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DETERMINING WILDLIFE USE OF WILDLIFE CROSSING STRUCTURES UNDER DIFFERENT SCENARIOS

Prepared For:

Utah Department of Transportation
Research Division

Submitted By:

Utah State University
Department of Wildland Resources and
Utah Transportation Center

Authored By:

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Final Report
May 2012

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16. Abstract

This research evaluated Utah's wildlife crossing structures to help UDOT and the Utah Division of Wildlife Resources assess crossing efficacy. In this study, remote motion-sensed cameras were used at 14 designated wildlife crossing culverts and bridges, and 21 existing culverts and bridges built for other purposes. Over three years (2008-2011), through June 2011, the 35 cameras recorded 23,957 mule deer passages through designated wildlife crossings, and 1,093 passages under existing culverts and bridges. The results support the statements: 1) mule deer will use bridges to pass under Utah highways, and the bridged overpass to pass over Interstate 15; 2) mule deer prefer shorter culverts, mule deer rates of repellency increased with culvert length, wildlife crossing culverts should be less than 120 feet (36.5 m) long ; 3) culvert width, as animals pass under the road, is more important to mule deer than culvert height, they prefer wider spaces; 4) mule deer, elk, and moose will rarely to never use existing concrete box culverts under interstates unless wildlife fencing (8 feet, 2.4 m high) is present, but once wildlife fencing is present, will only use these structures in limited numbers; 5) all US 6 and Interstate-70 wildlife crossing bridges, culverts, and arch bridges passed mule deer; 6) elk rarely used culverts and bridge structures, it is extremely difficult to build wildlife crossing structures for elk passage; and 7) overall wildlife crossings are working for mule deer. Future crossings that are predicted to work best should be short in length, and wide in span.

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EXECUTIVE SUMMARY

The Utah Department of Transportation (UDOT) constructed wildlife crossing structures along Utah highways in an effort to help prevent wildlife-vehicle collisions on Utah roads. Wildlife crossing structures are culverts and bridges built to accommodate wildlife under or over the roadway (Bissonette and Cramer 2008). The costs of these structures can be best defended and invested if the structural designs, dimensions, and materials are researched for their compatibility with wildlife use. This project, sponsored by the Utah Transportation Research Advisory Council (UTRAC) at UDOT, was designed to evaluate how different culvert and bridge designs function at passing mule deer, elk, and other wildlife. The overall goal was to help wildlife and transportation professionals understand the effects of structure variables such as height, length, width, and structure type on wildlife use. Other mitigation efforts were also evaluated.

The research involved the use of 35 motion-sensitive cameras placed across the state at 14 wildlife crossing sites, future wildlife crossing sites, and 21 existing bridges and culverts to help determine mule deer, elk, and moose reactions to and use of the structures, and use of sites of future structures. The roads with monitoring sites included: US Highway 6, Interstate 70 (I-70), US Highway 89/91, US Highway 191, Interstate 15 (I-15), Interstate 80 (I-80), and US Highway 189, see Figure 1. The study generated over one million pictures. Over three years (2008-2011), through June 2011, the study documented a total of 25,050 mule deer passages under roads and over the I-15 overpass. Of these, 23,957 were through established wildlife crossings, and 1,093 were under bridges and through culverts existing for other purposes, (Figures 2 and 3). During that time there were 45 elk passages and 127 moose passages. Other species of wildlife were also photographed using existing culverts, bridges and wildlife crossing structures, including: black bear, mountain lion (puma, Figure 4), bobcat, coyote, badger, grey fox, red fox, porcupine, mink, striped skunk, spotted skunk, raccoon, ringtail, ground squirrel, cottontail rabbit, white-tailed jackrabbit, and rodents. The results of this research will help develop the most effective and efficient wildlife mitigation designs for Utah. In turn, these developments will help reduce wildlife-vehicle collisions and help preserve wildlife populations, especially mule deer and elk, across the western United States.

Figure 1. Camera sites in study on Utah roads and interstates (beginning from the North): US Highway 91, I-80, US Highway 189, US Highway 6, I-15, I-70, and US Highway 191.

Figure 2. Mule deer used wildlife underpass bridge under US 6 at MP 200.7.

Figure 3. Mule deer used I-15 Beaver wildlife overpass.

Figure 4. Puma used box culvert under I-70 on Fish Lake National Forest.

This study was designed to answer a series of questions regarding wildlife crossings and local wildlife's preferences for using these structures in a variety of ecosystems. This report presents our preliminary findings based on the UDOT research contract scope. At the time of this writing the study was still underway with funding from Utah Division of Wildlife Resources (UDWR) and several conservation-sportsmen organizations. Future studies will include the development of statistical models to more rigorously answer these questions as more data is collected. Future data collection and rigorous statistical analyses will better elucidate many of the factors affecting wildlife use of structures.

Question 1. Are concrete box culverts, 200 to 280 feet, with no wildlife fencing, effective at passing mule deer and elk?

Concrete box culverts, 200 feet (61 m) and longer that were not built specifically for wildlife and had no attached wildlife fencing were not effective at passing mule deer, elk, and moose. These animals passed through these existing structures only occasionally, in numbers less than 5 passes per year, per culvert, see Figure 5.

Figure 5. Mule deer herd investigated Camp Creek South culvert under I-15. No mule deer were photographed using this 280 feet (85 m) structure during one year of monitoring.

Question 2. Are concrete box culverts 100 feet and longer, once retrofitted with wildlife fencing, effective at passing mule deer and elk?

At this time it can be concluded that the I-70 concrete box culverts 100 to 230 feet (30-70 m) long, not built for wildlife but when retrofit with wildlife fencing pass mule deer in minimal numbers, ranging from several dozen to one hundred passes per year per culvert. A portion of the mule deer populations in the areas of the culverts at mile posts three and six do use them. When wildlife fencing was placed at the first seven miles of I-70 near its junction with I-15, 209 mule deer passages occurred at two existing culverts under this stretch of highway in 138 days. It remains to be seen how well these culverts can function as de facto crossings for mule deer. It is expected that over time the mule deer will adapt to these culverts and use them in ecologically significant numbers, meaning hundreds of mule deer passes per culvert, per year (Figure 6). Eighty-nine elk appeared at these two I-70 culverts during the period of 138 days (Figure 7); 14 elk passages were recorded.

Figure 6. Mule deer assessed a 230 feet (70 m) culvert with new wildlife fencing at I-70.

Figure 7. Elk pondered and then repelled from a 230 feet (70 m) culvert with new wildlife fencing along I-70.

Question 3. Do some wildlife crossing culvert designs work better than others?

The shorter the culvert, the more wide the culvert, and the higher the culvert, the better success it has at passing mule deer. Seven culverts constructed as wildlife crossings were monitored for this study. All passed mule deer, but some had higher rates of repellence (when animals approached entrances then walked away) than others (Figure 8). The longer the culvert, the higher rate of repellence for mule deer. At this time the best recommendations are to keep culverts less than 120 feet (37 m) in length as they traverse under the road. If the road is greater than two lanes wide, such as divided highways, it appears breaking the culvert into two sections, one for each direction of travel (Figure 9) will reduce the rate of repellence for mule deer to less than 12 percent. It appears that increasing the width (span) of the culvert is more important than increasing the height to encourage deer use. This may help engineers in installing culverts under roads where there is a limited amount of flexibility for raising a road to accommodate a culvert crossing. Overall bridges have lower rates of repellence than culverts, making them generally better than culvert choices, but mainly best over the longer culverts, based on rates of repellence.

Figure 8. Herd of mule deer repelled from corrugated steel culvert under US 91 at MP 8. Wildlife exclusion fencing was present.

Figure 9. I-15 Wildcat South wildlife crossing culverts with a large open (now vegetated) median, and wildlife fencing.

Question 4. Are the wildlife crossing bridges and culvert on US 6 effective at passing the mule deer, elk, and moose that were detected pre-construction, and in comparable numbers?

Three wildlife underpass bridges and one wildlife underpass culvert were built on US Highway 6 during this study (Figure 10). In preconstruction monitoring, mule deer were detected at all future wildlife crossing sites. A single moose was detected at the Tucker Rest Stop future Starvation Creek Bridge site, and no other sites. Elk were detected at the future Rail Road Bridge site, the Tucker Rest Stop-future Starvation Creek Bridge site, and the Beaver Bridge future site. Post-construction monitoring to date revealed all wildlife crossing bridges and the culvert have passed mule deer. None have passed elk. The Starvation Creek Bridge passed one moose. At this time these bridges have limited use in passing the full suite of ungulates, meaning elk and moose do not use all crossings. However, they are becoming increasingly effective at passing mule deer.

Figure 10. US 6 Camera sites at wildlife crossing bridges and culvert. Gilluly Bridge is an existing bridge for rail cars and was monitored for wildlife use of the area. All other sites were monitored for structure efficacy at passing wildlife.

The MP 200.7 Rail Road Bridge passed hundreds of mule deer each year, making it one of the top five most used by mule deer crossings in Utah (Figure 11). The Starvation Creek Bridge (MP 204) passed 132 mule deer in the first 138 days of monitoring (Figure 12); five elk were repelled. It was functioning for mule deer to some degree, but not for elk. The Beaver Creek Bridge (MP 220) had an exceptional number of mule deer use the crossing: 600 animals used the bridge in the first 560 days of monitoring (Figure 13). It has failed at this point to pass elk which were present pre-construction and during construction. Mule deer were documented adapting to the Colton Culvert (MP 217) over time, with only 35 mule deer passes the first year, but 244 passes the second year. At this time elk have not been photographed at the culvert. Elk have been photographed approaching only the Starvation Creek Bridge. They were repelled. Until the cameras at other sites record elk and moose approaches to the structures, it is not known if they are functional for these species.

Figure 11. Several mule deer used the bridge on US 6 at MP 200.7. Several others remained behind and did not use the structure.

Figure 12. Six weeks after post-construction cameras began monitoring; the first mule deer herd to use the Starvation Creek Bridge under US 6 was photographed on Dec. 27, 2010.

Figure 13. A herd of mule deer used the US 6 Beaver Creek Bridge.

Question 5. Is the I-70 Arch Crossing Bridge effective at passing mule deer and elk in numbers comparable to pre-construction?

The I-70 Arch Crossing Bridge for wildlife at MP 5.3 was installed November of 2010 showed great promise in passing mule deer in numbers similar to pre-construction monitoring. There were 161 mule deer passes in two years of pre-construction monitoring, and 86 mule deer passes in first 165 days of post-construction monitoring. Elk passages were not as successful. There were 171 elk passes by the cameras pre-construction, and only eight elk passes through the structure in post-construction monitoring; all of these passes were by bulls (Figure 14).

Figure 14. Bull elk used Arch Crossing Bridge on I-70. No cows were photographed using the structure.

Question 6. Can mule deer, elk, and moose be funneled to use two existing bridge underpasses (not made for wildlife) at interchanges on I-80 with new wildlife fencing?

In 2009, three miles (4.8 km) of wildlife fencing was erected along I-80 from the Mountain Dell exit (MP 134) to the Lamb's Canyon exit (MP 137), see Figure 15. The purpose of constructing this fence was to try and funnel wildlife under the existing bridges at these locations in order to minimize wildlife movement over the road and into traffic on the interstate. Mule deer, elk, moose, and other wildlife need to move in a north-south direction across the path of the interstate to access water on the north side and seasonal habitat on both sides. When snows become deep, wildlife need to access the lower elevations on the north side of the highway, and with the coming of spring, wildlife needs to migrate south of the highway. Wildlife-vehicle collision carcass data collected along this stretch from 2005 to 2009 averaged 20 mule deer, 1.4 elk, and 1.8 moose per year. During the first year and a half of monitoring, no wildlife was verified using the area under the Mountain Dell Bridge, and only six mule deer were detected using the Lamb's Canyon Bridge. During 2010, the first full year of fencing, 27 mule deer, 0 elk, and three moose carcasses were recorded on this stretch of I-80 (D. Sakaguchi, UDWR, personal communication).

The lack of wildlife use under the bridges and no decrease in overall carcass numbers are partly a reflection of the lack of double cattle guards or wildlife guards at the entrance and exit ramps in the area, see Question 7 below.

Figure 15. Camera sites at I-80 exit 134, Mountain Dell Reservoir, and exit 137, Lamb's Canyon.

Question 7. Can white lines painted to mimic cattle guards deter moose, elk, and mule deer from crossing over and entering the road right-of-way?

White lines painted as cattle guards do not deter wildlife from passing over them. The white stripes painted as cattle guards for keeping wildlife off of I-80 at the entrance ramp for I-80 at the Mountain Dell interchange for east-bound traffic were monitored with a single camera for 118 days. In that time 213 wildlife passes were recorded across the stripes including three moose, 95 mule deer, and 115 elk (Figure 16). More wildlife was recorded entering the highway at this site than all wildlife detected combined at the four cameras at the Mountain Dell and Lamb's Canyon bridges.

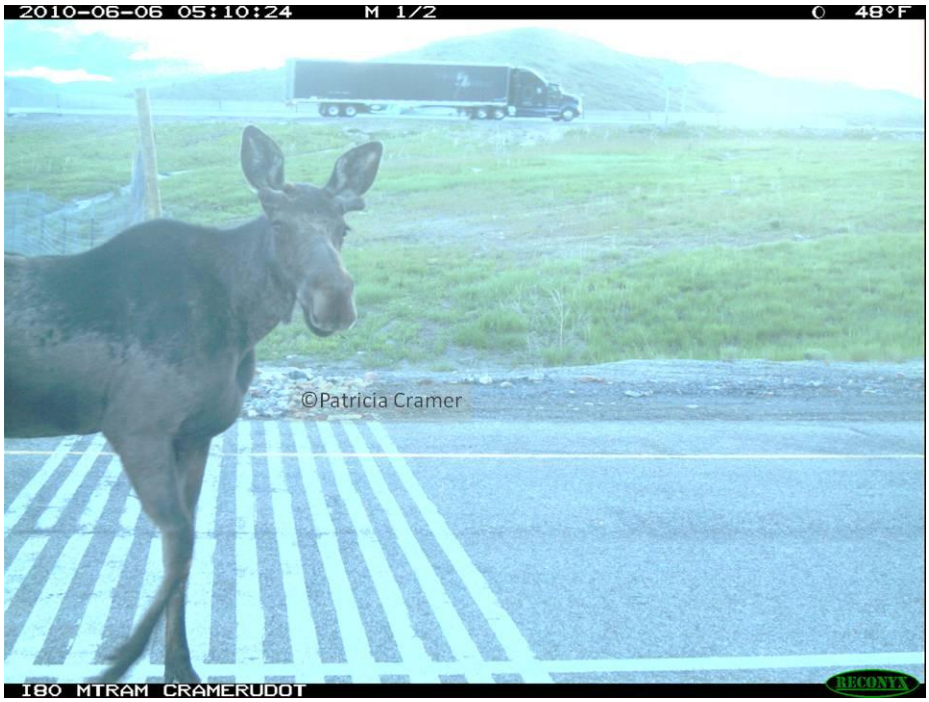

Figure 16. Moose accessed I-80 right-of-way over white stripes painted to mimic cattle guard.

Question 8. Does the I-15 Beaver wildlife overpass facilitate mule deer migration and elk migration across the interstate?

Mule deer traditionally migrated east to west to access summer and winter habitat across the area now occupied by I-15 near the town of Beaver. In the first 738 days of monitoring the wildlife overpass on I-15 just south of Beaver (Figure 17) 1,206 mule deer movements were photographed. This equates to 1.6 mule deer per day, or approximately 584 mule deer passes per year. Nineteen bull (male) elk passes and no female elk were photographed on the overpass. The Beaver overpass facilitated mule deer migration for both male and female deer (Figure 18) and only sparingly worked for an occasional male elk migrant, allowing for some genetic connectivity, but not population or habitat connectivity for elk in the area.

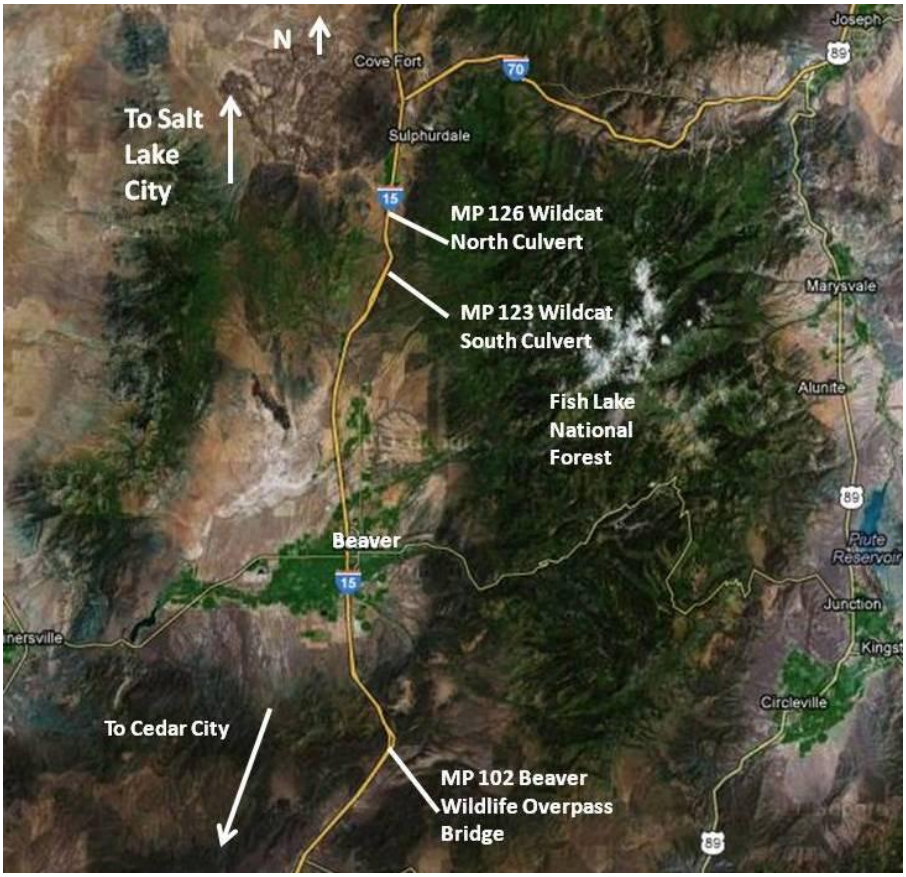

Figure 17. I-15 Beaver wildlife overpass and Wildcat wildlife underpasses monitored.

Figure 18. Mule deer migrated westward over I-15 Beaver wildlife overpass.

Question 9. How effective are the Wildcat North and the Wildcat South wildlife crossing structures under I-15 at passing mule deer and other species?

The two sets of culverts at Wildcat North and South under I-15 (see Wildcat South in Figure 9) can be considered the most successful crossings in Utah if success were defined by sheer numbers of mule deer and low rate of repellence (Figures 19 and 20). It is estimated that over 3,000 mule deer passes occur each year at Wildcat South alone. Although elk are in the area, only 18 elk approaches were recorded at Wildcat North, and no elk used the structure. The Wildcat North and South structures were effective at passing mule deer. They are not functioning for elk movement at this time.

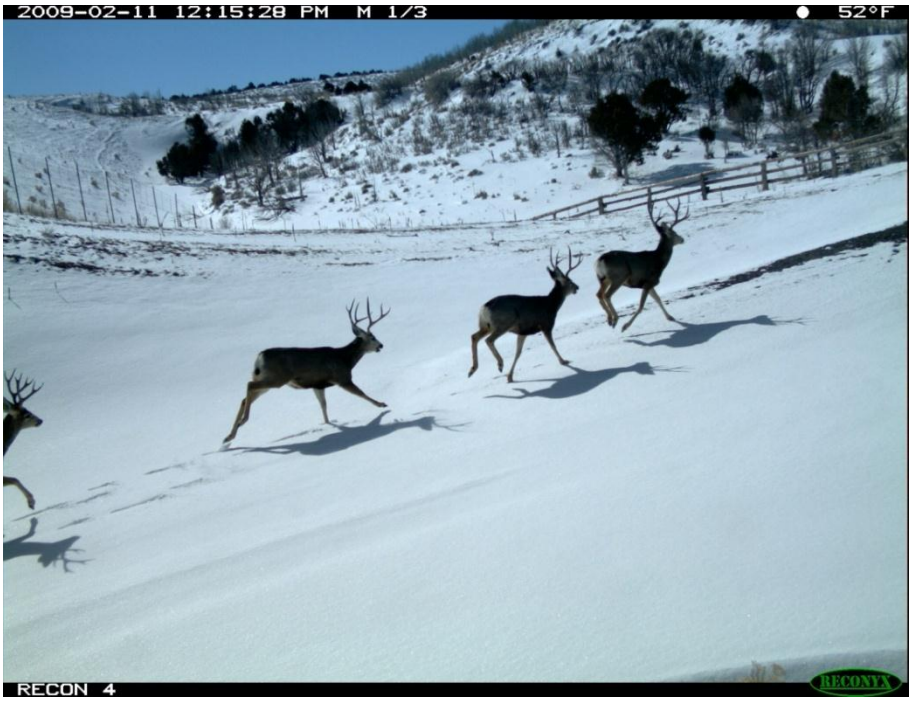

Figure 19. Mule deer passed through I-15 Wildcat North wildlife crossing culvert.

Figure 20. Mule deer herd passed through I-15 Wildcat South wildlife crossing culvert.

Question 10. Can you make elk use culverts and bridges to pass under roads?

Elk in Utah are extremely reluctant to use any kind of bridges or culverts to pass under roadways. At this time the data suggest elk will not pass through most culverts. Several individual elk (14) passed through two culverts in the first seven miles of I-70 once wildlife fencing was placed. Even bridges serving as wildlife underpasses were not being used more than occasionally by elk. The study documented 12 elk passages under I-70 at a pair of traditional span bridges and a pair of arch bridges on the Fish Lake National Forest, and no other elk passages under other bridges. The overpass bridge south of Beaver, Utah was the most highly used by elk structure in the study, with a total of 19 bull elk passages (Figure 21). It appears that the arch bridge on I-70 at MP 5 holds promise for passing additional elk, but it remains to be seen if cows and calves will use it. At this time only span bridges or the new arch spans should be considered adequate for passing elk.

Figure 21. Nineteen bull elk passages over the I-15 wildlife bridge overpass were recorded over three years.

In summary, the study demonstrated the success of Utah wildlife crossings in passing mule deer. In general, the more open wildlife crossing culverts were, i.e. shorter length as the animals traverse under the road, the wider the width (span) and the higher the height, the lower the rates of repellency of the culverts, under five percent. This low rate of repellency thus defined culverts with these characteristics as the most successful in passing mule deer. The study demonstrated that mule deer will readily use culverts. All five wildlife crossing single span and multiple span bridges monitored passed mule deer, with rates of repellency ranging from 1.7% to 11%.

Despite the preliminary nature of this report's results, several generalizations and recommendations can be made.

1. Mule deer will readily use short culverts as well as all studied bridges to move under Utah roads.
2. In order to ensure high mule deer successful passage, culverts should be designed with the shortest possible length, tallest height, and widest width as possible. Length is most important, width is second in importance, and height is least important.

3. All bridge designs monitored in this study were successful in passing mule deer, with success rates of 89 to 98%. Bridges are a very viable option for passing mule deer under and over roads and are recommended as the top design for wildlife crossings.
4. Wildlife crossings should include wildlife exclusion fencing 8 feet (2.4m) high to guide animals to the structures and encourage them to use them.
5. Double cattle guards or wildlife guards need to be used on entrance and exit ramps and other ingress-egress drives when wildlife fencing is placed along a road and used to encourage wildlife use of structures.
6. Mule deer move day and night. In structures with low human use, mule deer used the structures 50% of the time in daylight. If an area is being considered for wildlife crossings, its usefulness for wildlife is diminished with roads or recreational trails through the structure.
7. Elk will not use culverts regularly in Utah. All wildlife crossing structures in elk habitat should be designed as bridges with fencing to ensure some degree of use by all elk age classes and genders.
8. Stream crossings are excellent conduits for increasing wildlife crossing use by all species of wildlife. Wildlife crossing placement should consider inclusion of streams through the structure. This offers both an opportunity to restore aquatic connectivity and to increase the diversity of species of wildlife using the crossing. It can also allow for use of the structure by anglers who can avoid going up over the road to traverse a stream or river.
9. There should be continued research of wildlife crossings. For less than 2% of the total cost of a structure, it can be monitored for three years to verify if it is serving the intended purposes of passing wildlife, especially mule deer. In a period of time during smaller budgets for state agencies, UDOT can show the cost effectiveness of structures and their success with such research, as well as learn of the most cost-effective designs.
10. Continued collaboration and communication among state and federal agencies should continue. These continued dialogues can help identify areas of problems with wildlife and vehicle collisions, wildlife migration routes, maintenance fixes, and the successes of wildlife crossings, fencing, and existing structures in keeping wildlife off Utah roads. The US 6 Wildlife Advisory Committee that evolved into a statewide Wildlife Coordinating Committee is a perfect venue for these kinds of dialogues.

