

Case Study 4: Wildlife Crossing Structure Cattle Presence

The research team monitored two Cuba wildlife crossing structures bordered by two cattle grazing allotments. To determine if cattle presence (Figure 72) impacted the use of the structure by wildlife, the research team monitored cattle presence for the first 144 days (March 5, 2017 to July 27, 2017) of the Phase One project. During the 144 days, the team reviewed 54,749 camera images and documented the following number of species using the structures: 1,170 cattle, 68 elk, and 39 deer (Figure 73). The researchers determined that when cattle structure use increased, elk and deer use decreased (Figure 74). In addition, when cattle use was most prevalent (978 cattle) between the times of 05:00 and 18:00, the normal dawn and dusk periods when elk and deer are most active, only 13 deer used the structures to cross under the roadway. In addition, no elk used the structures during this time. These findings suggest that when cattle use is most prevalent within the the wildlife crossing, the effectiveness of those structures to allow wildlife to safely cross under the roadway is decreased.

FIGURE 72 Cattle using the North Rio Puerco Bridge located on US 550 at milepost 53.6 south of Cuba within Sandoval County, New Mexico

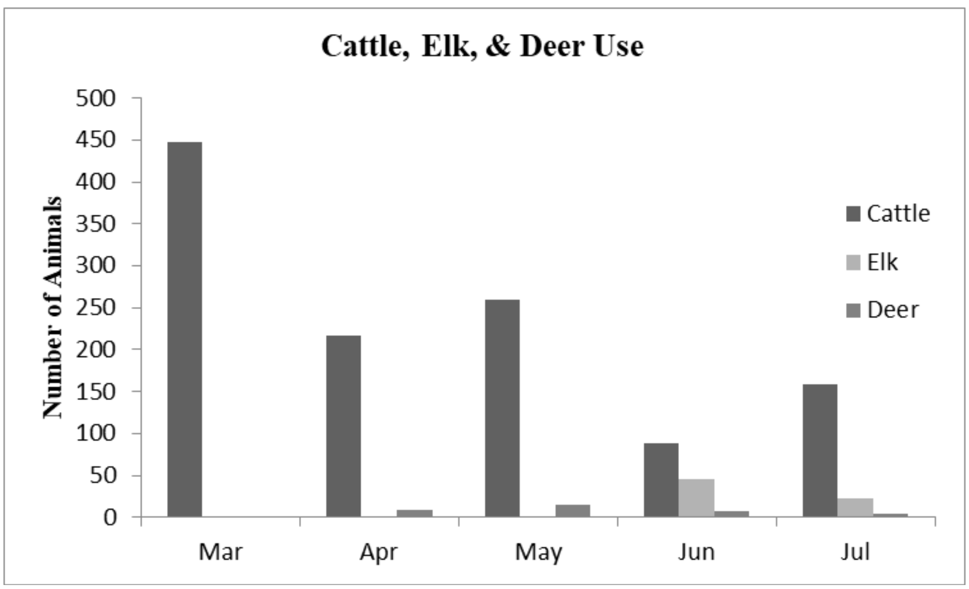

FIGURE 73 By month, cattle, elk, and deer documented at the two US 550 bridges south of Cuba within Sandoval County, New Mexico