The results of this study can assist UDOT personnel in designing the most cost-effective wildlife crossing structures that work for mule deer and other wildlife. Implementation of this research will be the continued design of crossings that are proven to pass mule deer and other species, and the maintenance of crossings and fencing. UDOT engineers can become more confident in the knowledge that most recent designs are working. This may free some designers to be more creative with design considerations. This study validated the basic wildlife crossing designs UDOT created and allows future research and designs to focus more on the most economical means to provide functional wildlife connectivity across roads while also reducing wildlife-vehicle collisions.

1.0 INTRODUCTION

This project was funded by Utah Department of Transportation (UDOT) – Utah Transportation Research Advisory Council (UTRAC) funds, the Utah Division of Wildlife Resources (UDWR), and numerous conservation organizations including the Mule Deer Foundation (MDF), Sportsmen for Fish and Wildlife (SFW), the Rocky Mountain Elk Foundation (RMEF), and the Foundation for North American Wild Sheep (FNAWS). The project monitored wildlife use of existing wildlife crossing structures, areas of future and potential future wildlife crossing structures, and other infrastructure along Utah roads. The overall goal of the study was to help wildlife and transportation professionals understand the effects of structure variables such as height, length, width, and structure type on wildlife use of those structures to pass over and under Utah roads. Other mitigation efforts were also evaluated. The UDOT-UTRAC funding for this project was awarded in 2007 and ended in 2010. The UDWR and conservation organization funding for this project began in 2010 with commitments through June 30, 2013.

This research was designed to address the following aspects of wildlife crossings.

1) Determine the species, numbers, and peak migration times of wildlife use of the areas underneath and/or over the existing bridge structures on US 6, I-70, US 89/91, I-15, and I-80 (see Figure 22).
2) Determine how the construction of the proposed new bridge at milepost (MP) 200.7 on US 6 (Structure C287) affects wildlife movement through the area.
3) Determine the effectiveness of this new bridge structure at MP 200.7 in facilitating wildlife movement under US 6.
4) Create an experimental situation that uses adjustable entrance doors-gates-curtains attached to the underside of the US 6 MP 200.7 Bridge or another bridge to change the dimensions of the openings and determine elk use of the passage under different dimension scenarios. This pilot project would also help determine the feasibility of using these gates for future research.

The fourth action was not undertaken due to the lack of elk use of any of the monitored bridges. Project resources were funneled from this experiment to expand the monitoring project to additional sites in Utah.

Results from the first three actions are presented in Section 4, Data Evaluation.

Figure 22. Map of the study area and camera sites.

The study began in 2007 with the placement of three infra-red, motion-sensed trail cameras along I-15 near Scipio, Utah (see Figure 22 above). In 2008, 35 infra-red, motion-sensed trail cameras were placed across Utah at sites that included: existing box culverts and bridges not designed for wildlife; existing wildlife crossing structures that included bridged underpasses, culvert underpasses, and a bridged overpass; and sites of future planned wildlife crossings. This report presents the data at these sites through June 2011 in terms of:

- the mule deer use of these sites,
- the rate of repellency at these sites which is when mule deer approached the entrance and then turned around and walked away,
- seasonal movements of mule deer at the site, and
- other data related to mule deer, the use or lack of use of the structures by elk and moose, and the use of the site by other species of wildlife.

For each of wildlife crossings monitored, there is a 'Pros and Prescription for Improvements' section to help readers understand how well the crossing works for wildlife and what can be improved.

Data evaluation or results are presented in Section 4 under three sub-sections: The questions and answers to this study; monitoring results for individual sites along the different roads monitored; and landscape variables and fecal pellet survey information. Section 5 concludes the report, and Section 6 gives recommendations for implementation of this research. Finally, there is an appendix with pictures of select wildlife crossings and several wildlife photos taken by the study cameras.

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2.0 RESEARCH METHODS

To gain an understanding of wildlife use of wildlife crossing structures and other transportation infrastructure, infra-red, motion-sensed trail cameras were placed at sites along various interstates and state highways throughout the state of Utah (see Figure 22 above). The sites were selected in tandem with UDOT and UDWR personnel familiar with UDOT projects that included wildlife crossing structures and other mitigation measures, and areas with a high occurrence of wildlife-vehicle collisions (WVCs). Cameras were placed inside metal utility boxes and locked to bicycle cables that were concreted into the ground. Stickers explaining the research and identifying UDOT ownership were placed on each box. Cameras remained on continuously and were checked every four to six weeks to download data and change batteries.

Four types of wildlife crossings and other mitigation were evaluated with camera monitoring:

1. Wildlife crossing underpass culverts and bridges made for wildlife;
2. Existing bridges and culverts not built for wildlife;
3. Sites where future wildlife crossings would be installed;
4. Entry ramp to an interstate with parallel white lines painted to mimic cattle guards.

2.1 Camera Placement

Camera placement at monitored sites varied according to the research objective for that site. At existing wildlife crossing bridges and culverts, two cameras were placed at the entrances to ascertain wildlife use and repellence. Placing a camera at each entrance to the crossing structure helped to determine not only the animals using the structure but also those that approached the entrance and did not go through. This method was also used on existing bridges not specifically built for wildlife which were monitored to better understand wildlife use and reactions to the structures. In existing box culverts not created for wildlife, a single camera was placed at one entrance to the culvert. This camera placement was deemed the best use of the limited cameras once it was discovered these structures were rarely used by wildlife. At sites of future wildlife crossing structures, two cameras were placed near the site of the future structure. Since there

typically was not a restricted space the animals were using as they do with structures, every effort was made to place cameras near the road right-of-way along wildlife paths and natural constrictions on the landscapes such as rock walls. The goal of these cameras was to capture the variety of species using the site, and a sample of the actual number of mule deer and elk using the area.

2.2 Monitoring Time Span

The minimum time to evaluate an area and structure for wildlife use was one year, independent the objective of the camera placement. In cases where the results were evident without statistical analyses, cameras were removed within a year. In the situation where a painted white stripe "cattle guard" was monitored for wildlife use or repellence, the results were clear enough within four months and the camera was removed. The longer the cameras monitored an area, the better chance there was to observe true wildlife movement patterns, the diversity of species, genders, and ages of those animals. Longer monitoring periods also help create stronger statistical rigor of the results. This is because added data to statistical tests strengthens our ability to make inferences about the true nature of what is happening at a particular area and over multiple sites. To best monitor areas of future wildlife crossings, a minimum of two years of monitoring pre-construction is preferable. This was the goal at all future crossing sites, but the reality of construction schedules sometimes limited this time period. Once crossings are installed, the scientific methods of monitoring wildlife crossings have found that it takes wildlife a minimum of three years to adapt to those structures (Clevenger et al. 2002, Dodd et al. 2007), and even four years to truly allow for wildlife to adapt and for researchers to understand how wildlife move in response to the structures (Clevenger et al. 2011, Gagnon et al. 2011). At the time of this report, no new crossing was monitored for that length of time, but efforts were underway to reach this goal. All wildlife crossings that were constructed since 2008 had cameras remaining at their sites as of this report.

2.3 Photograph Analyses

Photographic data was translated into information tallied for each location into first Microsoft Excel spreadsheets and then Microsoft Access databases. Each photographic event was translated into several values, beginning with the type of species photographed. If that species was a

human, and if that human was in a vehicle, then the type of vehicle (vehicle, ATV, motorcycle) was also recorded. In the case of mule deer, elk, and moose, the gender, age, direction of travel, and if that animal went through the crossing structure, moved parallel to the entrance, or was repelled away from it were also recorded. Others species of wildlife were recorded for their presence and if they went through the structure, without reference to specifics of type of animal or direction of travel. The date, exact time of day, and if the event occurred at night, day, or dawn or dusk were also tallied for all events.

The following calculations were made for each camera location, where applicable. Note; these calculations were only made for mule deer because they were the target species of this study and the species with enough photographic data to draw conclusions.

- Deer observations per day = the total number of deer photographed at the structure or site divided by the number of days a camera was in operation at the site. If two cameras were in operation at a site, the data was cross referenced to count the animals present only once per event, and the data was combined for each day.
- Deer through structure per day = total number of deer passes through the crossing structure or existing culverts and bridges divided by the total number of days that one or more cameras were in operation at the site. Each event was cross referenced with paired camera data from two cameras at the site and tallied only once per event.
- Success rate = the total number of deer moving through the structure or onto the roadway at future structures, divided by the total number of deer recorded at the structure or site;
- Rate of repellency = the total number of deer repelled at existing crossing structures or repelled at future crossing sites divided by the total number of deer recorded at the structure or site.
- Parallel rate = the total number of deer moving parallel to structures or sites divided by the total number of deer recorded at the structure or site.

2.4 Landscape Variables and Fecal Pellet Presence

Wildlife presence at the entrances to wildlife crossing structures is dependent on the landscape and the presence of the animals in the general area. In order to better gauge how well wildlife crossings are functioning, the researchers also collected data to document landscape variables

and wildlife fecal pellet presence near camera monitoring sites. A modified version of the UDWR vegetation and fecal pellet count methods was created to apply at each camera site. This method entailed a grid transect on each side of the roadway, branching out from the crossing structure. Within this grid, 25 sites were sampled for vegetation type (grass, forb, tree, etc.) and percentage of cover. Each site was also sampled for mule deer, elk, moose, rabbit, and carnivore fecal pellets. Values were tabulated according to UDWR methods to estimate vegetation densities and cover. Those values will then be statistically analyzed in relation to the number of mule deer photographed at a site to learn of relationships between number of mule deer successfully using a crossing and the vegetation nearby. Fecal pellet counts will also be compared with the number of mule deer photographed at a site. Statistical analyses will help us determine if there is a correlation with the number of fecal pellet groups in an area and the number of mule deer using the structure. In 2011, graduate student on the project, Megan Schwender began these analyses with different statistical software and will have concrete values on these analyses by the time of her defense at the end of the year 2012.

3.0 DATA COLLECTION

Cameras were programmed to help achieve monitoring objectives in each situation. Cameras were set to type of motion sensitivity, usually very high, number of pictures per trigger, the standard was 5 pictures per trigger, and on rapid fire with no time delay between triggers. When cameras were placed in areas where paved roads allowed for dozens to hundreds of vehicle passes per day, timers were turned on within the cameras so that pictures were only recorded dusk to dawn. All photographic data was collected from the field cameras every four to six weeks and stored on external hard drives. Cameras generated a minimum of 25,000 pictures per month, for over 1 million pictures in this three-year study. Photographic data was analyzed and translated to Excel spreadsheets summarizing the results of those data for each camera or structure location if two cameras were used, and then in turn the Excel spreadsheets were translated into Access databases for further analyses.

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4.0 DATA EVALUATION

This section presents the results of this study in three parts. Section 4.1 provides 14 questions this study sought to address and the answers to date. Section 4.2 presents the results for each road by each camera site on that road and how well each wildlife crossing is working for a diversity of wildlife. Section 4.3 presents preliminary information on the collection of vegetation and fecal pellet data at camera sites.

In the original research proposal, the first action addressed, 'Determine the species, numbers, and peak migration times of wildlife use of the area underneath and/or over the existing bridge structures on US Highway 6 (US 6), Interstate 70 (I-70), US Highway 89/91 (US 89/91), Interstate 15 (I-15), and Interstate 80 (I-80),' is answered in section 4.2 under the headings for each road and each site where cameras were placed. Additional cameras were placed on US Highway 191 (US 191), and US Highway 189 (US 189) and data is presented on these monitoring sites as well. Data on mule deer observations per day, through the structure per day, and graphs of weekly deer use over the study are presented for each site. Each wildlife structure also has a summary 'Pros and Prescription for Improvement' section which helps elucidate the factors that work for the structure in passing wildlife and an adaptive management approach to improving the area for passing more wildlife.

Actions two and three from the original proposal, 'Determine how the construction of the proposed new bridge at MP 200.7 on US 6 (Structure C287) affects wildlife movement through the area; Determine the effectiveness of the new bridge structure in facilitating wildlife movement under Highway 6,' are addressed in 4.1.4, and 4.2.1 under the US 6 descriptions.

All of actions one, two and three will continue to be addressed in this study through June 2013, and possibly longer with funding from the Utah Division of Wildlife Resources and conservation organizations.

4.1 The Questions and Answers to This Study

4.1.1 Are concrete box culverts, 200 to 280 feet, with no wildlife fencing, effective at passing mule deer and elk?

Concrete box culverts, 200 feet (61 m) and longer that were not built specifically for wildlife and have no attached wildlife fencing are not ecologically effective at passing mule deer, elk, or moose. Ecologically effective is defined as there were individuals passing through such culverts in numbers high enough to represent movements of a portion of nearby mule deer or elk populations. Seven of these culverts were monitored under I-70 and I-15. Six of these were monitored for one year, and the seventh was monitored for two years. In 2,963 camera nights among the cameras at these culverts, 181 mule deer appeared at the entrances to these culverts, and 35 mule deer passed through them, for a rate of 0.01 mule deer per day, and a success rate of 19%. There was no elk use of these culverts. The culverts were used by other wildlife such as one moose, one mountain lion, one black bear, coyote, bobcat, red fox, grey fox, striped skunk, spotted skunk, ringtail, raccoons, porcupine, and turkey. It can be assumed that these culverts do little for connectivity of the landscape for mule deer and elk, but serve as movement pathways for smaller mammals and possibly turkey.

4.1.2. Are concrete box culverts 100 feet and longer, once retrofitted with wildlife fencing, effective at passing mule deer, elk, and moose?

Mule Deer

At this time, it can be concluded that concrete box culverts 100 to 230 feet (30-70 m) long, and not built for wildlife with wildlife fencing, under I-70 pass mule deer in minimal numbers in certain locations, and in increasing numbers where wildlife exclusion fencing was placed in 2010. At two existing box culverts under I-70 with wildlife exclusion fencing in place for years, (Rattlesnake and Gooseberry culverts, MP's 63 and 64), 117 mule deer passes were recorded in 1,340 camera nights over two years. This averaged 0.09 deer per day, making these culverts minimally useful to the mule deer population, judging on the low numbers in relation to the mule deer population in the area. The existing culverts in the first miles of I-70 at MP 3 and MP 6 that

received wildlife exclusion fencing in the fall of 2010 were being monitored as of the completion of this report, and showed increased mule deer use over time. This area is an important migratory connection for mule deer and elk once snows fall in December. In the first 138 days of post-fencing monitoring of these culverts, 209 mule deer moved through these two culverts in 272 camera nights, for an average of 0.8 deer per day. These culverts provided connectivity for a portion of the population while also repelling 67 to 70% of the mule deer that approached them during this time. As time went on in 2011, mule deer use increased. At the time of this writing, it remains to be seen how well these culverts can function as de facto crossings for mule deer. It is expected that over time the mule deer will adapt to these culverts and use them in ecologically significant numbers, meaning hundreds of mule deer passes per year.

Elk

Although five elk approached the I-70 Rattlesnake and Gooseberry culverts, no elk used them. The cameras placed at the I-70 MP 3 and MP 6 culverts that received wildlife exclusion fencing in 2010 showed very limited elk use. One hundred three elk appeared at these two culverts during the first 138 days of monitoring, and 14 elk passages were recorded, for a success rate of 14 percent, and a repel rate of 86%. The majority of those repelled were cows and calves. These culverts at this time do not work in ecologically significant ways for the elk population that traditionally crossed the highway for winter habitat. They did allow occasional migrants under the highway. In the coming years further monitoring and analyses will better assist in answering this question, both at these culverts and three others with new wildlife fencing to be monitored on I-15 south of Cedar City. No other box culverts with wildlife fencing passed elk.

Moose

There are limited numbers of moose in the I-70 area where wildlife fencing was placed along box culverts, and a summary of their use cannot be deduced due to the scarcity of photos (only one moose was photographed approaching a culvert).

4.1.3. Do some wildlife crossing culvert designs work better than others?

The shorter the culvert, the more wide the culvert, and the higher the culvert, the better success it

has at passing the mule deer. An ideal culvert for passing wildlife under four to five lanes of traffic would be the Colton Culvert under US 6 (Figure 23). Seven culverts constructed as wildlife crossings were monitored for this study. All passed mule deer, but some had higher rates of repellence than others. The data suggest the longer a culvert is as it traverses under the road, the higher the rate of repellence (Figure 24). A linear regression using R programming language (R Development Core Team 2008) of culvert dimensions found length together with width as predictors of culvert success (Schwender et al. 2011), with shorter, wider culverts exhibiting the greatest success in passing mule deer. A logistical regression was conducted using Akaike information criterion (AIC) to measure the relative goodness of fit of the statistical model. The AIC rankings found that culvert width and length were the best predictors of mule deer success, culvert width alone was the next best predictor, and the window ratio, a figure Megan Schwender was working on for her master's thesis, was the third best predictor. It is a measurement of the openness of the culvert. It is important to remember that single structure dimensions cannot be taken in isolation (such as we have presented in Figures 24, 25, and 26), and that in general, it is the openness of a culvert that encourages mule deer and other wildlife use.

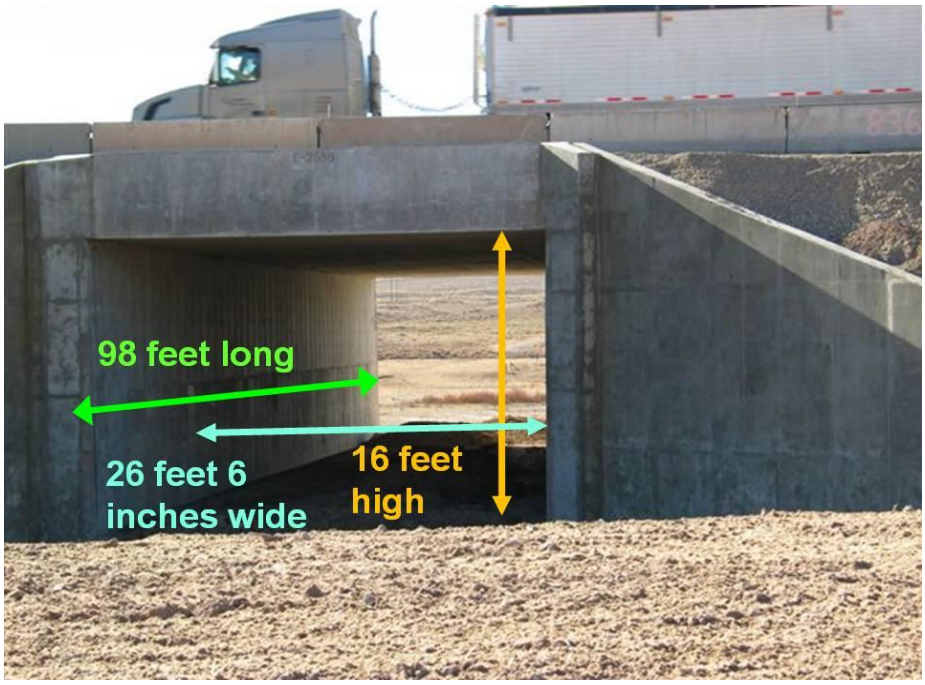

Figure 23. Colton Culvert under five lanes of US 6.

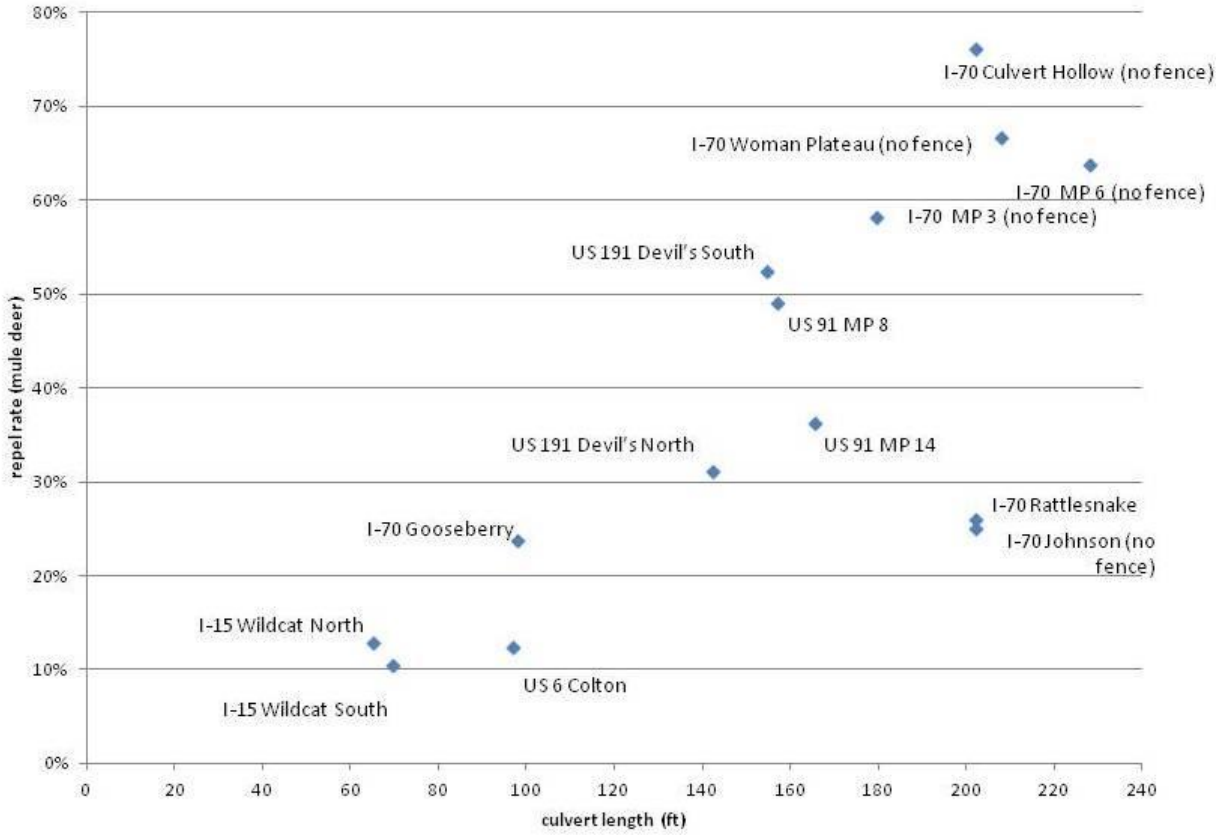

Figure 24. Rates of repellence of mule deer from wildlife crossing culverts with respect to culvert length. Culverts with no wildlife exclusion fencing marked as "no fence."

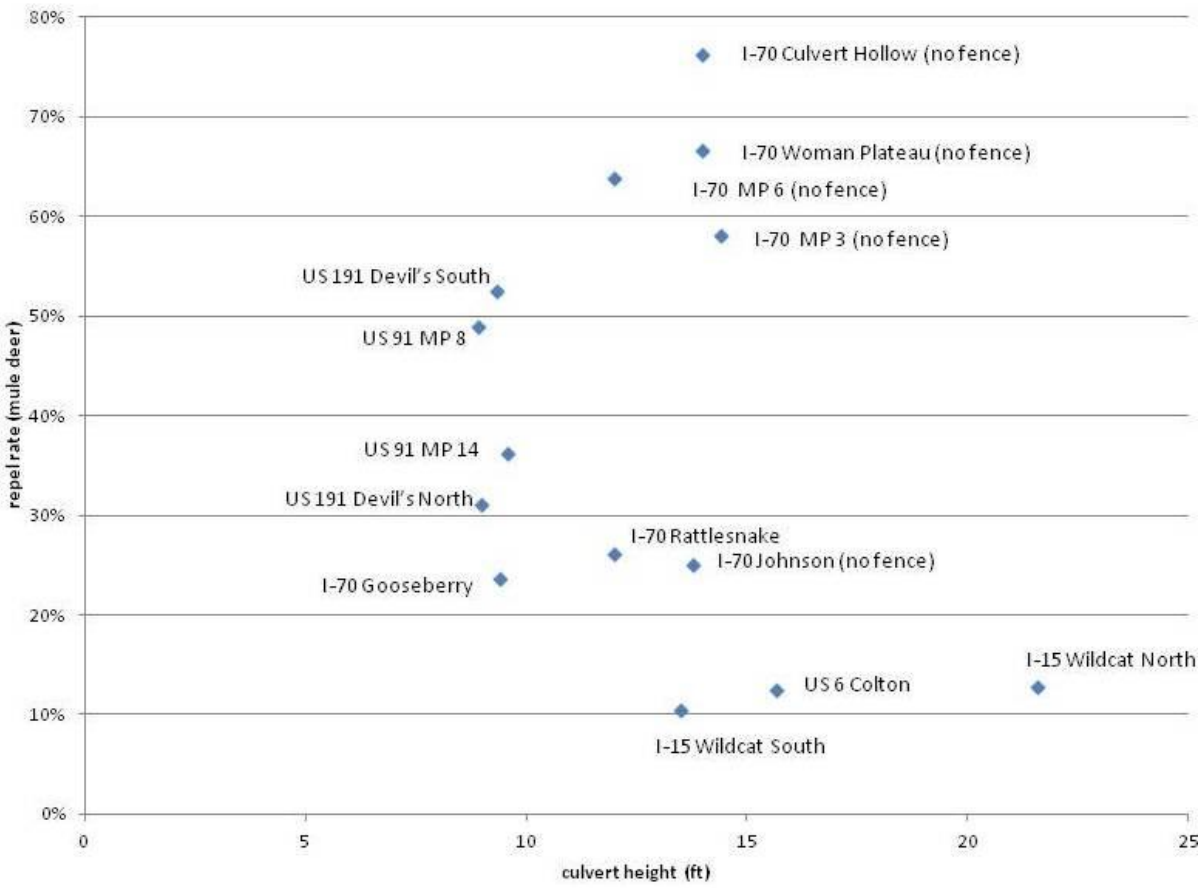

Figure 25. Rates of repellence of mule deer from wildlife crossing culverts with respect to culvert heights. Culverts with no wildlife exclusion fencing marked as "no fence."

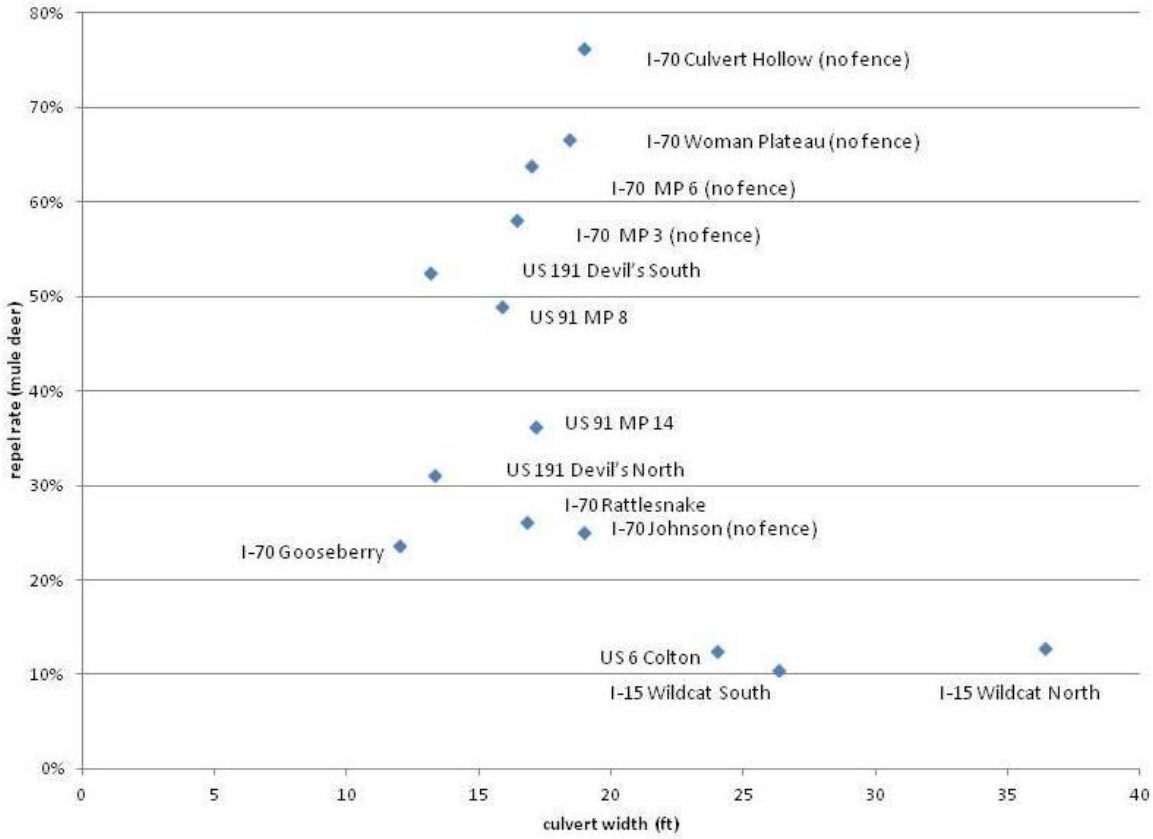

Figure 26. Rates of repellence of mule deer from wildlife crossing culverts with respect to culvert widths. Culverts with no wildlife exclusion fencing marked as "no fence."

At this time the best recommendations are to keep culverts under 120 feet (37 m) long, which is the length as they traverse under the road, and if the road is greater than two lanes, such as a divided highway, break up the culvert into two sections, one for each direction of travel. It appears that increasing the width (span) of the culvert is more important than increasing the height. This may help engineers in installing culverts under roads where there is a limited amount of flexibility for raising a road to accommodate a culvert.

4.1.4. Are the wildlife crossing bridges and culvert on US 6 effective at passing the mule deer, elk, and moose that were detected pre-construction, and in comparable numbers?

Three wildlife underpass bridges and one wildlife underpass culvert were built on US Highway 6 during this study (Figure 27). In preconstruction monitoring, mule deer were detected at all future wildlife crossing sites. A single moose was detected at the Tucker Rest Stop future

Starvation Creek Bridge site, and no other sites. Elk were detected at the future Rail Road Bridge site, the Tucker Rest Stop future Starvation Creek Bridge site, and the Beaver Bridge future site. Post-construction monitoring to date revealed all wildlife crossing bridges and the culvert passed mule deer. None passed elk. The Starvation Creek Bridge passed one moose. At this time these bridges have limited use in passing the full suite of ungulates, meaning elk and moose do not use all crossings. However, they are becoming increasingly effective at passing mule deer. Further details are provided for each structure.

Figure 27. Wildlife crossings monitored along US 6.

Rail Road Bridge (MP 200.7)

At the US 6 Rail Road Bridge at MP 200.7, hundreds of mule deer and four elk passes were photographed over 15 months pre-construction and during-construction. It was expected that this wildlife crossing would pass mule deer in the hundreds per year, and an occasional elk each year. In the first 22 months of monitoring this bridge, 1,435 mule deer passes were recorded, with a success rate of 98%. The rate of repellency was 1.7%. Both male and female mule deer were

photographed. The bridge was a success for passing mule deer. The cameras have not detected any elk near the bridge, although they are in the area. The bridge was not functioning for elk passage at this time.

Starvation Creek Bridge (MP 204)

At the Starvation Creek Bridge, formerly known as the Tucker Rest Stop site, cameras recorded 221 mule deer passes in front of two cameras pre-construction, over a period of 244 monitoring days. An elk and one moose were also recorded. It was expected that this bridge would pass several hundred mule deer, and an occasional moose and elk over the course of a year. In the first 38 days of post-construction monitoring, the bridge had 132 mule deer passes with a 70% success rate, and a 4% rate of repellence (26% of mule deer paralleled the structure). Five elk approached the bridge and repelled. One emaciated moose used the crossing. It is important to note the moose was emaciated because in this study and others conducted by the researcher, elk and moose that were not as healthy as other members of the population and have visible deteriorating conditions sometimes are the only members of their species to approach and use wildlife crossings. This may be because these animals have greater needs to access resources on both sides of the highway. Future monitoring will help to decide if this bridge works for moose. It appears that this bridge will work for mule deer, and it remains to be seen if elk and moose will use the structure.

Beaver Creek Bridge (MP 220)

During the 153 days of pre-construction monitoring, cameras recorded only one mule deer. Before the bridge and fencing were complete it was difficult to position the cameras in a place where animals were constricted to cross the road in one specific spot, thus the low numbers of wildlife. During construction 24 deer and seven elk were photographed in the area. From this data it was expected that dozens to hundreds of mule deer and several elk would use the structure each year. The number of mule deer passes through the new bridges was exceptional, with 600 animals using the area under the bridge in first 560 days of monitoring, with an 11% rate of repellence. To date, the cameras have not photographed elk approaches to the bridge, thus elk are not known to use the crossing.

4.1.5. How effective is the Colton Culvert on US 6 at passing mule deer and elk?

The Colton Culvert saw increasing numbers of mule deer use the structure from the beginning of post-construction monitoring in 2008 through 2011. This culvert was installed before the study could gather any pre-construction data. It was expected that this culvert would pass mule deer and elk due to the fact that mule deer and elk were known to cross from the north to the south side of the road to feed on the open high elevation meadows to the south of the road (L. Mead, UDWR, personal communication), and there were five elk carcasses picked up near MP 217, where the culvert is, from 2005 to 2010 (D. Sakaguchi, UDWR, personal communication). Because it is at a high elevation (over 7,000 feet, 2,133 meters), it is understood that the number of ungulates using the crossing in winter was limited. Mule deer passed through the culvert 35 times in the first year, and 244 times the second year. It appears that mule deer were adapting to this crossing, although we probably will not see as high of numbers of mule deer using this culvert as the bridges at lower elevations. Elk have not been photographed at the culvert. It is hoped they will accept this culvert in the future, because of its short length (less than 100 feet, 30 meters), and wide and high dimensions.

4.1.6. Is the I-70 arch crossing effective at passing mule deer and elk in numbers comparable to pre-construction?

The I-70 arch wildlife passage bridge at MP 5.3 (Figure 28) was installed November of 2010, and showed great promise in passing mule deer in numbers similar to pre-construction monitoring. Cameras were placed at this site for two years pre-construction. It was difficult to predict where animals would cross the road over the seven miles of this highway pre-construction since there was no wildlife fencing on this stretch. In the two years of pre-construction monitoring, there were 161 mule deer passes and 176 elk passes in front of the cameras. It was expected that the new crossing structure would pass hundreds of mule deer and hundreds of elk in this migratory area each year because the pre-construction cameras measured a small band of the area mule deer and elk used to migrate over the seven mile section, thus it was assumed hundreds of other mule deer and elk passages were occurring in this stretch.

Figure 28. I-70 MP 5 Arch Bridge crossing location, with two existing box culverts monitored.

Once the arch bridge and wildlife fencing were completed, 86 mule deer used the new structure in the first 165 days of monitoring, with a 16% rate of repellence. It appears this structure will work for mule deer and the rate of repellence will decrease over time. Nine elk approaches were photographed at the new structure, and eight times elk went through. All of these were bull elk passages. Within the first snows of the winter of 2010-2011, UDWR biologists found evidence of a herd of elk approaching the structure from the south, outside the range of the camera, but all were repelled. As of 2011, no cow or calf elk used this structure. In March of 2011, Bruce Bonebrake of UDWR removed a panel of rails from each side of the rail fencing at the approaches to the structure in an effort to encourage elk use. Perhaps if this can be done each winter and spring when the mule deer and elk are migrating and when livestock are not placed on the land, it may increase elk use. At this time the structure appears to be successful for mule deer. It may over time become successful for elk, as other studies have recorded, but at this time it is of only limited success in passing elk. In Arizona (Gagnon et al. 2011) and Alberta

(Clevenger 2011) researchers found it takes three to four years for local populations of ungulates, including elk, to adapt to new structures and use them. The challenge is for this structure to allow all members of the elk population to freely migrate to their winter and summer ranges on both sides of the highway. If only several bull elk passes occur each year, the structure only works for occasional genetic interchange among elk populations to the north and south of the highway, and the structure would be considered only a limited success in passing members of the local elk population. It is not known what would happen to other members of the population if they could not cross I-70.

4.1.7. Can mule deer, elk, and moose be funneled to use two existing bridge underpasses (not made for wildlife) at interchanges on I-80 with new wildlife fencing?

In 2009, three miles (4.8 km) of wildlife fencing was erected along I-80 from the Mountain Dell exit (MP 134) to the Lamb's Canyon exit (MP 137) (Figure 29). The intention was to funnel wildlife to the existing bridges at these interchanges so the animals would pass underneath rather than across the interstate. This mitigation did not work. During a year and a half of monitoring post fencing, no wildlife were verified using the area under the Mountain Dell Bridge, and only six mule deer were detected using the Lamb's Canyon Bridge. At the same time there were 43 mule deer observations at the entrances to the Mountain Dell Bridge and 86 mule deer observations at the Lamb's Canyon Bridge entrances. Clearly the mule deer are exploring the passage but only use the Lamb's Canyon Bridge in rare instances. One elk was detected at the Lamb's Canyon Bridge, but it did not use the area under the bridge. The challenges to this site are threefold: 1) the loud popping sounds underneath the bridges are extremely loud when heavy traffic passes above; muffling sound may be necessary; 2) there are vehicles using these interchanges day and night, thus making it difficult for skittish animals to use the structures; and 3) there were no devices to keep the wildlife from entering the highway right-of-way by using the entrance and exit ramps at the interchanges (see below section 4.1.8).

Figure 29. I-80 camera sites with wildlife exclusion fencing: Mountain Dell Bridge, Lamb's Canyon Bridge.

Additional fencing from Lamb's Canyon Bridge eastward, and on the south side of the interstate, was completed by 2012. Further monitoring may reveal different trends. At this time wildlife access the interstate via the entrance and exit ramps due to lack of wildlife or double cattle guards, and have been killed by vehicles during this time. If wildlife guards or double cattle guards can be added to all ramps, we should see an increase in wildlife movement beneath the structures and a subsequent reduction in wildlife mortality.

4.1.8. Can white lines painted to mimic cattle guards deter moose, elk, and mule deer from crossing over and entering the road right-of-way?

White lines painted to look like cattle guards do not deter wildlife from passing over them. The white stripes painted to mimic cattle guards to keep wildlife off of I-80 at the Mountain Dell entrance ramp for east-bound traffic were monitored with a single camera for 118 days. In that time 215 wildlife passes were recorded across the stripes including three moose, 95 mule deer, and 115 elk. More wildlife was recorded at this site entering the highway than all the wildlife detected over all camera nights combined from the four cameras at the Mountain Dell and Lamb's Canyon interchanges. Clearly the moose, mule deer, and elk adapted to entering the

interstate using these ramps and ignored the white stripes. Double cattle guards or wildlife guards are recommended for all eight ramps along this stretch of I-80.

4.1.9. What species and in what numbers used the Weber River Bridge under I-80 at Echo Junction?

Although the Weber River Bridge on I-80 near Echo Junction (Figure 30) was not designed to pass wildlife, cameras recorded successful mule deer passes 361 times over 543 days of monitoring, for 0.7 deer per day. One moose was photographed at the entrance but did not use the structure. Elk are in the area but were not photographed. The bridge was replaced in 2012, with accommodations for wildlife with passage pathways along the edges of the river under the bridge. With this pre-construction monitoring data, we can predict that the new structure should pass at least 0.9 mule deer per day (at least 300 deer annually) over the time of post-construction monitoring, and the rate of repellence should be under 10% as it was at this bridge when no impediments such as fencing were placed at the entrances. It is also expected that moose and elk will occasionally use the bridge each year. Future monitoring will help us determine how the success of the new structure correlates with these expectations.

Figure 30. I-80 Weber River Bridge site.

4.1.10. Does the I-15 Beaver overpass facilitate mule deer migration and elk migration across the interstate?

The camera on the wildlife overpass on I-15 near the town of Beaver (Figure 31) revealed 1,206 mule deer passes in 738 days of monitoring, for a value of 1.6 deer through per day. This equates to an average of 584 mule deer passes per year. Since the whole population of mule deer in this area needs to migrate to the west in the winter and the east in the summer, it is important that bucks use this crossing as well. The male passes were 16% of the total passes, which is comparable to the percentage of the males in the population. This lends credit to the idea that the wildlife overpass is allowing the majority of members of the population of mule deer to move to their seasonal habitats and is highly successful for mule deer.

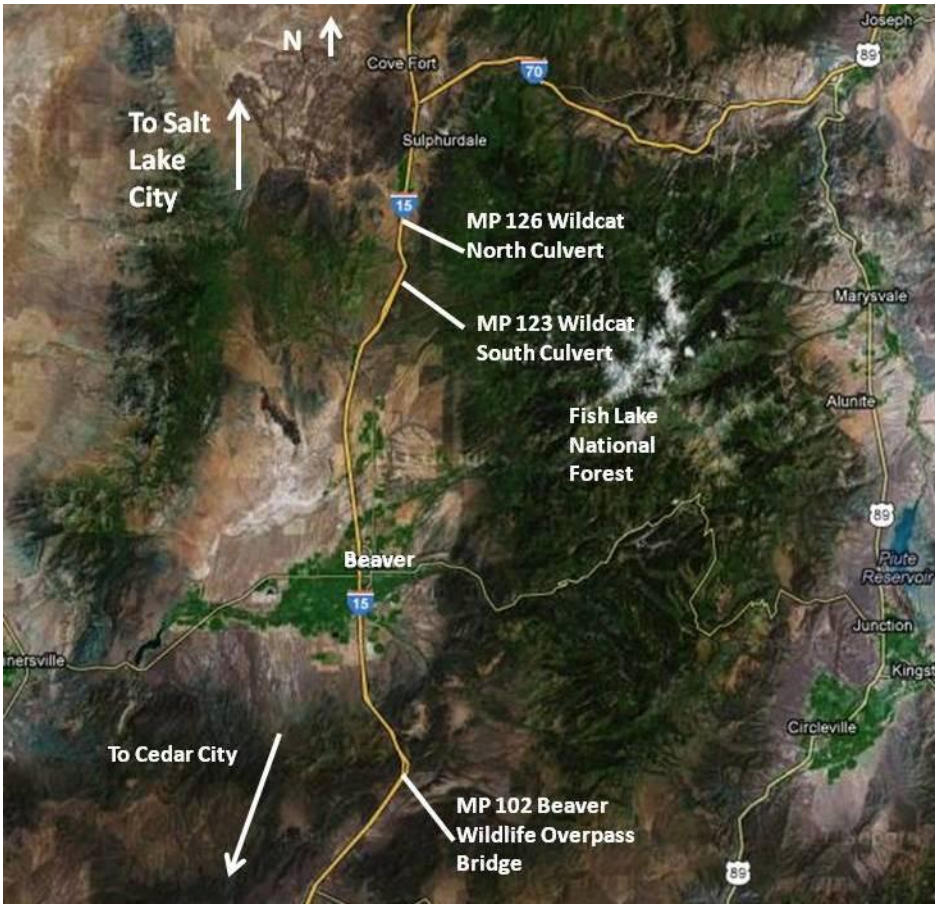

Figure 31. I-15 wildlife crossings and camera sites near Beaver, Utah.

Camera evidence revealed 19 bull elk passes over the overpass. No female or young elk were photographed. Of all wildlife crossing structures and existing bridges and culverts monitored in Utah in this study, this wildlife overpass was the structure most highly used by elk. While the overpass appears to pass all age cohorts and genders of mule deer, it fails to pass members of the elk population. The overpass does not facilitate elk population movements to winter and summer ranges or any other movements on both sides of I-15. If the objective is to allow an occasional bull elk to move between populations to maintain genetic diversity, the overpass appears to facilitate that purpose. It is not known how to encourage cow elk to use this overpass. If panels were placed in the chain link fence along the overpass to block the view and possible noise of traffic, it may create more of a tunnel effect and discourage elk use. A potential improvement would be to plant sagebrush and juniper on the overpass segments to provide a more natural "feel" to the area and to provide cover.

4.1.11. Do elk approach or use the two corrugated steel culverts under I-15 at the two Wildcat structures?

Wildlife monitoring cameras were placed at the entrances to the two I-15 Wildcat culverts (Figure 31) in part to determine if elk were approaching but not using these culverts. Recent history of elk in the area documents elk returning to Beaver Mountain after decades of absence, and attempts by individual elk to cross the interstate near these sites (B. Bonebrake, UDWR, personal communication), as judged from WVC carcass data and observations of elk tracks at the entrances to these culverts. In the three years of monitoring the I-15 Wildcat culverts, only 18 elk on 4 occasions were detected, all on the east side of Wildcat North. No elk used the crossings.

4.1.12. How effective are the Wildcat North and the Wildcat South crossing structures under I-15 at passing mule deer and other species?

The two sets of culverts at Wildcat North and South under I-15 can be considered the most successful crossings in Utah if success is defined by sheer numbers of mule deer and low rate of repellence. In the 1,087 days of monitoring at Wildcat North, 7,529 mule deer passes were

recorded through the structure for an average of 6.9 mule deer through the structure per day. In the three years (1,091 days) of monitoring at Wildcat South, 9,076 mule deer passes were photographed through the structures for an average of 8.3 mule deer per day. Rates of repellence were eight percent at Wildcat North and 11 percent at Wildcat South. The cameras at these crossings tallied 16,606 mule deer crossings under I-15, the majority of all mule deer crossings in the state. There were other mammals photographed at the crossings. Eighteen elk approaches were recorded at Wildcat North, but none used the structure. At Wildcat South three mountain lion, 68 coyote, nine bobcat, two badger and 15 rabbit/jackrabbit passes were photographed. At Wildcat North one mountain lion, nine coyote, nine red fox, and two rabbit/jackrabbit passes were photographed.

4.1.13. What structures do elk approach and repel from, and what structures do they use?

Elk in Utah are extremely reluctant to use any kind of bridges or culverts to pass under roadways. In the three years of monitoring in this study, there were 174 elk approaches to existing culverts, bridges, and wildlife crossings, with 45 elk passes recorded, for an overall success rate of 26%. There were four bull elk passes under a pair of existing bridges under I-70 on the Fish Lake National Forest. The wildlife overpass on I-15 had 19 bull elk passes, (Figure 21). No elk used box culverts without wildlife fencing, but once fencing was installed along I-70, 13 elk passages (10 bull, three cow) were recorded through the box culvert at MP 6 (Figure 65); eight bull elk passes were recorded under the MP 5 arch bridge (Figure 14), and one bull elk was photographed using the MP 3 split box culvert. This is a total of 45 elk passages during a period of time when over 25,000 mule deer passages were recorded. Elk repels and use of existing structures and wildlife crossings are presented in Table 1.

Table 1. Sites elk were photographed approaching, repelling from, and using structures.

Road and Mile Post Site	Number of Elk Repelled/Parallel	Number of Elk Through
US 6 MP 204 Starvation Creek Bridge with fencing	5	0
I-70 MP 3 split box culvert with wildlife fencing	49	1
I-70 MP 5 Arch bridge with wildlife fencing	1	8
I-70 MP 6 long box culvert with NO wildlife fencing	3	0
I-70 MP 6 long box culvert with wildlife fencing	40	13
I-70 MP 14 Elk Bridge with wildlife fencing	0	4
I-70 MP 63 Rattlesnake box culvert with fencing	1	0
I-70 MP 64 Gooseberry box culvert with fencing	4	0
I-70 MP 80 Culvert Hollow box culvert with NO fencing	1	0
US 91 MP 14 Corrugated Steel culvert with fencing	1	0
US 191 Devil's Canyon North Box culvert with fencing	4	0
I-15 MP 126 Wildcat North Culvert with fencing	4 (14 parallel)	0
I-15 MP 102 Wildlife Overpass with wildlife fencing	1 –but most unknown*	19
I-80 Lamb's Canyon Bridge with some wildlife fencing	1 parallel	0
Total	129	45

* Number unknown due to lack of camera at approaches; 1 camera only in middle of structure.

It appears that the arch bridge on I-70 at MP 5.3 holds promise for passing additional elk, but it remains to be seen if cows and calves will use it. The bridges on US 6 over Starvation Creek, Beaver Creek, and at the Rail Road crossing all are of adequate size to pass elk based on elk use of the I-70 MP 14 Elk bridge and the I-15 bridge wildlife crossing near MP 104 that Rosa (2006) documented elk passage, which was not included in this study. At this time only bridges should be considered adequate for passing elk. The box culverts on the first few miles of I-70 that received wildlife fencing in the fall of 2010 may provide evidence that elk can be forced to use culverts, but it is not known at this time if herds of elk will use them, thus providing passage for the majority of elk in an area.

4.1.14. The New Sage site at MP 83 along I-70 is the site of a potential new wildlife crossing. What were the species and what were their numbers at this site?