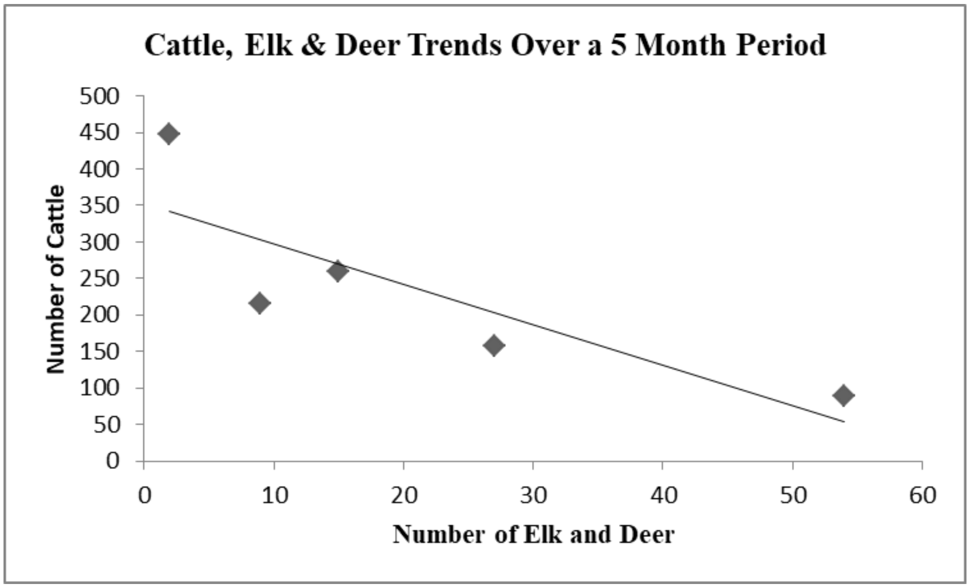

FIGURE 74 Cattle, elk, and deer use trends over a five month period at the two US 550 bridges south of Cuba within Sandoval County, New Mexico

CONCLUSIONS AND RECOMMENDATIONS

New Mexico WVC mitigation projects have had positive results and offered insights into cost-effective methods for reducing WVC and maintaining roadway permeability for wildlife. These projects have also provided opportunities to learn, improve existing and future mitigation efforts, and increase the ever expanding knowledge base of the Road Ecology field. This section analyzes Phase One conclusions and recommendations, and does not rely on the additional data and analysis that will occur during Phase Two.

GAME FENCING

Constructing game fencing that directs wildlife to safely cross the roadway at existing and appropriate drainage structures and bridges promotes motorist safety (i.e., reduce WVCs), as well as increases roadway permeability for wildlife. These are time and cost effective solutions to address WVC "hotspots" *(10, 12)*. NMDOT, which has more than 160,000 roadway lane miles to maintain and a relatively small budget when compared to other states, has successfully utilized roadway retrofitting to address some of the state's highest WVC incident areas. Two of these NMDOT retrofitting projects, Tijeras and Raton, have provided some unanticipated findings and are included in Phase One.

At Tijeras, the research team identified and documented two male deer, traveling together, using the at-grade Wildlife Crosswalk on NM 333 and then crossing under I-40 via the East Bridge. The path used by these deer demonstrates a habitat connection between the Sandia and Manzano mountain ranges, which are located on either side of these roadways. This finding, along with the reduction in WVCs, validates the conclusion that adding game fencing to function with existing roadway structures can reduce WVC and habitat fragmentation. In Raton, where the deer herd appears to be predominately residential and habituated to the town, the research team has documented that: 1) deer are using two six foot wide dirt "sidewalks" on either side of a trafficked residential road underpass to successfully cross under I-25 (Figure 75); and 2) deer are crossing over I-25 via a trafficked residential bridge overpass (Figure 76).

FIGURE 75 Deer using the Raton I-25 Lincoln Avenue structure within Colfax County, New Mexico

FIGURE 76 Deer using the Raton I-25 First Street Bridge structure within Colfax County, New Mexico

Conclusion – Constructing game fencing that directs wildlife to safely cross the roadway at existing drainage structures and bridges is a time and cost-effective option to reduce WVC and habitat fragmentation.

Recommendation – Continue to identify time and cost-effective game fencing opportunities throughout New Mexico on roadways with high incidents of WVC.

CBC USE

The research team will provide specific CBC structure design recommendations for deer and other target species within the Phase Two final report, once all data collection and analysis has been completed. However, the research team will provide general CBC structure recommendations based on Phase One data collection and analysis within this section.

The Aztec US 550 CBCs were completed in 2004. Since deer require time to adapt to new passage structures *(6, 11)*, the Aztec deer have likely learned to use the structures on a regular basis. Of the three CBCs, two measure approximately 16-ft tall x 20-ft wide x 120-ft long (Figure 77), and one measures approximately 16-ft tall x 12-ft wide x 92-ft long.