The New Sage site along I-70, MP 83 (Figure 32) is a potential site for a future wildlife crossing. In the 759 days of monitoring the area north of the interstate, 171 mule deer observations and 208 elk were recorded. As with any area that does not constrict wildlife movement, this number

is a percentage of the total numbers of animals at that location over that time. The majority of the elk observation by the camera (200) was in the winter months. Eight coyote and one bobcat observations by the cameras at the site were also recorded. An analysis of the wildlife-vehicle collision data over time near this location could help evaluate the benefits and costs of placing a wildlife crossing at this location.

Figure 32. I-70 camera sites, with MP 83, New Sage Site to the right (east) side of map.

4.2. Monitoring Results for Individual Sites Along US 6, Interstate 70, US 89/91, US 191, Interstates 15 and 80, and US 189

The monitoring results of individual sites are presented in this section under the road name where those sites are located. Sites are listed with the more commonly used name, typically from the nearby stream. Most structures' dimensions and photographs are included in Appendix A. All wildlife crossings were erected in conjunction with wildlife exclusion fencing that is a minimum of 8 feet (2.4 meters) high. There are two exceptions to this height along US 6 at the Colton Culvert and Beaver Creek Bridge wildlife crossings. The fencing at those sites is closer to six

feet (1.8 meters) high. Other sites are reported with information on the presence or lack of wildlife exclusion fencing.

The data for mule deer movements are calculated for each site and are presented in Table 2 below. This table allows for ease of comparison among the different wildlife crossing structures and existing culverts and bridges not built for wildlife. To compare the "success" of specific structures, the best data to compare would be the 'deer through structure per day' values because they are indexed to the number of days cameras were on at that site and represent the sheer number of mule deer using the structure, and the 'success rate,' which would be 90% and higher for a structure considered to be very successful.

Table 2. Camera locations, mule deer numbers photographed, and actions of mule deer photographed at those sites.

Camera Location	Camera Days	Number of Deer Observations at Site	Number of Deer Photo-graphed per Day	Number of Successful Crossings thru Structure	Deer thru Structure per Day	Success Rate (%)	Rate of Repellency (%)	Parallel Rate (%)
US 6								
RxR Bridge MP 200.7 South side of US 6 pre-construction	28	62	2.2	na	na	na	na	na
RxR Bridge MP 200.7 South side of US 6 during construction	368	64	0.2	na	na	na	na	na
RxR Bridge MP 200.7 north side of US 6 during construction	788	628	0.8	na	na	na	na	na
RxR Bridge MP 200.7 post-construction	565	1,435	2.6	1,410	2.5	98.3	1.7	0
Starvation Creek (Tucker) Bridge MP 204 pre-construction riparian	244	81	0.33	na	na	na	na	na
Starvation Creek (Tucker) Bridge MP 204 pre-construction upland	210	140	0.67	na	na	na	na	na
Starvation Creek (Tucker) Bridge MP 204 post-construction	138	186	1.3	132	1.0	70.1	3.7	26.2

Camera Location	Camera Days	Number of Deer Observations at Site	Number of Deer Photo-graphed per Day	Number of Successful Crossings thru Structure	Deer thru Structure per Day	Success Rate (%)	Rate of Repellency (%)	Parallel Rate (%)
Colton Culvert MP 217	579	291	0.5	279	0.5	94	4	2
Beaver Creek Bridge MP 220 pre-construction	153	1	0.01	na	na	na	na	na
Beaver Creek Bridge MP 220 post-construction	560	697	1.2	600	1.1	88	12	1
Gilluly MP 205 RxR Bridge	605	777	1.3	na	na	na	na	84
I-70								
Split concrete box culvert MP 3 pre fence	305	13	0.04	0	0	0	0	100
Split concrete box culvert MP 3 post fence	134	665	4.9	193	1.4	29	67	4
MP 5.3 Arch crossing pre-construction site	1,210	161	0.1	na	na	na	10	18
MP 5.3 Arch Crossing post-construction	165	102	0.6	86	0.5	84	16	0
230’ concrete box culvert MP 6 pre fence	624	76	0.1	6	0.01	7.8	70	22.2

Camera Location	Camera Days	Number of Deer Observations at Site	Number of Deer Photo-graphed per Day	Number of Successful Crossings thru Structure	Deer thru Structure per Day	Success Rate (%)	Rate of Repellency (%)	Parallel Rate (%)
230’ concrete box culvert MP 6 post fence	138	63	0.5	16	0.1	25.4	60	14.6
Rattlesnake 200’ concrete box culvert MP 63 (w/Fence)	678	155	0.2	98	0.1	63	31	6
Gooseberry 98’ concrete box culvert MP 64 (w/Fence)	662	25	0.04	19	0.03	76	20	4
Johnson 200’concrete box culvert MP 79	288	4	0.01	3	0.01	75	25	0
Culvert Hollow 200’ concrete box culvert MP 80	351	12	0.03	2	0	25	50	25
Woman Plateau 200’ concrete box culvert MP 83	328	17	0.05	1	0	5	0	95
Ivy Creek Bridges MP 84	375	10	0.02	4	0.01	40	60	0
USFS Road Bridge MP 14 – Elk Bridge (w/Fence)	839	413	0.5	361	0.4	87	9	4
Ranch Access Bridge MP 7	0	0	0	0	0	0	0	0

Camera Location	Camera Days	Number of Deer Observations at Site	Number of Deer Photo-graphed per Day	Number of Successful Crossings thru Structure	Deer thru Structure per Day	Success Rate (%)	Rate of Repellency (%)	Parallel Rate (%)
MP 83 Mountain pass Pre-construction site – Sage site	759	171	0.2	na	na	na	na	na
US 89/91								
MP 8 Arched Steel 157 feet culvert (w/Fence)	581	1,187	2	643	1.1	54	37	9
MP 14 Arched Steel 165 feet culvert (w/Fence)	826	1,945	2.4	1,907	1.5	63	31	6
US 191								
Devils Canyon S Arched Steel 120 feet culvert MP 60 (w/Fence)	350	134	0.4	62	0.2	46	32	22
Devil's Canyon N Arched Steel 120 feet culvert MP 62 (w/Fence)	362	438	1.2	295	0.8	67	18	15
I-15								
Wildcat North Arched steel 65 feet paired culverts MP 126 (w/Fence)	1,087	8,470	7.8	7,529	6.9	89	8	3

Camera Location	Camera Days	Number of Deer Observations at Site	Number of Deer Photo-graphed per Day	Number of Successful Crossings thru Structure	Deer thru Structure per Day	Success Rate (%)	Rate of Repellency (%)	Parallel Rate (%)
Wildcat South Arched steel 65 feet paired culverts MP 123 (w/Fence)	1,091	10,581	9.7	9,076	8.3	86	11	3
Beaver Overpass Bridge MP 102 (w/Fence)	738	1,289	1.7	1,206	1.6	94	6	0
Camp Creek N concrete box culvert MP 44	371	16	0.04	12	0.03	75	25	0
Camp Creek S concrete box culvert MP 42	299	32	0.11	0	0	0	100	0
Ash Creek Reservoir concrete box culvert MP 36	397	11	0.03	11	0.03	100	0	0
Scipio North Bridge Wildlife Crossing MP 186 (w/Fencing)	174	722	4.5	722	4.5	na	na	na
Scipio South Bridge MP 182 (w/Fencing)	214	93	0.4	na	na	na	na	na
Scipio Paved Overpass MP 184 (w/Fencing)	69	0	0	0	0	0	0	0
I-80								

Camera Location	Camera Days	Number of Deer Observations at Site	Number of Deer Photo-graphed per Day	Number of Successful Crossings thru Structure	Deer thru Structure per Day	Success Rate (%)	Rate of Repellency (%)	Parallel Rate (%)
Mountain Dell Bridge MP 134 (w/Fence)	344	43	0.1	0	0	0	12	88
Lamb Canyon Bridge MP 137 (w/Fence)	512	86	0.2	6	0.01	7	2	91
Mountain Dell entrance ramp white lines MP 134 (w/Fence)	118	95	0.80	na	na	na	na	na
Weber River Bridge (Echo Junction) MP 168 pre-construction	543	496	0.9	361	0.7	73	20	7
US 189								
Deer Creek State Park Culvert MP 20	9	12	1.3	10	1	83	17	0

W/Fence = Wildlife exclusion fencing (8 feet - 2.4 m high) present at site. Na = not applicable to situation.

4.2.1 US Highway 6 Summary

Wildlife crossings structures on US Highway 6 (US 6) monitored in this project include:

- The bridge (C287) at MP 200.7 known here as the RxR bridge at MP 200,
- The bridge at Starvation Creek near the former Tucker Rest Stop (MP 204),
- The culvert near MP 217, known as the Colton Culvert,
- The bridge near MP 220 known as the Beaver Creek Bridge,
- A fourth site near the Gilluly Bridge (MP 205) was monitored to determine wildlife use of the area near the bridge that accommodates 3 rail lines.

The objectives of the study at these sites were to determine wildlife use of these areas pre-construction if possible and wildlife use of the new crossings once construction was finished (post-construction). The objective of the camera placed at the Gilluly Bridge was to determine wildlife use of the area. The information gathered at the Gilluly site may help management and construction decisions that help to funnel wildlife to use the area under the existing rail road bridge rather than crossing over the road. See Figure 33 for camera locations along US 6.

Figure 33. US 6 monitoring locations.

US 6 RxR Bridge at MP 200.7

Cameras were first installed at this site in March 2008. Pre-construction and during construction data was collected using three cameras at the site from March 2008 through August 2009. During pre-construction monitoring, the camera on the south side of US 6 photographed mule deer and elk near Soldier Creek. Once construction began on May 19, 2008, wildlife activity was reduced at the site. Eventually the camera was moved to a location outside the construction zone, just to the west by approximately 200 feet (61 meters), and in a sage brush-natural area. Mule deer usage was lower during construction (see Table 3 and Figure 34). Two cameras were placed north of the highway on a hillside approximately 30 feet (10 meters) from the construction site. Mule deer usage of the site was low until late January and into February when mule deer began to forage on vegetation in front of cameras, and move through the area. There were 59 to 125 mule deer observations per week through February 2009 (those high observation weeks were truncated in Figure 34).

Figure 34 shows the results of mule deer number observed per week for all three cameras pre-construction and during construction. This figure is instructive, as it shows how different the mule deer use was on the two sides of the road. The areas differed in water availability; the south side of the highway, the south camera, R2 had a creek nearby, but the uphill cameras did not; and vegetation availability in the winter differed, with the hillside cameras, R1 and R3 in an area with a southern exposure, and thus higher potential for vegetation to be exposed above the snow. Overall between the three cameras, mule deer photographed in the area was 2.2 mule deer per day on the south side pre-construction, and averaged 0.2 to 0.8 per day among the cameras during the construction period. The pre-construction number of deer per day is instructive in helping to determine how to gauge success at the site once the crossing was built. It should be used cautiously though, since it is based on just 28 days of monitoring.

Male mule deer photographed pre-construction and during-construction comprised 21 percent of the adult mule deer.

Elk were photographed in the area, with three elk photographed at the south camera pre-construction, and one bull elk photographed on the north hillside during construction. Elk were found dead along the rail lines near this site during this study.

The post-construction monitoring phase began August 24, 2009, with two cameras at the new bridge, and a single camera in the uplands to the north of the site. See Appendix A for crossing dimensions. Wildlife exclusion fencing was placed approximately one quarter mile to the west and one half mile to the east. Data summaries for mule deer at the site post-construction are presented in Table 3. In the first year of monitoring post construction, 808 deer were detected using the crossing, for a total of 2.2 deer per day. As of June 7, 2011, this total was up to 2.5 deer per day, making it one of the most highly used wildlife crossings for mule deer in Utah (Figure 35). The rate of repellency decreased to less than two percent. The bridge passage is used by mule deer every month of the year. Male mule deer predominantly appeared in the fall and winter at this site. Male mule deer comprised 12% of the total adults photographed at the site post-construction, which is a reduction from the 21% photographed pre-construction and during-construction. The majority of mule deer movements at the site appear to be attributed to 12 to 20% resident animals.

Unfortunately, the crossing does not pass other wildlife. This may be due to the fact it is open and devoid of vegetation, which is important to some species of wildlife needing hiding cover. Ongoing analyses of vegetative characteristics of the most successful crossings were conducted by the project graduate researcher during the writing of this report. Vegetative characteristics favorable to both mule deer and other species may be contradictory, and it is best to wait on making recommendations. If stumps, logs, and boulders could be placed in a line going into and through the crossing, they could increase use of the crossing by small and meso mammals, which would not adversely affect mule deer use. This approach has been taken at wildlife crossings in Oregon and Vermont (Bellis 2008). The bridge is a success for passing mule deer. It is not a success, at this time, in passing elk, and other wildlife.

Pros: This bridge is one of the first bridge wildlife crossings for Utah in this century and it was uncertain how well it would work. The design and placement of the bridge were working excellent for mule deer at this time. There are no human activities nearby to affect mule deer behavior, and the rail lines south of the crossing do not appear to adversely affect the mule deer in ways that can be measured by the cameras.

Prescription for Improvements: This bridge only passes mule deer. Elk are known to be in the area, both through camera evidence and wildlife-vehicle accidents and wildlife-train accidents. Elk are wary of changes to their environment and are reluctant to use structures. Perhaps if additional vegetation near the entrances to the bridge area were planted and maintained, the area would appear more natural and therefore more appealing to elk. These actions would probably help make the crossing more attractive to other wildlife such as moose, bobcat, coyote, and meso-mammals. A latent problem at this site is the inability of those accessing the railroad at gates to the east to close those gates, in spite of UDOT signs placed on those gates asking the users to close them for wildlife. Perhaps UDOT utilities and rail coordinators could work with the rail line workers on informing them of the importance of closed gates. Figure 36 demonstrates the potential results of opened gates.

Table 3. Mule deer camera data tabulated for US 6 MP 200.7 bridge wildlife crossing, pre-construction, during construction, and post-construction. Once completed, the crossing had wildlife fencing attached in both directions.

Camera Location	Camera Days	Number of Deer Observa-tions at Site	Number of Deer Photo-graphed per Day	Number of Successfl. Crossings thru Structure	Number of Deer thru Struc-ture per Day	Success Rate (%)	Rate of Repel-lency (%)	Parallel Rate (%)
RxR south pre-construction	28	62	2.2	na	na	na	na	na
RxR south during construction	368	64	0.2	na	na	na	na	na
RxR north during construction	788	628	0.8	na	na	na	na	na
RxR bridge post-construction	565	1,435	2.6	1,410	2.5	98.3	1.7	0

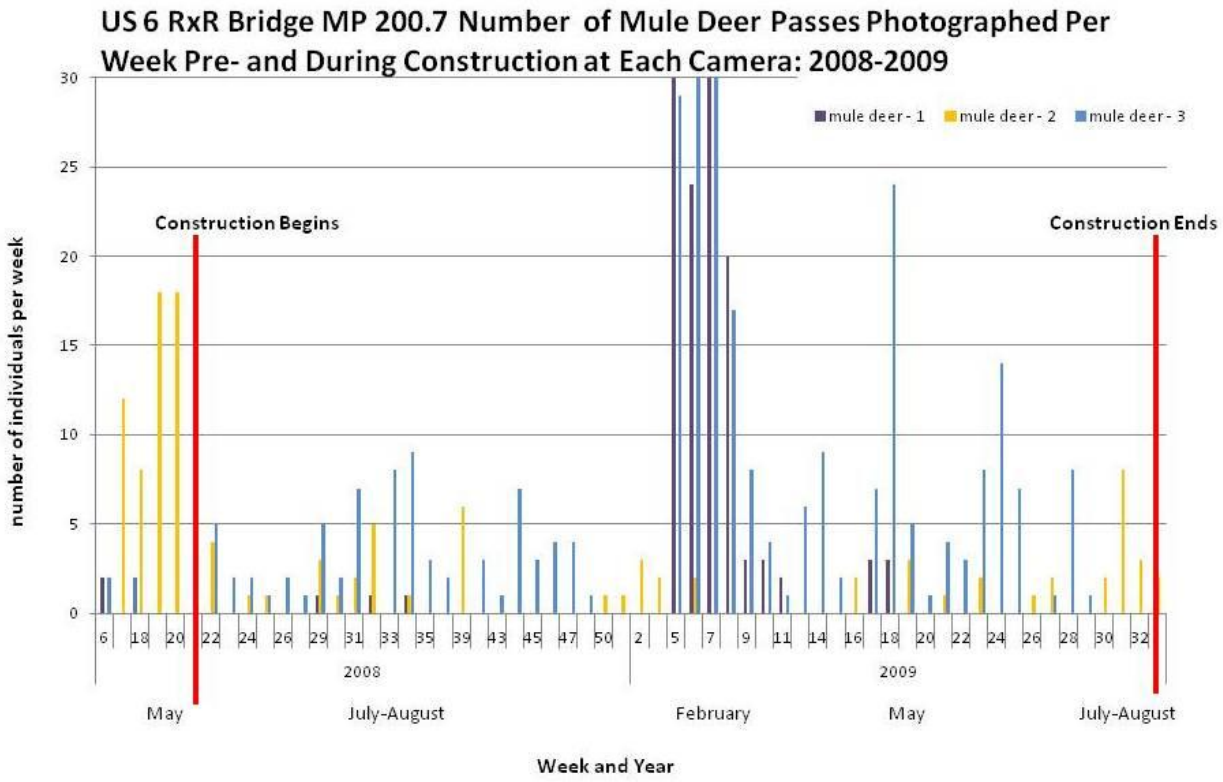

Figure 34. Mule deer photographed at US 6 RxR bridge site, pre-construction and during construction. Yellow bars refer to camera data from south side of the site (mule deer 2 on graph). Blue and dark bars refer to cameras R1 and R3, which were placed on the hillside north of the highway, outside of the construction zone. High mule deer usage in weeks five through eight in 2009 were truncated: week 5 there were 59, week 6: 125, and week 7: 111 mule deer observations.

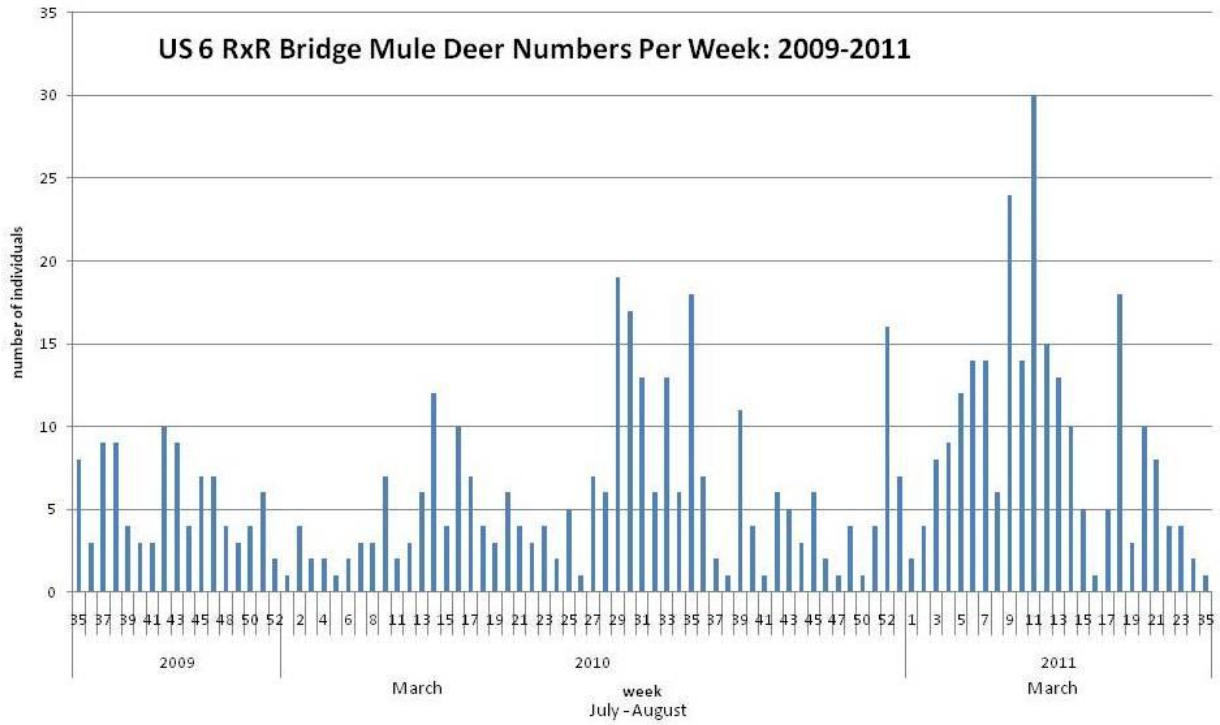

Figure 35. Mule deer use of the US 6 Rail Road Bridge at MP 200.7 per week.

Figure 36. US 6 MP 200.7 Bridge: mule deer herd approached a mule deer carcass that appeared just 4 minutes earlier. It is hypothesized that the deer was hit by a vehicle on the bridge above and this was her herd.

US 6 Starvation Creek Bridge MP 204

Two pre-construction cameras were installed at this site, formerly known as the Tucker Rest Stop, in September 2008. One camera was placed in the riparian area within 80 feet (25 meters) of the site of the future crossing, and one camera was placed in the uplands along a wildlife path leading to the highway. The cameras recorded continual mule deer use of the site year round, and a lone moose and a lone elk at the site. Deer photographed per day ranged from 0.3 to 0.7 pre-construction on both cameras. In the first 138 days of monitoring post-construction, deer through the structure was 1.0 per day. Future expectations are to see a rise in the number of mule deer through the structure over time, and elk and moose in comparable numbers to pre-construction: several animals per year.

The bridge was completed in late summer 2010. See Appendix A for crossing dimensions. Wildlife-proof fencing was placed approximately one mile to the east, and one-quarter mile to the west. On November 3, 2010, four new cameras were placed at the entrances under the new wildlife crossing bridge, now called Starvation Creek Bridge for post-construction monitoring. Post-construction monitoring revealed heavy deer use in this area in the early winter (Figures 37 and 38) and a second peak in use in May and June. A short video has been made of the first mule deer herd to parallel the bridge, and then the first herd to use the bridge (Hamlin 2011a). When at the crossing, the mule deer exhibited behaviors that represent a high sense of wariness.

The repel rate was greatest on the southeast corner of the bridge. The repel rate increased from March through May, 2011. This may be because the water levels rose in Starvation Creek, and it was more difficult for the mule deer to negotiate the stream's edge that is lined with large rocks on the east side. Future modifications to this bridge should include adding features to the southeast side of the bridge so hoofed animals can walk along the edge of the stream to use the east side of the crossing.

Several other species were detected. A male moose used the crossing while walking up the creek (Figure 39). Other wildlife has been detected at this crossing including bobcat and marmot. A herd of five elk that approached the bridge from the south was repelled. It included cows, calves, and a spike bull. It is hoped future elk attempts will result in use of this structure.

Data on pre-construction and post construction cameras are presented below in Table 4.

Pros: This crossing passes a stream making it more likely that many different species of wildlife will encounter and use it. Vegetation was maintained at the south end of the structure and it has helped wildlife come more close to the crossing than if the area was barren, such as the north side was during this period of monitoring. The open nature of the bridge is excellent for all species of wildlife. The elk that refused to use the structure may use it at a later time when vegetation is renewed and silt fencing is removed.

Prescription for improvements: The black silt fence to the north of the structure may be a visual barrier to some animals. The fence should be removed as soon as possible so wildlife can move through the terrestrial parts of the structure. A second change to the structure would be the addition of soil to the southeast corner of the structure. Mule deer move along the wall on the southeast side and skirt the stream at the edge of large boulders to access the crossing. In May of 2011 when the waters of Starvation Creek were high, the mule deer coming from the northeast were consistently repelled at this side. It is believed they could not skirt the edge of the stream due to the high level of the water within the boulders. If soil cannot be added, perhaps the boulders could be replaced with smaller rip rap. Otherwise this is an almost perfect wildlife crossing at this time.

Table 4. Mule deer camera data tabulated for US 6 Starvation Creek Bridge wildlife crossing pre-construction and post-construction.

Camera Location	Camera Days Ana-lyzed	Number of Deer Observa-tions at Site	Number of Deer Photo-graphed per Day	Number of Successfl. Crossings thru Structure	Number of Deer thru Struc-ture per Day	Success Rate (%)	Rate of Repel-lency (%)	Parallel Rate (%)
Starvation Creek (Tucker) Bridge pre-construction riparian	244	81	0.33	na	na	na	na	na
Starvation Creek (Tucker) Bridge pre-construction upland	210	140	0.67	na	na	na	na	na
Starvation Creek (Tucker) Bridge post-construction (w/fencing)	138	186	1.3	132	1.0	70.1	3.7	26.2

w/fencing = wildlife fencing present

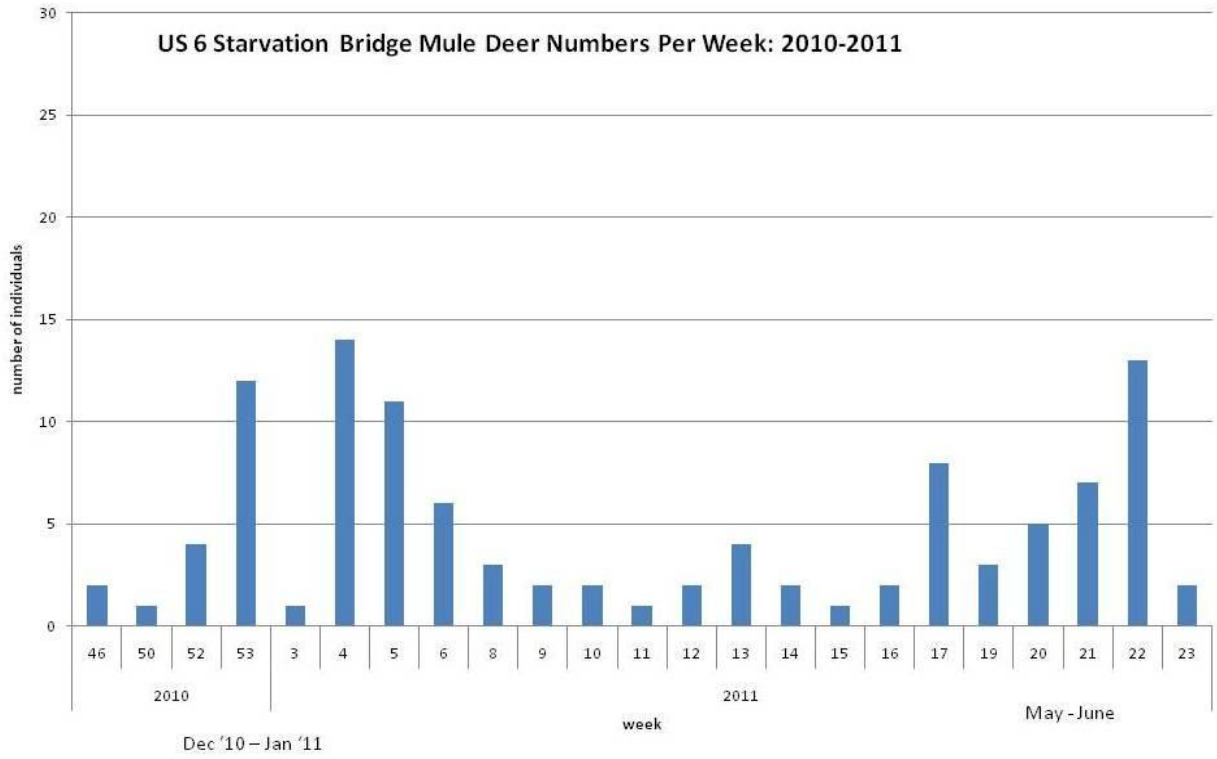

Figure 37. Mule deer use of Starvation Creek Bridge under US 6 by week.

Figure 38. Mule deer approached the Starvation Creek Bridge, from the south.

Figure 39. Moose used the Starvation Creek Bridge passage.

US 6 Colton Culvert – MP 217

The Colton Culvert was created in 2008. There were no opportunities for pre-construction data collection. See Appendix A for crossing dimensions. Wildlife fencing is less than the standard 8 feet (2.4 meters) high fence and closer to 6 feet (2 meters) high, and extends several miles to the east and west. Post-construction cameras were placed at the north and south entrances in November 2008 and August 2009 respectively. Since that time, at least one camera has been in operation for a total of 579 days. Deer use of the culvert was 0.5 deer through per day (Table 5). Data reveal two strong trends: seasonal use and greater use with time (Figure 40). The mule deer leave the area in mid-November, just before the major snow storms drop the snow that stays all winter. They do not return until late May or June. This culvert is at an elevation of over 7,000 feet (2,133 meters) and cannot be judged for wildlife use against lower elevation crossings.

The second trend is the jump in mule deer use in 2010 (Figure 40). In the first year of monitoring (November 2008 through November 2009), only 38 mule deer were detected at the site, and 35

went through (Figure 41). In the second year, (2010), 253 deer were detected at the site, 244 went through. These animals were all photographed from August through November.

There is a variety of other wildlife photographed at this culvert. In the winter months there are dozens of appearances of jackrabbits and occasional cotton-tail rabbits at the culvert. It appears at least some of those jackrabbit photos are events that result in the jackrabbits using the culvert. Fox, coyote, and badger have been photographed at entrances. Bobcat (Figure 42) and coyote have been verified as passing through the culvert. It was expected that this culvert would pass mule deer and elk due to the fact that mule deer and elk were known to cross from the north to the south side of the road to feed on the open high elevation meadows to the south of the road (L. Mead, UDWR, personal communication), and there were five elk carcasses picked up near MP 217, where the culvert is, from 2005 to 2010 (D. Sakaguchi, UDWR, personal communication). Elk have not been photographed at the culvert. It is hoped they will accept this culvert in the future, because of its short length (less than 100 feet, 30 m), and wide and high dimensions.

Pros: The dimensions of this culvert make it the most wildlife friendly culvert under four or more lanes of traffic in Utah. It is high, wide and short for a structure accommodating five lanes of traffic. Mule deer use has increased as more animals learned to use it. Other species of wildlife are adapting to it, such as coyote, bobcat, and jackrabbit. Rail fencing near the entrances works for wildlife.

Prescription for Improvement: Vegetation is lacking for dozens of meters to the north and south of this structure. Vegetation such as sage brush provides cover for wildlife wary of predators or humans. Without vegetation, the approaches to the structures are less “inviting” to individual animals, and are more risky for wildlife than if they had some hiding cover. Planting of sagebrush or other types of vegetative cover is recommended. The wildlife fencing is substandard; it is lower than the required 8 feet (2.4 m). Moose tracks in the snow have been observed on the right-of-way side of the fence. If there is any possibility of increasing the height of the fence, it would help increase wildlife use of this and nearby crossings and bridges.

Table 5. Mule deer camera data tabulated for US 6 Colton Culvert with wildlife fencing.

Camera Days Analyzed	Number of Deer Observations at Site	Number of Deer Photo-graphed per Day	Number of Successful Crossings thru Structure	Number of Deer thru Structure per Day	Success Rate (%)	Rate of Repellency (%)	Parallel Rate (%)
579	291	0.5	279	0.5	94	4	2

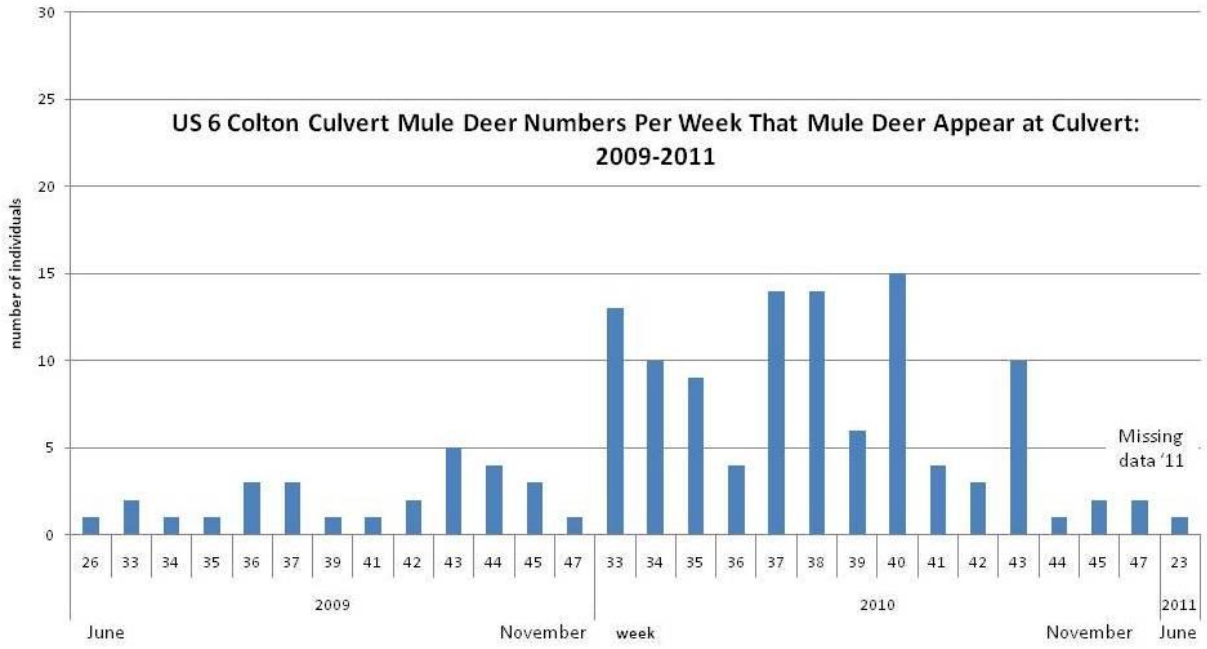

Figure 40. Mule deer use of Colton Culvert under US 6 by week. Missing weeks are times when no mule deer were at the culvert, typically December through April.

Figure 41. Mule deer doe lead buck through Colton Culvert under US 6.

Figure 42. Bobcat used Colton Culvert under US 6 in winter.

US 6 Beaver Creek Bridge – MP 220

Pre-construction and during construction monitoring at this site from November 2008 through September 2009 revealed limited mule deer use of the area. This was due, in large part, to the inability to catch wildlife movements with two cameras over a large area where the animals were not moving through a constrained area such as a bridge with wildlife fencing. Pre-construction monitoring revealed only one deer photographed (Table 6). During construction, twenty-three deer and seven elk were photographed. The Beaver Creek Bridge was completed by October 2009. Wildlife-proof fencing was erected approximately one-quarter mile (0.4 kilometer) to the east and several miles (kilometers) to the west. See Appendix A for crossing dimensions.

Post-construction monitoring began in November 2009 with two cameras mounted at the entrances to the bridge. This bridge is at a high elevation, over 7,000 feet (2,133 m), which places this crossing in a habitat that is high in snow through the winter. There were 560 days of monitoring post-construction as of the writing of this report. The data demonstrated that mule deer rarely used the area after December, and returned from between the end of April and the first days of May. The bridge passage was highly used from June through November, with 607 mule deer photographed at the entrances in 2010 during those months (Figure 43). If the average number of deer photographed per day were only calculated for the months deer appeared at the structure, the average jumps from 1.2 deer per day for all months to 2.6 deer per day for active months. The majority of the movements are from an estimated 10 deer, although a January passage showed 24 mule deer passing through the site in one event (Figure 44, and in Hamlin 2011b video).

Other species of wildlife were photographed at the crossing entrances. They included a bobcat that regularly used the area in the winter months (perhaps it was more than one bobcat). Coyote and red fox have approached but have not used the crossing. Two badger and two marmot occurrences were recorded, although their use of the crossing is not known. Jackrabbits appear to also use the culvert. No elk have been detected by the cameras at the site since construction ended.

Pros: This is one of the most successful wildlife crossings in Utah, for the number of mule deer that use it, the decreasing rate of repellency, and the diversity of species that use the area. Rail

fencing near the entrances works for allowing wildlife access to the passage. The preservation of vegetation at both entrances and the presence of Beaver Creek have helped mule deer and a variety of species approach the entrances. The openness of the bridge helps wildlife move through the structure.

Prescription for Improvement: If elk do not use this structure in the coming two years, modifications may have to be made to the approaches. This may include removing a section of the rail fence during times when domestic cows are not in the area. Otherwise, this structure is working well.

Table 6. Mule deer camera data tabulated for US 6 Beaver Creek Bridge pre-construction and post-construction.

Camera Days Analyzed	Number of Deer Observations at Site	Number of Deer Photo-graphed per Day	Number of Successful Crossings thru Structure	Number of Deer thru Structure per Day	Success Rate (%)	Rate of Repellency (%)	Parallel Rate (%)
Pre-construction 153	1	0.01	na	na	na	na	na
Post-construction (w/F) 560	697	1.2	600	1.1	88	12	1

w/F = Wildlife fencing present

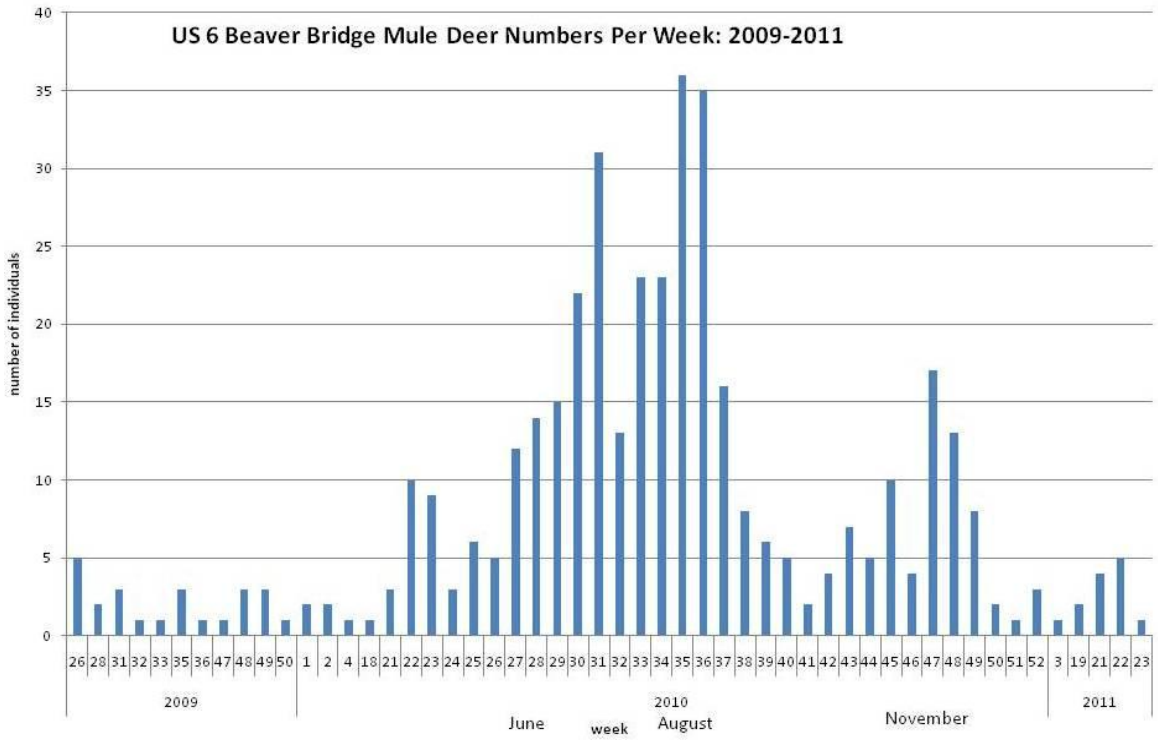

Figure 43. Mule deer use of the Beaver Creek Bridge under US 6 by week.

Figure 44. Mule deer used Beaver Creek Bridge under US 6 in winter. Herd was 24 individuals.

The Gilluly Bridge – MP 205

The Gilluly Bridge carries US 6 vehicular traffic over three rail lines. There was no wildlife-proof fencing until the fall of 2010 when new fencing was attached to the west side of the bridge and extended one mile to the west to the Starvation Creek Bridge and beyond. The 2:1 (horizontal to vertical) slopes under the bridge were concrete from top to bottom, and there was a wall greater than 12 feet (3.7 meters) high on the northeast side of the bridge to keep the hillside up and away from the tracks. A camera was placed on the south side of the site in the fall of 2008. The objective of the monitoring at this site was to help determine wildlife use of the area as animals paralleled the road. The camera could not be placed in a manner to determine animal use of the area under the bridge due to rail traffic.

The camera was in place from the fall of 2008 through June 2011. The various cameras placed at the site were operable a total of 605 days throughout this period (data was lost over various weeks of all four years). During those days, 777 mule deer passes, 200 elk passes, 29 coyote passes, five red fox passes, and two mountain lion passes were recorded (Table 7, Figure 45). The number of deer per day over these camera days was 1.3. Of note is that at this location the camera is not in a constricted area such as a bridge, so wildlife was using a much larger area and not all wildlife passes were caught by the camera. There were a high number of mule deer, elk, and other species using this area, as compared to other camera sites along US 6. While the majority of deer appeared to be moving parallel to the road (650), 124 appeared to come off of the highway or headed for it, and 3 deer appeared to come from under the Rail Bridge.

More elk were present at this site than all other US 6 sites combined. The photographic data support the statement that elk are using the area from approximately late December through May of each year (Figure 45, and Appendix A for elk photograph). Of note is the Starvation Creek Bridge is within a mile of this site and no elk were photographed using the bridge. No elk tracks were observed under this bridge during field visits.

A male and a female moose were recorded at this site in separate events.

Snow tracking at the site during camera visits revealed little to no use of the rail tracks area under the bridge by ungulates. In December 2010, five mule deer carcasses were discovered in the tracks south of the bridge and were presumed to have been hit by a train.

Pro: The three ungulate species of concern, mule deer (Figure 46), elk, and moose use this area. As modifications are made to the area nearby, the Gilluly Bridge could work as a wildlife crossing. Low human use of the area could help encourage wildlife to use the area under the bridge. The addition of fencing to the east may help encourage wildlife to use the area under the bridge.

Prescription for Improvements: Wildlife was not forced to use the bridge with wildlife fencing on both sides, and somewhere between 10 to 20% of all mule deer photographed at this crossing were headed for or coming off the road. Winter tracking in the past two winters revealed less than a half dozen ungulate tracks per winter under the bridge and toward the wild land area. Wildlife would probably prefer to move up the slope on the east side of the bridge to access the wild area on the north side of the road. The presence of five carcasses on the tracks attested to the fact mule deer do not share spaces with trains well. If the now deteriorating concrete panels along the slope under the bridge could be removed and retrofit to allow a one to three meter walkway under the bridge, wildlife would be more apt to use the area under the bridge. If additional fencing could be added to US 6 toward the east this also would help encourage wildlife to use the area under the bridge.

Table 7. Mule deer camera data tabulated for US 6 Gilluly Bridge.

Camera Days Analyzed	Number of Deer Observations at Site	Number of Deer Photo-graphed per Day	Number of Successful Crossings thru Structure	Number of Deer thru Structure per Day	Success Rate (%)	Rate of Repellency (%)	Parallel Rate (%)
605	777	1.3	na	na	na	na	84*

* The remainder of the mule deer photos appears to indicate that 10 to 20% of the animals were coming off or headed to US 6 road right of way.

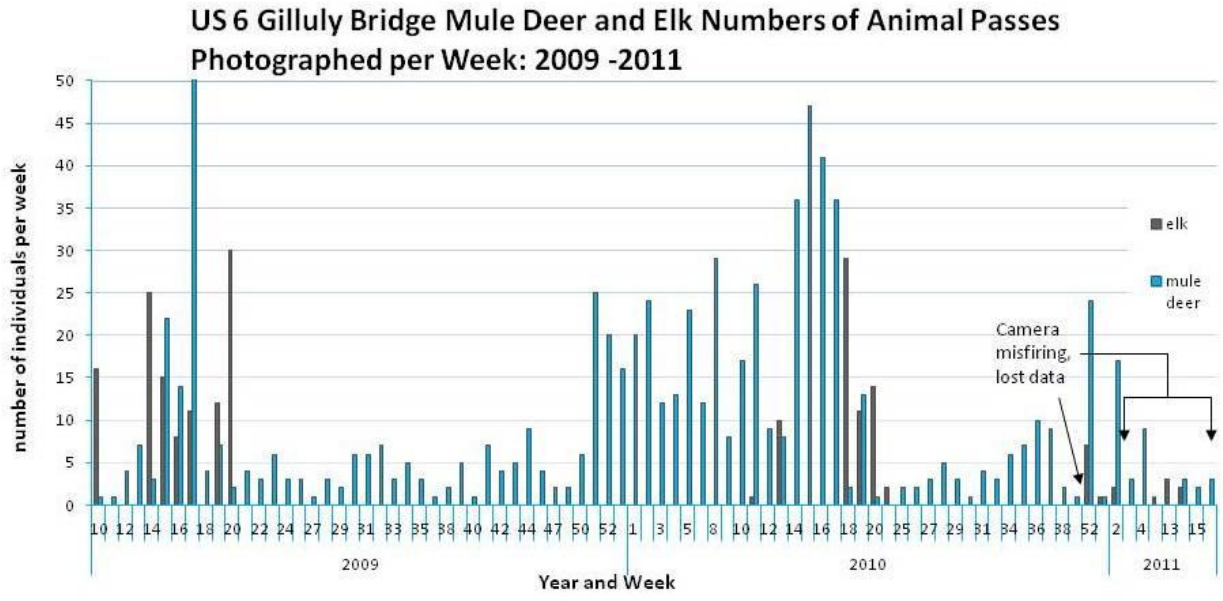

Figure 45. Mule deer and elk use of the area near the Gilluly Bridge on US 6. Note Y-axis scale of individuals per week is above the 30 individuals per week of other US 6 sites.

Figure 46. Mule deer grazed and moved near the Gilluly Bridge in background while US 6 vehicles pass by.

4.2.2 Interstate 70 Summary

Sixteen cameras were placed at 12 sites along I-70 for this study (Figure 47).

- Cameras were placed on four, 200 feet plus (>61 meters) box culverts that were approximately 12 to 15 feet (3.7 to 4.6 meters) high and wide with unpaved U.S. Forest Service roads running through them at MP 6, 79.5, 81, and 83.2 to help determine if mule deer would use long box culverts without wildlife fencing. At MP 3.7, a pair of shorter (~60 feet, 18 m long) box culverts with an open median between them was also monitored for wildlife use without wildlife fencing.
- Cameras were placed at a box culvert at MP 62.5, Rattlesnake culvert; and MP 63.5, Gooseberry culvert, to ascertain if ungulates would use these 200 feet (61 m) and 100 feet (30 m) long (respectively) concrete box culverts that have had wildlife fencing in place for years.
- Two cameras were placed at MP 84.8 at the three bridges that accommodate Ivy Creek to help determine if mule deer could use the heavily bouldered area under the bridges.
- Two cameras were placed at MP 14.3 at a U.S. Forest Service dirt road that has I-70 bridges overhead, in an effort to find a site where elk were traversing under highway bridges that also have wildlife fencing.
- One camera was placed at MP 7.9 to determine if wildlife was using the bridge site at an interchange that also accommodates local traffic.
- Two cameras were placed at a natural area near MP 82.3 to determine wildlife use of the area in the event a future wildlife crossing will be placed there.
- Two cameras were placed at MP 5.3 to determine wildlife use of the area pre-construction of a new wildlife crossing. There was no wildlife fencing at this site at that time. The crossing and 7 miles (11.26 kilometers) of concurrent wildlife fencing were completed in November 2010 and the post-construction cameras were placed at that time.

Figure 47.Monitoring sites along I-70.

I-70 Concrete Box Culverts Over 200 feet with No Wildlife Fencing

In an effort to understand if mule deer and other wildlife will use long concrete box culverts under interstates with no wildlife fencing, cameras were placed on four, 200 feet (61 meters) long or longer concrete boxes in areas with no wildlife exclusion fencing along I-70. Three cameras were placed on similar culverts under I-15 (see I-15 summaries for results on those culverts). All I-70 culverts had U.S. Forest Service access roads through them, with varying amounts of vehicle use. See Appendix A for photo samples of box culvert dimensions, and Table 8 for actual dimensions of each culvert. In one year of monitoring, all these box culverts had little to no use by ungulates. During that time there were 1,896 camera nights from all cameras combined, 122 mule deer were photographed, and 12 may have used these culverts (see Table 8). The most highly used structure was the 228 feet (70 meters) long box culvert which was monitored for 624 days. During this time, 76 mule deer appeared at the entrance and six may have moved through; these deer through numbers could not be verified, but are classified as successful deer passes. The human and vehicle rate per day averaged 0.3. This is the lowest amount of vehicles for all these culverts (see Table 8). There is a correlation with human-vehicle use and lack of use by mule deer and other wildlife. In the next phase of research this question will be addressed statistically.

During 624 camera nights of monitoring this 228 feet (70 meters) culvert, one mountain lion and one bear were photographed passing through the culvert. This was the only documented black bear use of a structure in the entire study. Seventy deer and three elk that approached the culvert were repelled from the structure. Several coyote and bobcat may have used the culvert, but their movements through could not be verified.