During Phase One, the research team documented 6,012 crossings of these CBCs by deer. The majority of these crossings (5,347 or 89 percent) were documented at the two larger CBCs and indicate that culverts of this dimension (16-ft tall x 20-ft wide x 120-ft long) can successfully promote regular mule deer passage. These findings, along with those by Cramer *(31)* highlighting the importance of culvert length, demonstrate the importance of considering CBC dimensions and roadway width when either retrofitting or constructing CBCs that are meant to function as wildlife crossing structures for deer. The placement and spacing (i.e., the distance between structures) of the Aztec CBCs have also factored into the structures' ability to function as wildlife crossings. NMDOT placed the CBCs at locations near frequently access deer resources (e.g., agricultural fields and water (Figure 78)), and spaced the structures close enough (approximately one mile apart) to offer the deer adequate opportunities to encounter structures within their home range *(34)*.

Conclusion – CBCs that are approximately 16-ft tall x 20-ft wide x 120-ft long, strategically located, and adequately spaced can effectively promote mule deer passage over time.

Recommendation – Consider replacing smaller culverts with CBCs that are 16-ft tall x 20-ft wide x 120-ft long in areas with high DVC occurrence. Consult with NMDOT Environmental Bureau and NMDGF if upsized culverts need to be longer than 120-ft to accommodate wider roadways.

FIGURE 77 The upsized Concrete Box Culvert (16-ft tall x 20-ft wide x 120-ft long) located on US 550 north of Aztec within San Juan County, New Mexico is adequate for mule deer passage

FIGURE 78 The upsized Concrete Box Culvert passage structures located on US 550 north of Aztec within San Juan County, New Mexico are placed near frequently accessed deer resources (agricultural field and water)

GAME GUARDS

Although gates are intended to function as a continuation of game fencing, gates are regularly left open, which defeats the purpose of the gate and the adjacent fencing. Open gates allow deer and other large wildlife unfettered ROW access and result in areas of concentrated WVCs. Gates often render mitigation projects less effective.

In New Mexico, Aztec exemplifies this scenario; although thousands of deer used the crossings, the continued DVCs due to open gates limits the project's success. To address this issue, NMDOT obtained funds from the Highway Safety Improvement Program (HSIP), which will be used to replace open gates with game guards (Figure 79). Although deer can occasionally cross them, well-designed guards are ultimately effective at limiting ungulate access to the ROW *(23)*.

During Phase Two, the team will continue to collect images of deer attempting to enter the road at the locations of the open gates. When the gates are replaced with game guards, monitoring will continue to determine if there is a reduction in deer accessing the road at these locations. The team will also continue to monitor WVC incidences. Given that the game guard monitored during Phase One was only crossed by 4 percent of deer that approached, the team anticipates that the newly installed game guards will be more effective then open gates (80 percent of deer that approached crossed into the ROW) at reducing collisions with deer.

Conclusion – Gates are regularly left open and increase the risk of WVC. Gates should be avoided, kept locked, and/or only used on lateral access roads with very low traffic volume (a few cars per month).

Recommendation – Install game guards instead of gates to address lateral access roads with more than a few vehicles per month in areas with existing game fencing.

FIGURE 79 Game guard installed across a US 550 lateral access road south of Cuba within Sandoval County, New Mexico

WILDLIFE CROSSING OBSTRUCTIONS

Deer and other wildlife will often adapt and use relatively small, short-length CBCs to cross under a roadway. However, when these structures are obstructed by a fence or other obstacle (Figure 80), most deer will cease use due to the obstruction. This was observed in both the Raton and Aztec projects when deer crossings went from 1,264 crossings without an obstruction to 4 crossings with an obstruction. Although obstructions such as these may seem to be minor details when designing and planning mitigation projects, they play a major role in a project's success. If fencing or gates are required for livestock management, wildlife friendly ROW fencing should be used (Figure 81). Wildlife friendly fencing has a total height of 42-in., contains 4 wire strands, and has the bottom wire between 14-in. and 16-in. from the ground. The bottom wire can be smooth. The top two wire strands are spaced between 10-in. and 12-in. apart and can also be smooth wire. The fences or gates should be installed away from the crossing (i.e., on the ROW boundary) and can satisfy the objectives of mitigation and livestock management (Figure 82).