A pair of box culverts with an open median at MP 3, with no wildlife fencing, named Split Box Culvert, was also monitored during the first year. No deer, elk, or any other wildlife was documented using the crossing. Mule deer and elk were documented jumping the right-of-way fence and crossing the interstate at grade at this site.

A moose was photographed approaching the 208 feet (63 meters) long box culvert at Old Woman Plateau Road (Figure 48). Several coyote and bobcat were believed to use other culverts. Overall, the five culverts were rarely used by wildlife, in part because of the crossings structural

qualities, and in part because there was no wildlife fencing to force them. The research supports the statement that concrete box culverts 200 feet (61 m) and longer, with no attached wildlife fencing, were not ecologically effective at passing mule deer, elk, moose, and other wildlife. They do show anecdotal evidence of occasional crossings by solitary mule deer and moose.

Table 8. I-70 concrete box culverts with no wildlife fencing, dimensions and monitoring results for mule deer.

Culvert	Height in feet	Width in feet	Length in feet	Deer Observed	Deer Through	Days monitoring	Vehicles/ day
MP 3 Split Box	14.5	16.5	90	13	0	305	3
MP 6 Long Box	12	17	228	76	6	624	0.3
MP 79 Johnson	14	19	202	4	3	288	4.3
MP 80 Culvert Hollow	14	19	202	12	2	351	4.7
MP 83 Woman Plateau	14	18.5	208	17	1	328	2.4
Totals				122	12	1,896	

Figure 48. Moose approached Woman Plateau culvert under I-70 in Fish Lake National Forest.

I-70 Concrete Box Culverts 98 feet and longer with Wildlife Fencing

Two concrete box culverts at Rattlesnake (MP 62.5) and Gooseberry (MP 63.5) had wildlife fencing (8 feet, 2.4 m high) attached to culverts, and extending for miles in both directions. The Rattlesnake culvert was 202 feet (61 m) long; the Gooseberry culvert was 98 feet (30 m) long. See Appendix A for photo samples of these box culverts. These culverts were monitored for two years to see if wildlife, especially ungulates, used these culverts at higher rates than similar culverts on I-70 without wildlife fencing. Mule deer use of the Gooseberry culvert was limited to predominantly summer months (Figure 49). The Rattlesnake culvert saw mule deer more evenly distributed throughout the year with higher numbers in May and the fall months (Figure 50). During this time, mule deer appeared at the Rattlesnake culvert 155 times, and 63% of the time mule deer went through. Thirty-one percent of the mule deer observations resulted in repels. The Gooseberry culvert had less deer, with only 25 deer observed at the entrance, and 76% of the time the deer went through, 20% of the observations resulted in repels from the culvert (Table 9, Figures 51 and 52). These results provide evidence that concrete box culverts 200 feet (61 m) long and shorter, with wildlife fencing, pass more mule deer than similar culverts without wildlife fencing. It is important to note that the rate of repellence for the longer Rattlesnake culvert was 31%, while the rate of repellence for the shorter Gooseberry culvert was 20%. The number of mule deer using these culverts is significantly greater than the number that used the concrete box culverts without fencing, yet less than designated wildlife crossing culverts.

Four elk approached the Gooseberry culvert, none used it. One elk approached the Rattlesnake culvert and was repelled. These culverts did not appear to pass elk during the monitoring period.

Other animals appeared at the culverts. At the Rattlesnake culvert, several rabbits and raccoons appeared. A young mountain lion came through the culvert one night. Gooseberry culvert had no other animals photographed at the site other than mule deer and elk.

Human use was somewhat high. The Rattlesnake culvert had 915 vehicle passes in 678 days of monitoring for an average of 1.3 vehicles per day. The Gooseberry culvert had 1,549 vehicle passes in 662 days, for an average 2.3 vehicles per day. This may affect wildlife movement. One daylight event captured a mule deer attempt to use the culvert, but it ran back out as a vehicle came through.

The ongoing study at this time monitors four culverts that when originally monitored had no wildlife fencing, but are now part of wildlife fenced areas. The data from monitoring these once wildlife fenceless culverts may provide evidence that mule deer and wildlife use of such culverts increases with wildlife fencing. It will be interesting to see what the successful passage rates and rates of repellency will be for these culverts, and how they compare to the Gooseberry and Rattlesnake culverts. At this time, the data suggest that culverts between 98 and 202 feet (30 to 61 meters) in length can pass ungulates, but the data do not allow a conclusive statement as to whether or not the mule deer and other wildlife numbers are ecologically significant (dozens to hundreds of passes per species).

These culverts did not pass elk or moose during the course of this study, although five elk approaches were recorded. It is surmised that these culverts were not adequate for elk. The moose population is limited in the area. A fecal pellet analysis of the area was conducted in the summer of 2011 and future reports will help elucidate if elk were detected in the area near these two culverts.

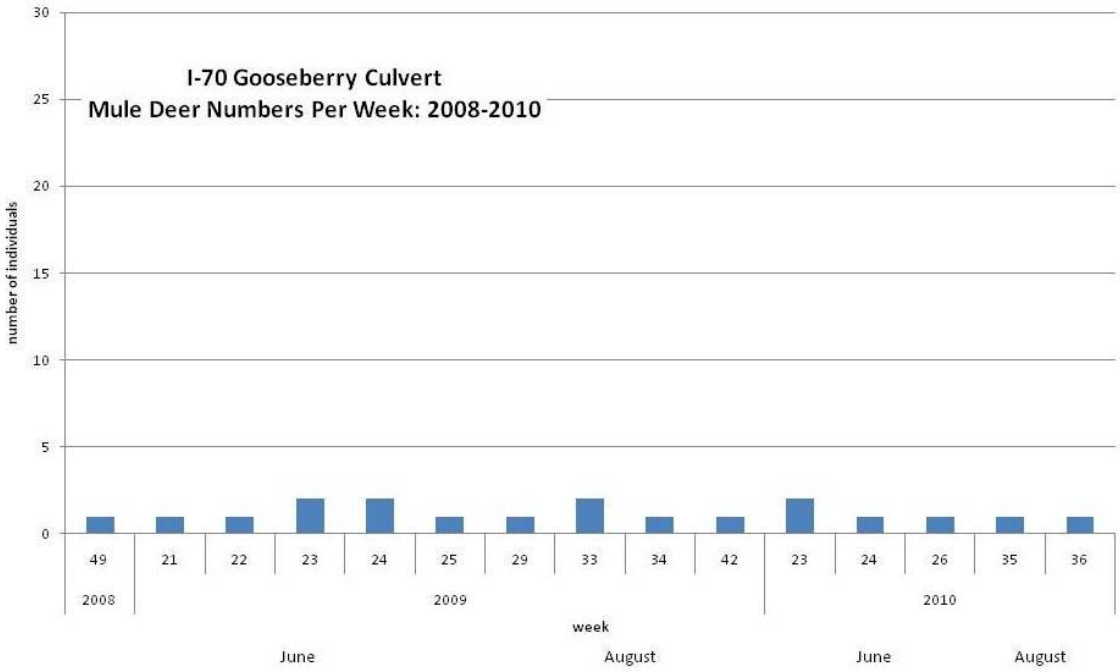

Figure 49. Mule deer use of Gooseberry Culvert under I-70 by week. Missing weeks were during times when mule deer were not detected by camera.

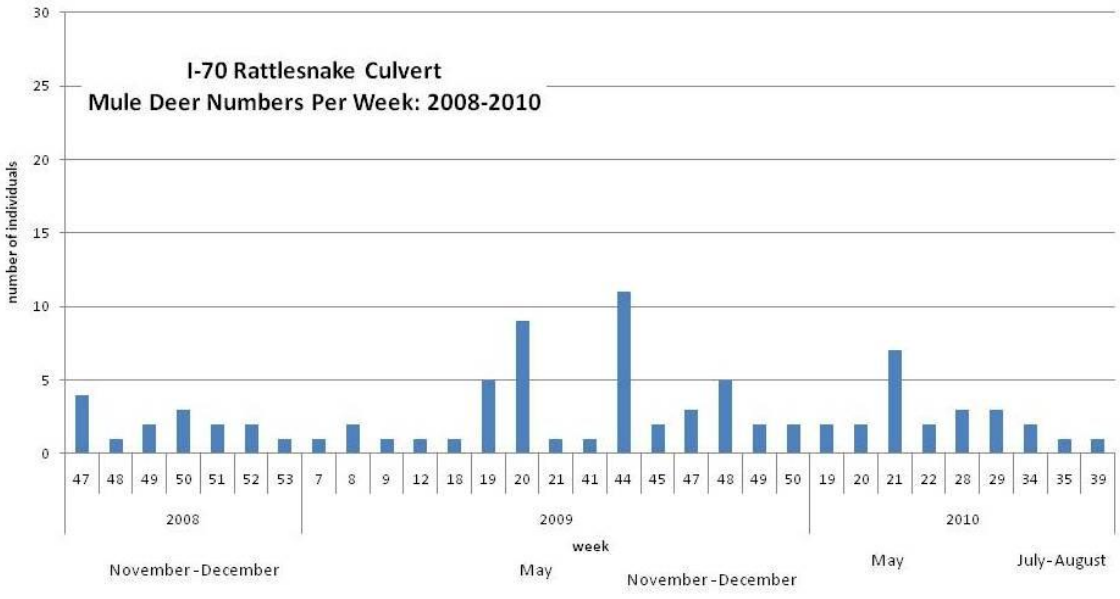

Figure 50. Mule deer use of Rattlesnake Culvert under I-70 by week. Missing weeks were during times when mule deer were not detected by camera.

Figure 51. Mule deer used Gooseberry culvert (98 feet – 30 m long) under I-70 at MP 64.

Table 9. Monitoring results for mule deer photographed at Rattlesnake and Gooseberry culverts under I-70.

Camera Location	Camera Days Ana-lyzed	Number of Deer Observa-tions at Site	Number of deer photo-graphed per day	Number of Successfl. Crossings thru structure	Deer thru Structure per day	Success Rate (%)	Rate of Repel-lency (%)	Parallel Rate (%)
Rattlesnake concrete box culvert 12'high, 17' wide, 202' long, MP 63 (w/Fence)	678	155	0.2	98	0.1	63	31	6
Gooseberry concrete box culvert 9'high, 12' wide, 98' long, MP 64 (w/Fence)	662	25	0.04	19	0.03	76	20	4
Totals	1,340	180	0.1	117	0.09			

Figure 52. Mule deer pondered and then used Rattlesnake culvert (202 feet – 61 m long) under I-70 at MP 63.

I-70 Ivy Creek Bridges – MP 84.8

There was a pair of bridges at this location that accommodated the two directions of I-70 traffic, and a third bridge that accommodated the unpaved frontage road running parallel to the interstate. There was no wildlife-proof fencing along this stretch of highway. The area along Ivy Creek had very large boulders all along the creek, making even human passage difficult. This site was monitored with two cameras to determine if mule deer and other wildlife were attempting to cross under the interstate at this site and if their attempts were successful. In 375 days of monitoring, ten mule deer approaches to the bridge were recorded, and the cameras recorded four successful mule deer passages (Table 10). The mule deer traversed the passage in the middle of the stream (Figure 53). All other deer were recorded turning away from the passage.

Pros: This area has very little human use, and the bridges are more than adequate to pass mule deer and other wildlife. With a creek running through the structures and natural vegetation throughout, the area has many factors that encourage wildlife use.

Prescription for Improvements: The large boulders all along this stream make passage difficult, even for field biologists. It is suggested that in the future the large boulders be moved to allow for a movement pathway along the Ivy Creek, even during high water levels. This is especially important during winter months when ice covers the creek.

Table 10. Mule deer camera data tabulated for I-70 Ivy Creek Bridges.

Camera Days Analyzed	Number of Deer Observations at Site	Number of deer photo-graphed per day	Number of Successful Crossings thru structure	Deer thru Structure per day	Success Rate (%)	Rate of Repellency (%)	Parallel Rate (%)
375	10	0.02	4	0.01	40	60	0

Figure 53. Mule deer bucks used Ivy Creek stream bed to cross under all three Ivy Creek Bridges.

I-70 MP 14 U.S. Forest Service Road Bridges (Elk Bridges) with Wildlife Fencing

Two cameras were placed at the Elk Bridges at MP 14 that accommodate a U.S. Forest Service road to help determine if elk use the area, and as a potential site to begin Action 4 in the original grant proposal: the placement of door-gates-curtains to shrink the size of the passage down and

see how elk react. Cameras were placed at the entrances from November 2008 through March 2011 (Figure 54). Unfortunately, only four bull elk observations occurred in front of the cameras, and all resulted in successful passes (Figure 55). These movements were during summer months and at night. This is only the second structure in the state of Utah that elk were recorded using the area under a bridge. This was the only structure, bridge or culvert, in this study which recorded elk movement successfully from the beginning of the study through the fall of 2010. One mountain lion and five bobcat passes were also photographed under the bridge at this site.

In 839 days of monitoring, 413 mule deer observations were recorded at the site, and 361 or 87% of the mule deer successfully moved under the bridges. Mule deer use also increased from 2008 to 2010, the reasons for this are uncertain. These bridges, although installed for the Forest Service road beneath, function as a de facto wildlife crossing for mule deer and other species photographed. The bridge is of the same size as a pair of bridges under I-15 that were recorded to pass elk during Rosa's (2006) study, and it is believed the I-70 Elk Bridges are adequate for elk passage, even though elk use was scant.

An important observation was made when the data was tabulated for the number of deer using the structure plotted per week for the monitoring period (Figure 54). The Twitchell Canyon fire occurred in the late summer through October in 2010 on the public lands south of the site. The fire came to within 300 meters of the crossing and crossed the interstate. During the period of time when the fire was closest to the crossing, in late September into October, mule deer use of the crossing increased to the highest levels recorded at this site. These results support the idea that wildlife crossing structures and existing bridges and culverts are important conduits for wildlife movements during times of natural and human caused disturbance events such as fire, floods, and land use change. These structures help to keep wildlife off the road during these turbulent times.

Pros: This structure, although not constructed for wildlife, is adequate for both mule deer and elk. Vegetation occurs up to the entrances and throughout the median. The area is part of the Fish Lake National Forest, making it conducive to wildlife in perpetuity.

Prescription for Improvement: Reduction in vehicle use is the only change that would be necessary to increase wildlife use. Even if night time vehicle use could be reduced, it would assist the wildlife trying to use the structure.

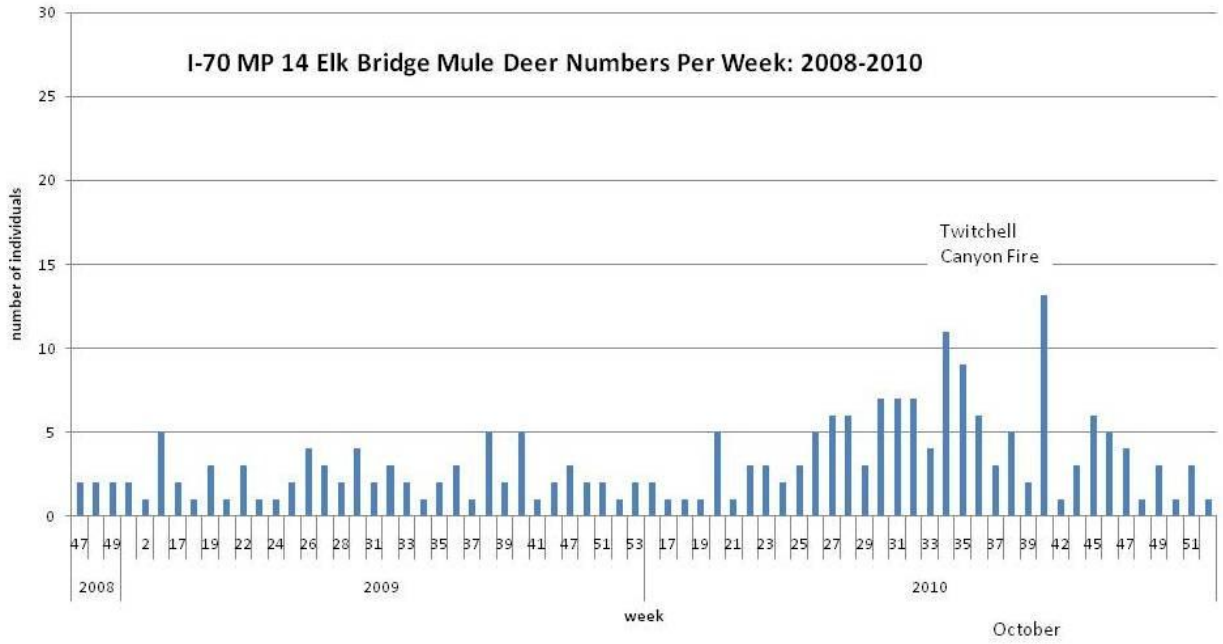

Figure 54. Mule deer use by week of the I-70 MP 14 Elk Bridge for 2008 – 2011. Note jump in use in the fall of 2010 when the Twitchell Canyon fire was near the bridges.

Figure 55. Bull elk used passage underneath "Elk Bridge" at MP 14 of I-70. A second bull elk passed at this event. No cow elk were recorded using this bridged area.

I-70 MP 7.9 Bridges

A camera was placed in October 2008 under one of the pair of bridges to help determine wildlife use of the area at a paved interchange where vehicles use this area right off the highway, and the wildlife fencing ended. In three months of operation, this camera recorded no wildlife, hundreds of vehicle passes, a pair of men breaking into the camera, and a man and boy using paintball guns to destroy the camera. It was removed in December 2008.

I-70 MP 82.3 New Crossing Location - Sage

Two cameras were placed in the wild lands on the north side of I-70 near MP 82.3 as a potential new crossing site, which has no wildlife fencing at this time. The goal was to record the wildlife species in the area and their numbers. Catching wildlife in the camera field of view ranges was difficult because there was no restricted space that animals had to pass through to cross the road or return to the wild area. Nevertheless, in 759 days of monitoring, there were 171 mule deer observations, and 208 elk observations. Two-hundred of these elk observations occurred in the winter months. Mule deer were observed uniformly throughout the year (see Figure 56 below).

There were eight coyote and one bobcat observations recorded. In the event UDOT decides this site is worthy of a future wildlife crossing, it is hoped this data will help UDOT plan a crossing that accommodates elk as well as mule deer.

Pros: This area is far from human settlement and has no U.S. Forest Service roads on the north side of the road. Mule deer and elk were recorded in this area that is a natural funnel of surrounding hills to a movement corridor across the highway.

Prescription for Improvement: Installation of a bridged wildlife crossing would greatly facilitate the movement of mule deer, elk, and other wildlife under the highway. The bridged crossing should remain free of any roads. Wildlife-proof fencing should be placed for at least one-half mile (0.8 kilometers) in both directions from the crossing, on both sides of the road.

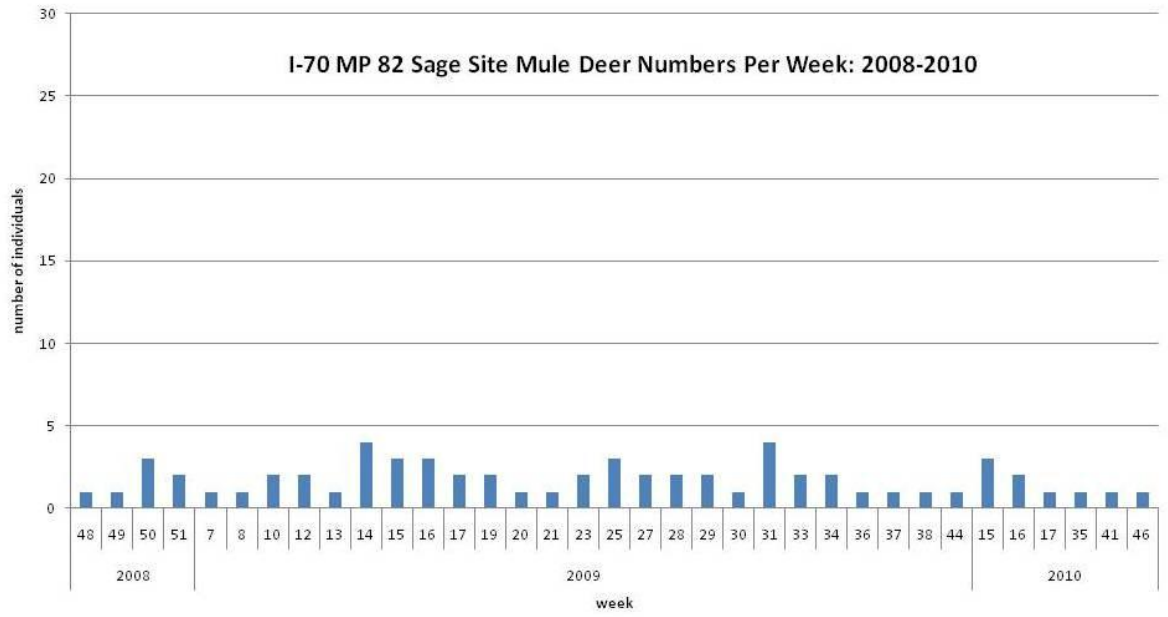

Figure 56. Mule deer observations at the north side of I-70 at MP 82.3 at the site called Sage, a potential future wildlife crossing site.

I-70 MP 5.3 New Crossing Location with Wildlife Fencing

This site was correctly predicted to be the site of I-70's first wildlife crossing. Two cameras were placed at this site two years prior to construction to learn of the species of wildlife and their

numbers crossing I-70 at this location. These data were used to help evaluate the success of the new crossing in passing the same species of wildlife and if they passed in similar numbers recorded pre-construction. The wildlife were crossing I-70 along the entire seven miles of the interstate without wildlife fencing, from its start to the west at I-15 (Cove Fort) to MP 7 where wildlife fencing existed. With this almost sheet flow of mule deer, elk, and other wildlife prior to fencing, it was difficult to determine the best place for cameras to catch these movements near the new crossing. Nevertheless, a camera was placed on each side of the highway in the exact location of the future crossing, at the edge of the right of way.

Analysis of the pictures revealed the majority of events on each side of the highway were independent, meaning cameras did not catch the same animals moving across and parallel to the highway. As such, the cameras were considered independent and the camera days were combined. In a total of 1,210 of camera nights, 161 mule deer and 176 elk were photographed. The results were very different between the two years, with the majority of the animals photographed the first year. In year one, there were 595 camera days, and 109 deer photographed, for a total of 0.18 deer per day (Table 11). In the second year, there were 615 camera days, and just 52 deer, for a total of 0.08 deer per day (Figure 57). Elk numbers followed the same trend, with 131 elk observations the first year, for an average of 0.22 elk per day, and 45 elk observations the second year, for an average of 0.07 elk per day. Other wildlife recorded included one mountain lion, four coyote, 20 jackrabbit, 10 rabbit, a ground squirrel and a raccoon.

The concrete arched wildlife crossing and seven miles (11.3 kilometers) of wildlife fencing were installed as of November 26, 2010. The crossing consisted of two arches, one for each direction of traffic. They were 16 feet (4.9 meters) high as the wildlife passes through, 38 feet (11.6 meters) long, and 48 feet (14.6 meters) in span. Two cameras were placed at the entrances of the crossing on November 29, 2010. See Appendix A for photo of arch crossing.

Within hours of camera installation, the first mule deer using the crossing were recorded. Over the first 165 days of post-construction monitoring there were 102 occurrences of mule deer at the crossing. Sixteen animals were repelled, and 86 times mule deer went through. The total deer through the crossing over the total number of days of monitoring = 0.52 through per day. The

rate of repellence was 16%. Elk were photographed at the crossing. In six events, nine elk were photographed. All were bull elk. Only one was repelled, for a total of eight bull elk passes (Figure 58).

Because this crossing is in such an important migration corridor for mule deer and elk (Figures 58 and 59), and because the type of structure is more experimental than the other crossings built in Utah, more detailed analyses are presented below.

Table 11. Monitoring results for mule deer of I-70 MP 5.3 arch crossing pre- and post construction.

Camera Location	Camera Days Ana-lyzed	Number of Deer Observa-tions at Site	Number of deer photo-graphed per day	Number of Success-ful Crossings thru structure	Deer thru Struct-ure per day	Success Rate (%)	Rate of Repel-lency (%)	Parallel Rate (%)
I-70 MP 5.3 Arch crossing pre-construction site	1,210	161	0.1	na	na	na	10	18
I-70 MP 5.3 Arch Crossing post-construction	165	102	0.6	86	0.5	84	16	0

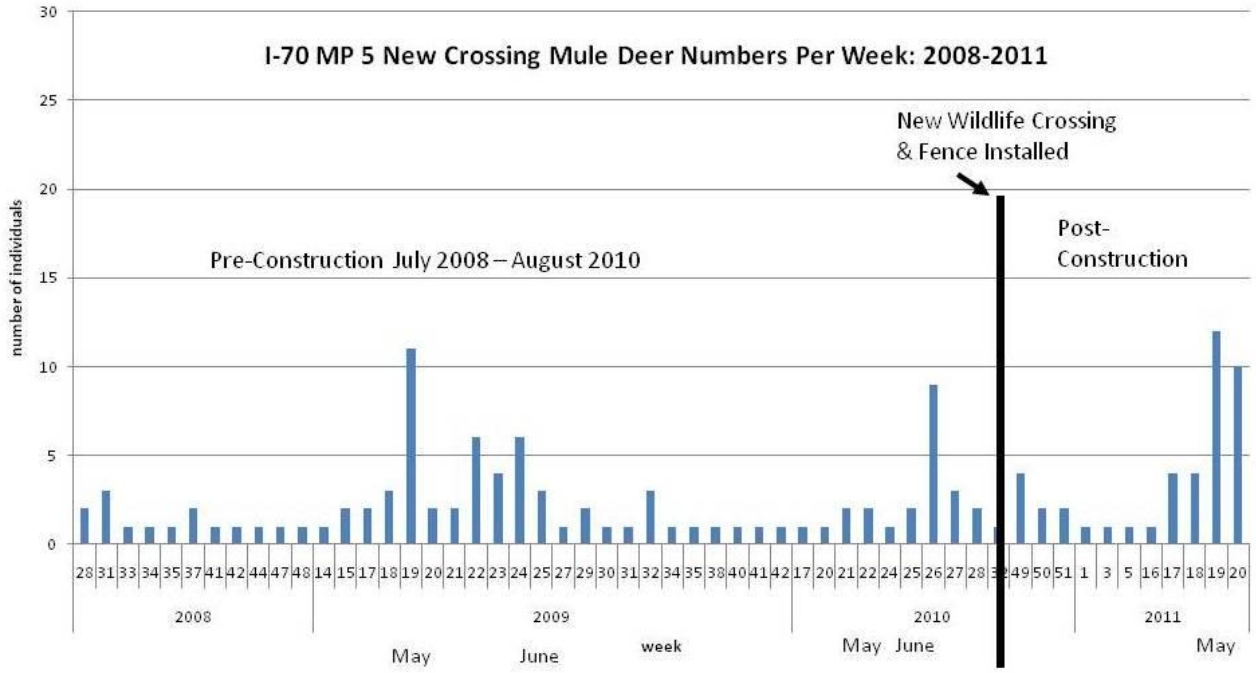

Figure 57. Mule deer observations at I-70 MP 5.3 pre-construction and post-construction of a new wildlife crossing, 2008 -2011.

Figure 58. First elk to use new arch bridge crossing on I-70, MP 5.3.

Figure 59. Mule deer returned to the I-70 MP 5.3 crossing in May, 2011, headed to the south side of the interstate.

The genders of mule deer and elk are important to compare between pre and post construction because of the necessity for the whole mule deer population to move for migration. For mule deer, pre-construction found that males compromised 45% of deer occurrences. Post-construction they were 20% of the total deer occurrences. During pre-construction, the majority of the elk occurrences were cows, 62%, with just 6% of elk occurrences bulls (the rest were immature elk). Post construction, only bull elk were photographed at or came through the crossing. UDWR wildlife biologists detected an entire herd of elk on the south side of this crossing in early December, but only singular and pairs of bull elk came to the entrance.

Daylight and night time hours appear to be important in animal movements. During pre-construction, mule deer passed the cameras day and night. While 40-50% of the events occurred at night, the mule deer traveled in larger herds during the day, so that 44 to 56% of the total mule deer passed in the day. Post-construction, 62% of the mule deer events (single occurrences with groups of deer) and 64% of the total number of mule deer photographed occurred during the day. Night is far more important to elk. Pre-construction, 91% of elk occurrences occurred at night. Post-construction, seven of the nine (78%) elk photographed at the new crossing were at night, with two elk photographed at dawn. There were no daytime events with elk.

Seasonal movements were distinct at this site. Pre-construction, deer appeared at the site in the beginning of April, and were photographed until the beginning of December. Post-construction, deer were photographed from November and through January. They were absent in February and March, and appeared again in the beginning of April. For mule deer, pre-construction, the summer through fall found more movements (events) from the north (61-87%), while spring showed fewer movements from the north (48-58%). After construction, the fall of 2010 saw 52% of mule deer events were from the north. Spring 2011 movements showed 77% of the mule deer events from the north, a reverse from pre-construction percentages. Before the crossing was constructed, it appears the mule deer and elk moved more freely back and forth across the interstate throughout the year.

Of note is that herds of deer moved up into the median area between the two crossing spans post-construction, and were not photographed by the south camera. It may be because of the camera location, but it also may be because there were holes in the fence in the median. The majority of deer that disappeared from in front of the cameras went to the west side of the median. There were several occurrences of mule deer disappearing on the east side of the median as well. It is suggested personnel from UDWR and UDOT check the fence in the median regularly.

Having two years of pre-construction data is a rarity in transportation ecology research and the UDOT and UDWR personnel responsible for helping to place these cameras so far in advance should be commended (Bruce Bonebrake of UDWR, and Randall Taylor and Monte Aldridge of UDOT).

Cameras will remain at this site for as long as this study continues. It is expected that mule deer use will increase with time and female elk will learn to use the crossing. It is hoped other wildlife species will also use the crossing, perhaps as vegetation begins to grow in the median and at the entrances.

Pros: The new crossing design appears to work for mule deer and bull elk. It is very open, making the area more natural appearing for wildlife. There are no roads leading to it, making it exclusively for wildlife.

Prescription for Improvement: Vegetation at the approaches and in the median along the line of movement between arches would help wildlife to feel more secure at the site and more prone to using it. Removal of the rail fence from November until when domestic cows return in May could help cow and calf elk approach and use the structure. Bruce Bonebrake of the UDWR made this change in March of 2011. Perhaps seasonal changes in the rail fence will help increase the chances that these elk will encounter the crossing and use it. If female and young elk do not use this structure within the expected first three years after construction (as other studies in Arizona, Gagnon 2011, and Alberta, Clevenger 2011, have found), UDWR and UDOT may look to other solutions such as baiting elk with food, and vigilant care of the wildlife fencing to make sure elk are not breaching it to enter the road right of way.

I-70 MP 3 and MP 6 Culverts Post-Fencing

In the fall of 2010, seven miles of wildlife fencing was placed along I-70 from its junction at I-15 at Cove Fort, east to MP 7 where there is existing wildlife fencing for dozens of miles eastward. This fencing was placed in conjunction with the new arched wildlife crossing at MP 5.3. As stated above, the two existing culverts along this stretch were monitored pre and post fencing. The pair of culverts at MP 3 Split Box Culvert camera never recorded passing wildlife pre-fence. The MP 6, 228 feet (70 m) concrete box culvert passed only six of 76 mule deer that approached its entrance pre-fencing (Table 12, Figure 60). Neither culvert passed the elk that approached them.

Fencing was placed along the corridor over the course of the fall of 2010. A camera was in place at the box culvert on MP 6 along the entire course of this study. In December of 2010, a second camera was placed on the northeast side of this MP 6 culvert. Also in December the first post-construction camera was placed on the south side of MP 3 Split Box Culvert. On March 22, 2011 a second camera was placed on the north side of this culvert.

At the MP 3 Split Box Culvert, the first 134 days of post-fence data revealed 665 mule deer observations at the cameras, with 193 deer through the culvert. This equates to just a 29% overall success rate and a 67% overall rate of repellence. The rate of repellence changed over time. During the initial fall migration, the rate of repellence was 73%. In the 52 days of the spring migration, the rate of repellence dropped to 56% (Figure 60). The spring migration appears to

begin at the beginning of April; mule deer began using the MP 3 Split Box Culvert and the new arch crossing at MP 5.3 in early April (Figure 60).

Table 12. Monitoring results of mule deer photographed by cameras pre and post fencing on I-70 at MP 3 and MP 6.

Camera Location	Camera Days Ana-lyzed	Number of Deer Observa-tions at Site	Number of deer photo-graphed per day	Number of Success-ful Crossings thru structure	Deer thru Struct-ure per day	Success Rate (%)	Rate of Repel-lency (%)	Parallel Rate (%)
Split concrete box culvert MP 3 pre fence	305	13	0.04	0	0	0	0	100
Split concrete box culvert MP 3 post fence	134	665	4.9	193	1.4	29	67	4
230’ concrete box culvert MP 6 pre fence	624	76	0.1	6	0.01	7.8	70	22.2
230’ concrete box culvert MP 6 post fence	138	63	0.5	16	0.1	25.4	60	14.6

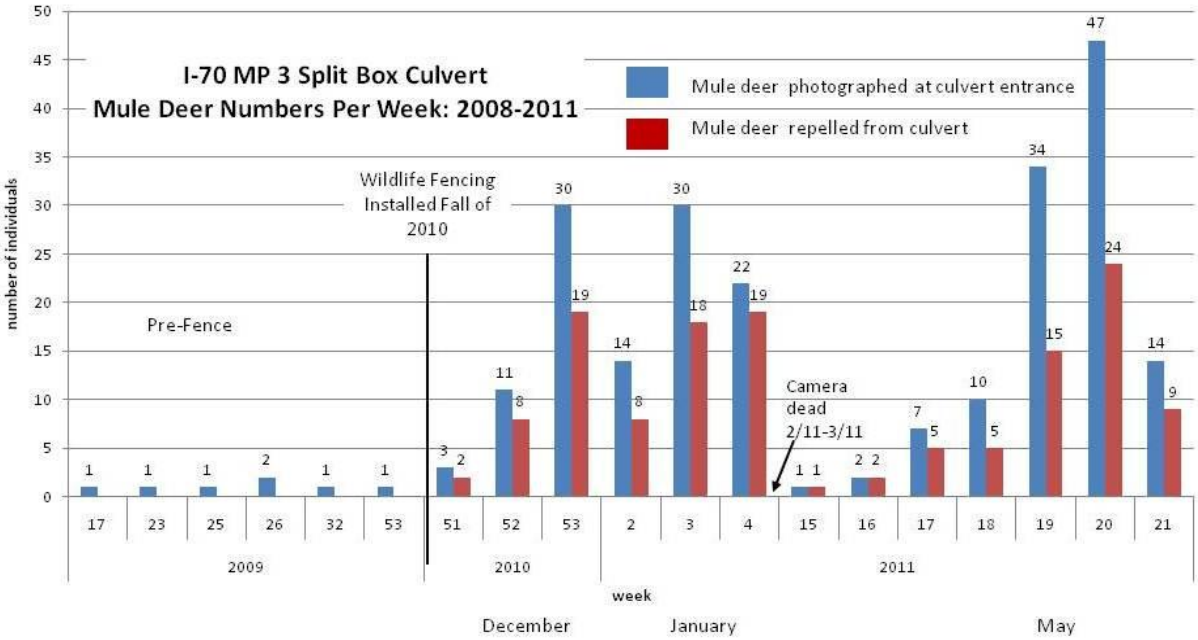

Figure 60. Mule deer appearances at the entrance to I-70 MP 3 split box culvert by week, in blue, and number of repels the same week. Note: all pre-fence approaches resulted in repels.

Figure 61. Mule deer approached and used split box culvert at MP 3 of I-70. Wildlife fencing present.

This pair of culverts at MP 3 is the only open median culvert monitored on I-70. It was hypothesized that because it was open in the median, mule deer would find it less enclosed and more apt to use it than a longer culvert 200 feet (60 m) or longer. This has not proved to be the case at this time. For example, the concrete box culvert at MP 6 is over 200 feet (60 m) and the overall rate of repellence for mule deer since the fence was erected is 70%, very close to the 67% overall rate of repellence for this pair of culverts. Light may play a role. In the spring migration, mule deer were photographed at the culvert more in daylight hours than at night. The overall rate of repellence by day was 58% as opposed to the 72% rate of repellence at night. During the spring migration it appears the mule deer adapted more readily to the culvert during daylight hours than night hours. This is an interesting contrast to the new arch crossing two miles to the east on this stretch of road, which had all repel events occur during the day, none at night.

Only one bull elk used the culvert at MP 3, out of a total of 49 elk approaches recorded (Figure 62). The elk that were repelled included 26 cows, seven bulls, and 15 unknown gender individuals and juveniles. All approaches were from the south side of I-70 and occurred in late December and January, except for one approach from a bull elk that occurred in June 2011. The singular elk event that occurred by day was pieced together to create a video (Hamlin 2011c).

MP 3 Split Box Culvert cameras recorded a mountain lion near the entrance, but it did not use the culvert. A coyote and a turkey were also photographed at the entrance and may have used the culvert.

Humans were a continual presence at this site. In the 134 days of post-fence monitoring, there were 434 passes of vehicles, for an average of 3.2 vehicles per day. Pre-fence, 929 vehicles passed in 305 days, for an average of 3 vehicles per day. If the mule deer come to this culvert by day, there is a chance they will encounter humans in vehicles, thus making it less optimal for them and other wildlife.

Pros: The open nature of the median should help encourage mule deer and other wildlife to use the culvert more readily over time. Natural vegetation present at the site is also an enhancing feature. The site is on the Fish Lake National Forest, making it protected from development in perpetuity.

Prescription for Improvements: Reducing the vehicle travel at this site is probably not an option, but would help the wildlife feel more secure at the crossing. Monitoring this site over the next two years may help us see if improvements are an option.

Figure 62. Elk approached and repelled from split box culvert at MP 3 of I-70. Wildlife fencing was present.

The 228 feet long concrete box culvert cameras at I-70 MP 6 also had increases in mule deer appearance and use post-fencing. In the first 138 days of post-fence monitoring, 63 deer were photographed at the entrance. Only 16, or 25%, of these deer succeeded in passing through the culvert. The rate of repellence prior to the fence was 70%, post-fence in the first 138 days it was reduced to 60% (Figures 63 and 64).

Prior to the fencing, three elk appeared at the entrance of the culvert and none used it. In the first 138 days since the fencing was erected, 53 elk occurrences were photographed at the culvert entrance, and 13 elk passages were recorded for a passage rate of 25%. Forty elk observations resulted in repels, for an elk rate of repellence of 75% (Figure 65). A daytime series of photos of a herd of elk repelling from this culvert were made into a video (Hamlin 2011d).

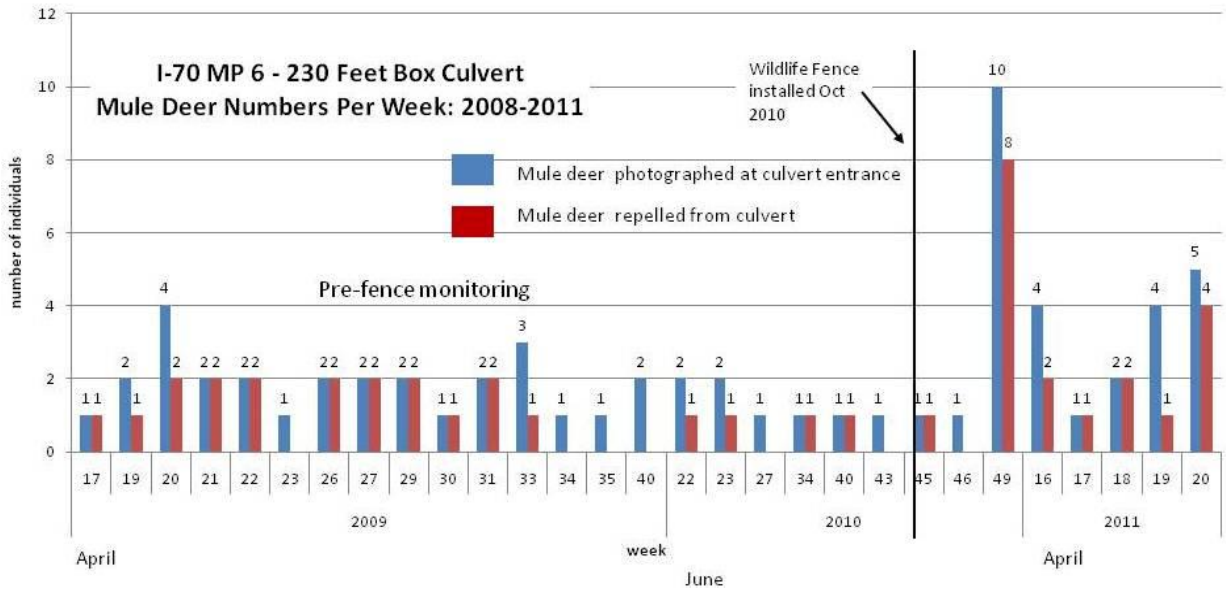

Figure 63. Mule deer photographed at the entrance to the I-70 MP 6, 230 foot concrete box culvert, pre and post fencing. Note: the blue columns represent total deer per week, the red columns represent those repelled, and there were deer that moved parallel to the entrance to the culvert and those numbers are not represented in this chart. Also note mule deer did not appear at this culvert until April through June, and then stopped appearing at the culvert by early December, pre-fencing.

Figure 64. Two mule deer used I-70 MP 6 culvert within 6 months after fencing was installed. One deer was already through, the second one followed.

Figure 65. Two elk approached I-70 MP 6 culvert. One bull went through, the second one repelled.

Other animals were photographed at this culvert over the years of monitoring. A mountain lion and black bear used the culvert on one occasion each (pre-fencing). Several times coyotes approached the culvert; only one passage could be verified. A bobcat approached the culvert on four occasions, none of which appeared to result in the animal using the culvert. A red fox appeared twice at the culvert after fencing. It did not use the culvert. Dozens of jackrabbits and cotton-tail rabbits were photographed at the culvert entrance, and on several occasions, it appeared the jackrabbits used the culvert.

Human use of the culvert occurred throughout the year, with few to no humans in January through March. The highest occurrence of humans and vehicles occurred in fall. The human and vehicle rate per day averaged 0.2 per day for both pre and post fence monitoring.

At the time of this writing, it was still not certain how successful the fencing was at funneling mule deer and elk to and ultimately through this culvert (Figure 66). Over the next two to three years of monitoring there should be an increase in ungulate use. This is one of the longest culverts ever monitored for mule deer and elk use in North America. This information should be digested in conjunction with the use of the new crossing three-quarters of a mile (1.2 km) to the

west of this culvert, and MP 3 Split Box Culvert 2.7 miles (4.3 km) to the west of this MP 6 culvert.

Figure 66. Two mule deer decided to not enter the I-70 MP 6 Long Box Culvert once this elk appeared. None of the animals entered the culvert.

Pros: This culvert is located in the Fish Lake National Forest and is in an important migratory corridor for mule deer and elk. Natural vegetation exists at the entrances. Although there is a U.S. Forest Service road through the culvert, it dead ends on the north side, thereby reducing its use by vehicles. Six species of large and medium sized mammals have approached this culvert, increasing the potential for a diversity of species to use this structure.

Prescription for Improvement: Since this is the longest culvert in the study we would expect wildlife to use for movement, it is recommended to add light in the culvert toward the median to help add clarity throughout the view of the culvert. If there is a possibility that the U.S. Forest Service road to the culvert can be closed in the fall starting in October and continued through May, this would help wildlife, especially migratory mule deer and elk, move through the area with less reluctance. This culvert is especially important to our theories that mule deer and elk can be "highly encouraged" to use long structures with wildlife fencing. Monitoring over the next two years will help us evaluate improvement options.

4.2.3 US Highway 89/91 Summary

Cameras were placed at two corrugated steel plate arch culvert wildlife crossings (Figure 67).

- An objective was to evaluate the efficacy of the crossings.
- A second objective was to compare rates of usage and repellence with other corrugated steel culverts of varying lengths in Utah in an effort to help make design recommendations for the most effective corrugated steel plate culverts for wildlife.

Figure 67. Monitoring sites at culverts along US 91/89 in the Wellsville Mountains.

US 91 MP's 8 and 14

Four wildlife crossing culverts were placed under US 91 in the Wellsville Mountains near Logan in 1995 along with approximately 12 miles (19.3 km) of wildlife fencing. Two of these culverts were included in the study to learn how well they passed wildlife and to see if there was a difference in the successful passage rate with these culverts when compared with the passage rates of the I-15 Wildcat Wildlife crossing culverts and the US 191 Monticello – Devil's Canyon culverts. These culverts are at an elevation of approximately 5400 to 5500 feet (1645 to 1676 meters). No monitoring had ever been conducted at these sites. Monitoring began in October of 2008 (MP 14) and September 2009 (MP 8). Both culverts are approximately 10 feet (3 meters) high, and 17 feet (5 meters) wide. The corrugated steel culvert at MP 14 is 165 feet (50 m) long, and the culvert at MP 8 is 157 feet (49 m) long (see Appendix A).

The MP 14 culvert has one of the highest numbers of deer to approach a crossing in the state; it has a rate of 2.4 deer approaches per day, and 1.5 per day use it (Table 13, Figure 68). The culvert at MP 8 has a rate of 2 deer approaches per day. Unfortunately, the MP 8 culvert has the highest rate of repellence of any wildlife crossing in Utah at 37% (Table 13, Figure 69), so only 1.1 deer per day go through it. The culvert at MP 14 is second to the culvert at MP 8 for rate of repellence, with a rate at 31%. These culverts are the longest wildlife crossing culverts in Utah, and it is believed that the length of the culvert in conjunction with their height and width dimensions present a cave like situation to prey species, and thus are not as conducive to movement (Figure 70, and see Appendix A). The high repellency rate at the MP 8 culvert may be due in part to rail fencing placed illegally at the east entrance to the culvert. The repel rate at the west side of the entrance, where deer look through the culvert and see the fence at the other end, approached 50%. In the fall of 2011 the fencing was taken down and replaced with a rail fence back at the UDOT right of way, courtesy of UDWR personnel. Further monitoring will assess the change in rate of repellency and mule deer use over time after this fence removal.

Table 13. Mule deer camera data tabulated for US 91 corrugated steel wildlife crossing culverts.

Camera Location	Camera Days Ana-lyzed	Number of Deer Observa-tions at Site	Number of deer photo-graphed per day	Number of Success-ful Crossings thru structure	Deer thru Structure per day	Success Rate (%)	Rate of Repellency (%)	Parallel Rate (%)
MP 14 Arched Steel 165 feet culvert (WF)	826	1,945	2.4	1,907	1.5	63	31	6
MP 8 Arched Steel 157 feet culvert (WF)	581	1,187	2	643	1.1	54	37	9

WF = Wildlife fencing present

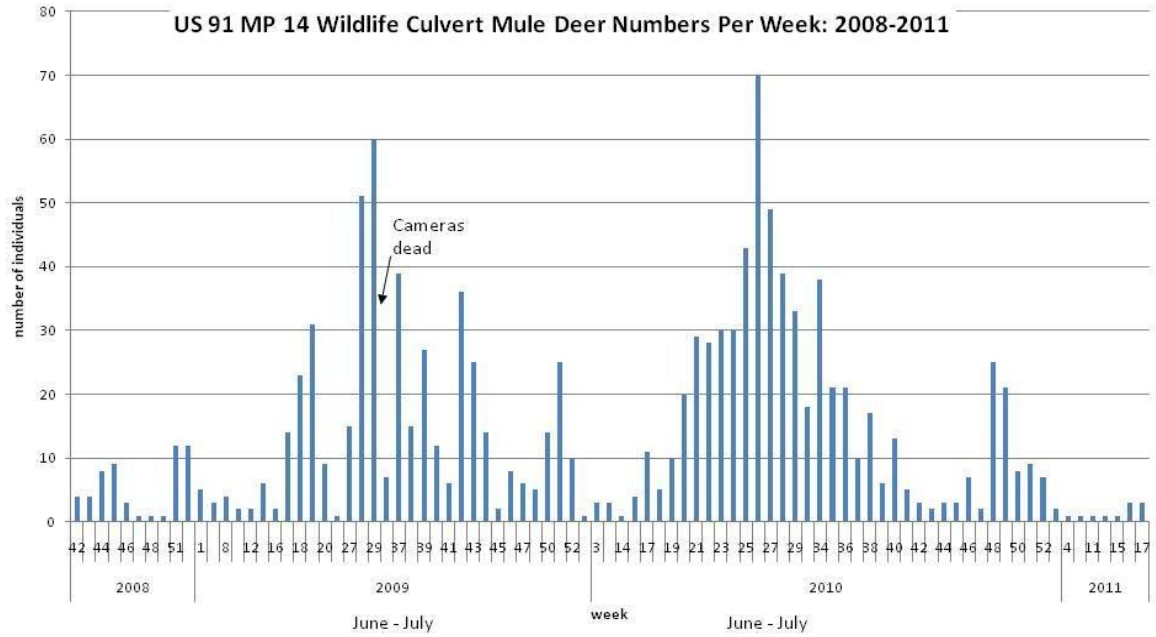

Figure 68. Mule deer use of US 91 MP 14 culvert by week. Note scale is more than double of other similar figures in report where the y-axis was set to 30 mule deer per week, this is 80 mule deer per week.