Conclusion – Wildlife crossing obstructions (e.g., fences and gates) can prevent wildlife from using the structure to safely cross under the roadway.

Recommendation – If fences or gates are needed for livestock management, use a wildlife friendly fence design (42-in. tall 4-strand wire fence) and place on the ROW boundary.

FIGURE 80 A barbed wire fence obstructing a CBC opening north of Aztec on US 550 within San Juan County, New Mexico

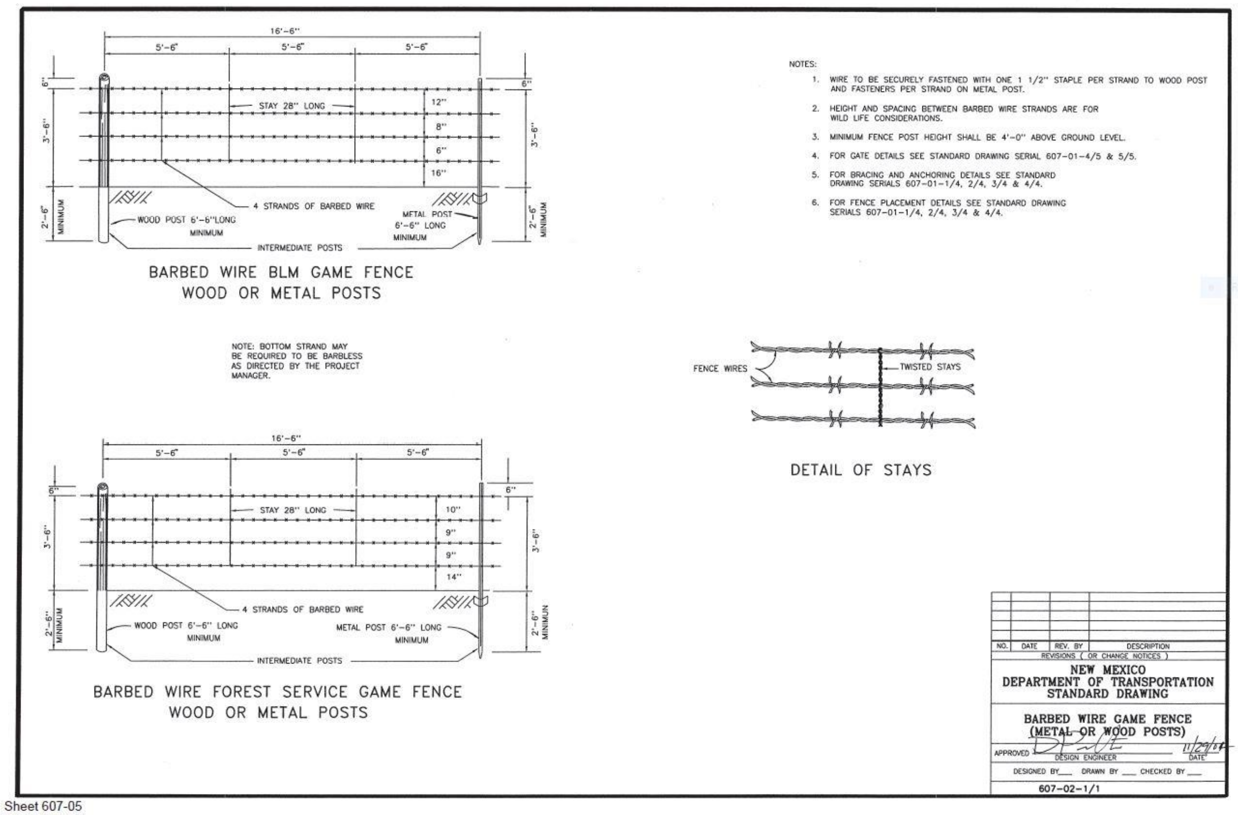

FIGURE 81 NMDOT wildlife friendly right-of-way fence plan sheet

FIGURE 82 A wildlife friendly fence placed on the right-of-way boundary near an upsized CBC north of Aztec on US 550 within San Juan County, New Mexico

WILDLIFE CROSSINGS AND LIVESTOCK

The presence of livestock at wildlife crossing structures is thought to limit the structures' use by wildlife; however, this has not been adequately studied. The regular presence of cattle in large numbers at the Cuba wildlife crossings provided the opportunity to compare wildlife use during the presence and absence of cattle at the wildlife crossings. Throughout the hot summer days, cattle may rest in the crossing structures shade (Figure 83), and will often stay under the structure throughout the night. This behavior can continue for multiple, consecutive days. During this time, wildlife did not use the designated wildlife crossing structures to cross under the roadway. These results indicate that wildlife avoided the crossings when cattle were present, which reduces the structures ability to maintain habitat connectivity, forcing wildlife to "test the fence" for alternative crossing locations, and decreasing the potential effectiveness of the mitigation projects. In order to encourage wildlife structure use in areas with livestock, wildlife friendly ROW fencing should be installed to remove the livestock from the crossings' immediate area.

Conclusion – Regular livestock presence reduces the effectiveness of wildlife crossings.

Recommendation – Limit livestock access to the wildlife crossing structure by installing a wildlife friendly ROW fence.

FIGURE 83 Cattle using the shade under the North Rio Puerco Bridge located on US 550 south of Cuba within Sandoval County, New Mexico

PHASE TWO RESEARCH

In general, during Phase Two (November 1, 2020 – 2023) of this research project, the research team will continue to collect data at the Phase One mitigation project locations (Aztec, Tijeras, Raton, and Cuba), as well as start collecting data at additional project locations (Chicorica Creek - US 64/87 and Raton Pass - I-25). The research team will then analyze all collected data to produce a Phase Two final report containing final results and recommendations for all mitigation project locations. The Phase Two report's intent will be to serve as an NMDOT reference document for site specific mitigation projects or used to inform statewide WVC and/or wildlife corridor planning decisions. The Phase Two research will include:

CONTINUED RESEARCH

- Aztec US 550
  - long-term, post-construction data collection and evaluation
  - new game guard data collection and evaluation

- Tijeras Canyon I-40/NM 333
  - long-term, post-construction data collection and evaluation

- Raton I-25
  - long-term, post-construction data collection and evaluation

- Cuba US 550
  - long-term, post-construction data collection and evaluation
  - game guard data collection and evaluation

ADDITIONAL RESEARCH

- Chicorica Creek US 64/87
  - post-construction data collection and evaluation of a "short run" game fence project

- Raton Pass I-25
  - long-term, pre-construction data collection and evaluation for two CBCs
  - post-construction data collection for new 32-foot wide wildlife underpass if completed during Phase Two

- Cuba US 550
  - post-construction data collection and evaluation for ADSs

- Animal Detection Research

PHASE TWO OBJECTIVES

This research will evaluate the passage rates of mitigation project crossing structures (CBCs) and relative use (bridges) for target species (deer, elk, black bear, and mountain lion), as well as the presence of other wildlife species. When game fencing is installed during data collection, the team will evaluate crossing structures use over time. Additional specific research objectives are to:

- Compare crossing passage rates or relative use with crossings in other western states
- Identify factors that may contribute to low passage or relative use rates
- Evaluate WVC data to either 1) determine if mitigation reduced WVC; or 2) establish a WVC baseline that can be used for future projects
- Evaluate ADSs to determine if the systems 1) reduces WVCs; and 2) influences driver behavior
- Evaluate game guard's effectiveness in repelling wildlife
- Create a wildlife crossing design guide for improving existing drainage structures for mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), black bear (*Ursus americanus*) and mountain lion (*Puma concolor*)
- Share research findings from Phase One, Phase Two, and other nationwide studies with NMDOT and the NMDGF

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