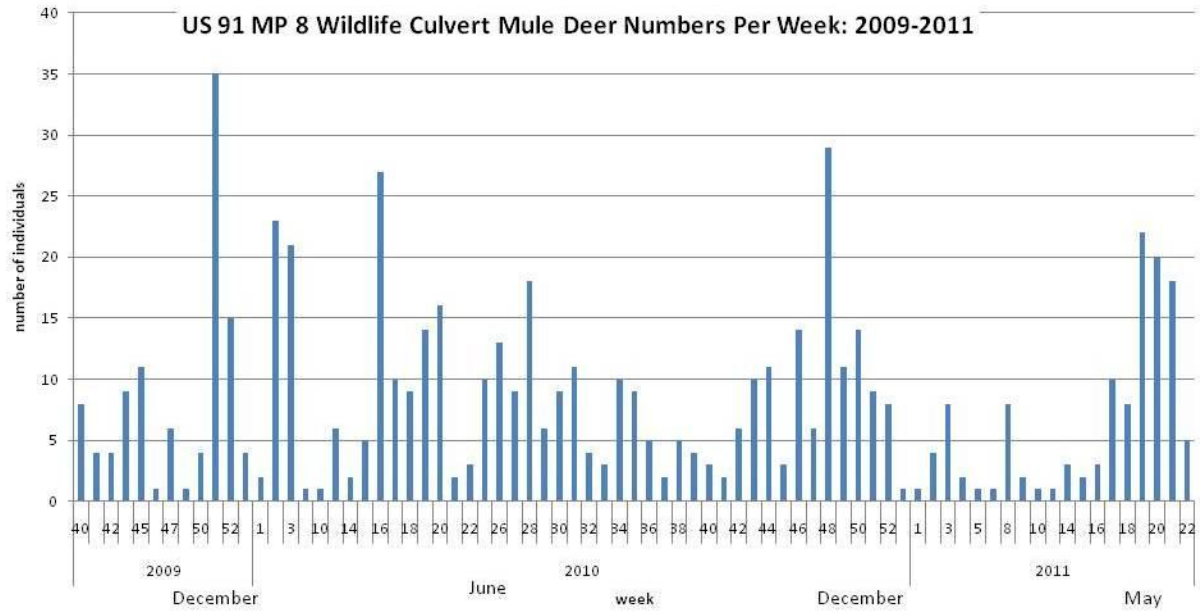

Figure 69. Mule deer use of US 91 MP 8 culvert by week. Note scale is higher than other figures at other locations that typically had a y-axis of 30, this has 40 mule deer per week.

Figure 70. Mule deer used US 91 MP 14 culvert in deep snows.

Elk are present in the Wellsville Mountains, but only one female elk appeared in front of the cameras at the MP 14 culvert, and was repelled.

Moose have used the MP 14 culvert heavily, with 152 occurrences at the entrances in data analyzed to date. Twenty-seven (18%) of these occurrences resulted in moose repels. This left a total of 125 moose passes through this culvert (82% success rate), making it more used by moose than all other Utah wildlife crossing structures combined. The moose photographed were adult males, females, and young, and they occurred throughout the year (Figure 71). Two moose have used the MP 8 culvert, a male and a female, during winter months. Videos were created of some of the photographs and posted on YouTube, see references Hamlin 2011e, f, and g.

Other wildlife occurring at these culverts included: a coyote, an ermine, skunk (108), raccoon (36), red fox (3), ground squirrel (8), rabbit, marmots (20), and an owl. This is the only site where there was evidence of predators waiting for prey at a wildlife crossing. Cameras caught a rodent running across the snow in February at one side of the MP 8 culvert and the other camera caught a picture of a magpie catching the rodent and walking away with it. A visit to the camera during that time revealed piles of entrails of several rodents.

Humans rarely visit these culverts. It does not appear that the nearby Ruby pipeline construction affected mule deer use of the culvert, but over time, the data will help us observe the natural rise and fall of mule deer numbers. The pipeline construction in the beginning months of 2010 resulted in open gates and mule deer deaths on the road over the crossing and along this stretch of road. At the time of this writing the gates were more consistently closed but there were still problems with mule deer being able to access the road at this site due to holes in the gates and fencing. UDOT maintenance crews were painstakingly diligent about repairing the fence along this highway, but we still see mule deer not using these crossings and getting hit on the roadway. Monitoring continues as solutions are debated and enacted.

Pros: These culverts lie at the interface of public and private lands. Human use is limited in both culverts, thereby allowing wildlife to pass more freely than those places shared with humans. Moose readily use the MP 14 culvert.

Prescription for Improvement: The single most important action that needed to occur was the removal of the private landowner's rail fence at the east entrance to the MP 8 culvert, and this occurred in the fall of 2011. Continued monitoring will evaluate if this helps create a reduction in mule deer rate of repellence. If this does not decrease to a rate comparable to the MP 14 culvert, other options may have to be visited, such as adding light to the culvert. The roadway above the culverts has no median at both sites, thus there are no options for light boxes or opening the culverts in the median. Culvert retrofit options are limited at this time. The most proactive action would be to make certain fencing is repaired seasonally and gates and ingress points remain closed.

Figure 71. Moose used US 91 MP 14 culvert.

4.2.4 US Highway 191 Summary

Cameras were placed at two corrugated steel plate arch culvert wildlife crossings on US 191 south of Monticello (Figure 72).

- An objective was to evaluate the efficacy of the crossings.

- A second objective was to compare rates of usage and repellence with other corrugated steel culverts of varying lengths in Utah in an effort to help make design recommendations for the most effective corrugated steel plate culverts for wildlife.

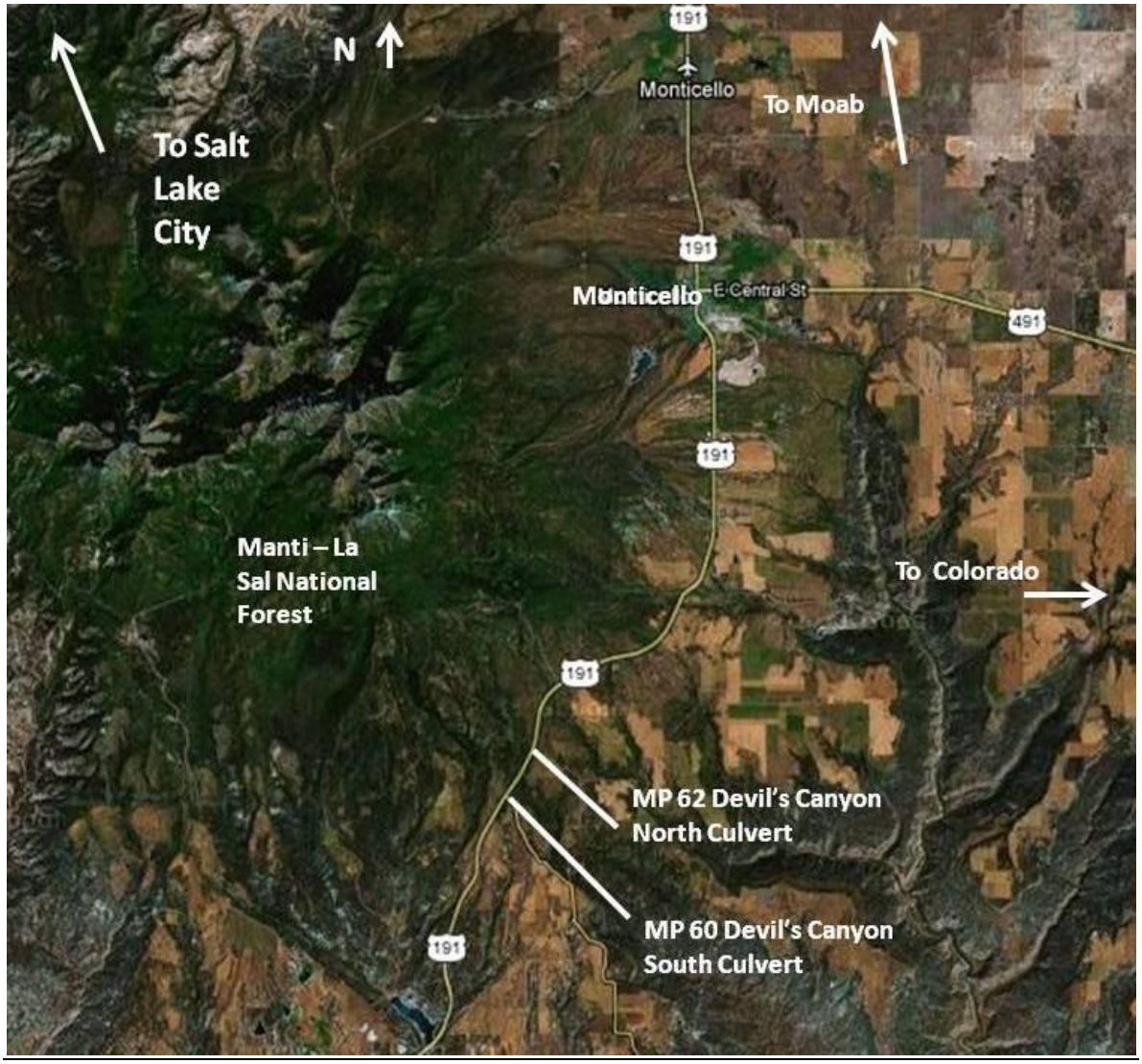

Figure 72. Two wildlife crossing monitoring sites on US 191, south of Monticello.

Monticello Corrugated Steel Plated Culvert Wildlife Crossings with Wildlife Fencing

The two wildlife crossing culverts south of Monticello on US 191 were added to the study in May 2010. These culverts lie within several miles of wildlife fencing both north and south of the sites. The cameras were mounted in a different method than in utility boxes. The maintenance crew of the UDOT maintenance unit in Monticello replicated the steel boxes manufactured for

the cameras and mounted them on the ceiling of the culverts, pointed down toward the wildlife. At the end of this study this method will be evaluated for its lessened impact on wildlife because it is out of their line of site. The two Devil's Canyon area culverts were approximately 10 feet (3 meters) high, 14 feet (4 meters) wide and 120 feet (36 meters) long (See Appendix A for photo) and were made of the same materials as the US 91 and I-15 corrugated steel culverts. A goal of this research was to better understand the different rates of repellency among these types of culverts. These culverts will be monitored through 2012 and results will be brought into a large statistical analyses model to evaluate culvert crossing dimensions.

This research helped to see how successful these two crossings were in passing mule deer (Table 14) and the other animals approaching the entrances. Mule deer use of these crossings was strongly seasonal (Figures 73 and 74). The Devil's Canyon North (Devil's North) crossing structure had higher numbers of mule deer use than the Devil's Canyon South (Devil's South) structure (Table 14, Figures 73 through 75).

Table 14. Mule deer camera data tabulated for US 191 corrugated steel wildlife crossing culverts.

Camera Location	Camera Days Ana-lyzed	Number of Deer Observa-tions at Site	Number of deer photo-graphed per day	Number of Success-ful Crossings thru structure	Deer thru Structure per day	Success Rate (%)	Rate of Repel-lency (%)	Parallel Rate (%)
Devil's Canyon N Arched Steel 120 feet culvert MP 62 (WF)	362	438	1.2	295	0.8	67	18	15
Devils Canyon S Arched Steel 120 feet culvert MP 60 (WF)	350	134	0.4	62	0.2	46	32	22

WF = Wildlife fencing present

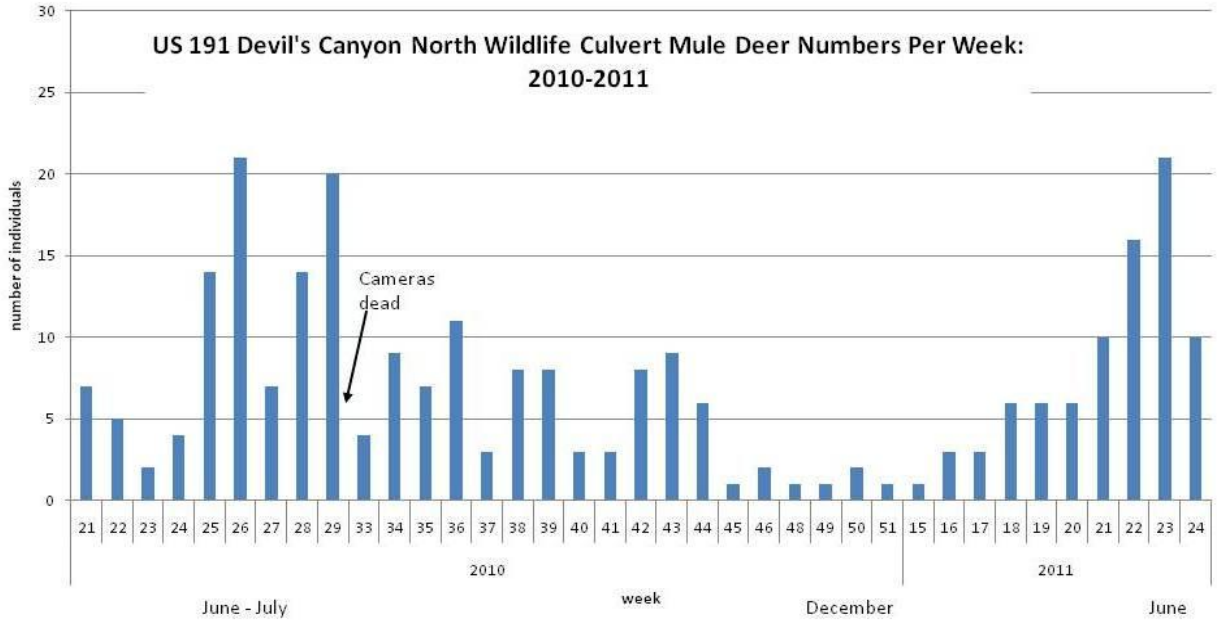

Figure 73. Mule deer use of US 191 Devil's Canyon North culvert by week. Note period of dead cameras was only 2 to 3 weeks of the study, but during a time of high mule deer use. Later data will help compensate for this missing data.

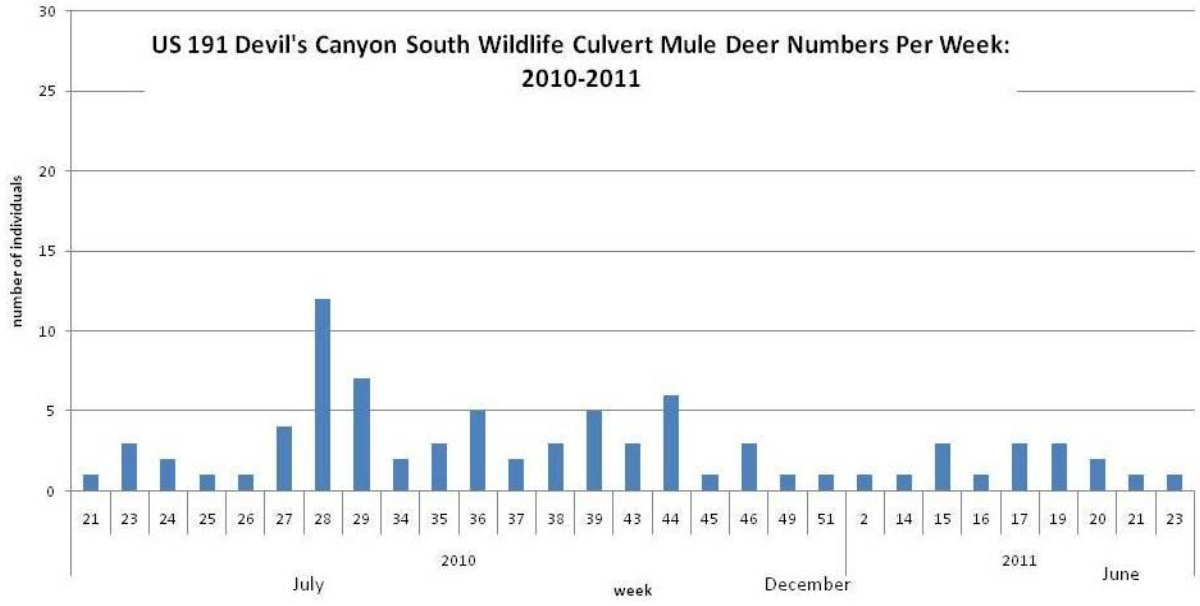

Figure 74. Mule deer use of US 191 Devil's Canyon South culvert by week.

Figure 75. Mule deer doe and fawns used US 191 Devil's Canyon south culvert.

In three events, four elk were photographed at the entrance to Devil's North, but none used the culvert. Devil's North cameras revealed 10 coyote, 12 grey fox, a rabbit and one squirrel observations at the culvert entrances and were assumed to be passages. The Devils South camera recorded 12 coyote, 10 fox, one bobcat, one mountain lion (Figure 76), and eight jackrabbits. The night the mountain lion used the Devils South culvert, a coyote used the same culvert within one hour of the mountain lion passage.

Pros: These culverts are in areas of private land, but at this time this helps protect the wildlife from human visitations at the crossings. A variety of wildlife visited both culverts, thereby increasing the diversity of wildlife that used these culverts for movement.

Prescription for Improvements: It is worth a try for UDWR and UDOT personnel familiar with the area to discuss why so few mule deer appear at the Devil's Canyon South culvert, and try to find actions that can be taken to increase mule deer use if there are more mule deer in the area than the culvert cameras reveal. Discussions with local UDOT personnel indicate less mule deer movements in that area (C. Johnson, UDOT, personal communication).

Figure 76. Mountain lion (puma) used US 191 Devil's Canyon South culvert.

4.2.5 Interstate 15 Summary

Cameras were placed along I-15 to meet several objectives.

- Two cameras were placed on each of the Wildcat North paired wildlife crossing culverts (MP 126) and Wildcat South paired wildlife crossing culverts (MP 123) to determine mule deer and elk use of these corrugated steel plate culverts. They were studied in the past (Rosa 2006) and it was thought elk were approaching these culverts but not using them. Future potential actions included adding sound muffling materials to the culverts to encourage wildlife (and in particular elk) use.
- One camera was placed on the Beaver wildlife overpass (MP 102) to determine how well it is working for mule deer and elk (see Figure 77 for map of the Wildcat and overpass sites).
- One camera was placed on each of three long (greater than 200 feet, 61 m) concrete box culverts without wildlife fencing south of Cedar City (MP's 36, 42.5, and 44) to help

determine wildlife use of culverts without wildlife fencing in that area. Fencing was added to this area in 2011 (See Figure 86 for map).

- Three cameras were installed in the Scipio area of I-15 to determine if mule deer and elk were using the designated wildlife crossing bridge at MP 186, the area under the bridge for a U.S. Forest Service road at MP 182, and a paved overpass at an interchange at MP 184 that could potentially become a wildlife overpass (See Figure 89 for map of sites).

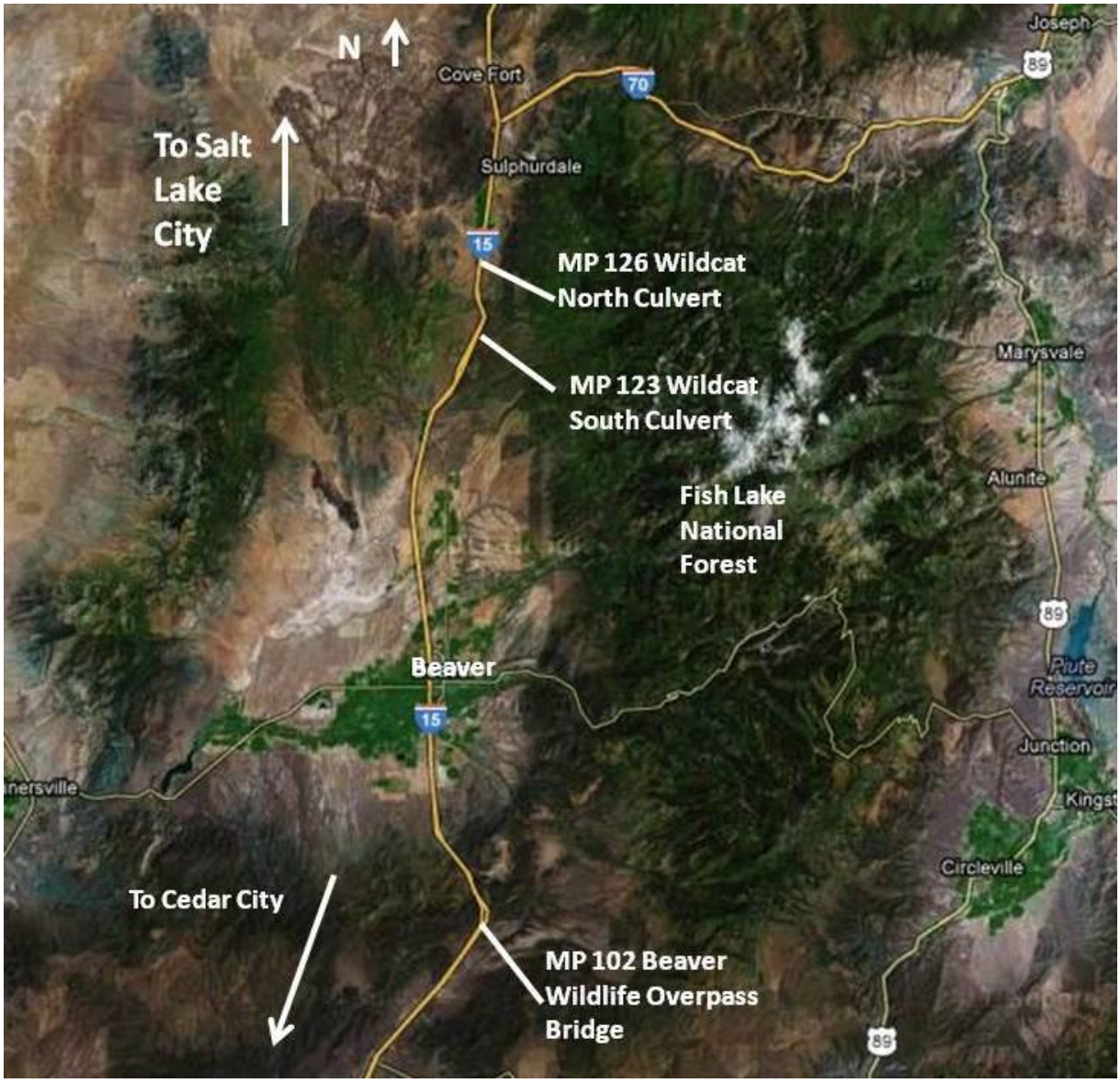

Figure 77. I-15 monitoring sites near Beaver.

I-15 Wildcat North and South – MP's 126 and 123

The two Wildcat wildlife crossing culverts were built in 2004, constructed of corrugated steel plates with natural bottoms. Each crossing is a pair of culverts for opposing lanes of traffic with an open median. Each culvert measures 27 feet (8.2 m) wide, and ranges in height from 13 to 15 feet (4 to 4.5 m), and 65 feet (20 m) to 76 feet (23 m) long. Wildcat North has a county/U.S. Forest Service road running through it. Wildlife fencing occurs for miles north and south of these crossings. See Appendix A for crossing photos. The objective of placing cameras at these sites was to learn if elk were approaching these culverts and turning away, which might necessitate a retrofit of the structures. The four cameras at these two wildlife crossings, placed July, 2008, recorded more mule deer activity than any other cameras in the state (Table 15, Figures 78 through 82). In fact, Wildcat South can be considered the most highly used wildlife crossing in Utah.

Table 15. Mule deer camera data tabulated for I-15 corrugated steel wildlife crossing culverts.

Camera Location	Camera Days	Number of Deer Observa-tions at Site	Number of deer photo-graphed per day	Number of Success-ful Crossings thru structure	Deer thru Struct-ure per day	Success Rate (%)	Rate of Repel-lency (%)	Parallel Rate (%)
Wildcat N Arched steel 65 feet paired culverts MP 126 (w/Fencing)	1,087	8,470	7.8	7,529	6.9	89	8	3
Wildcat S Arched steel 65 feet paired culverts MP 123 (w/Fencing)	1,091	10,581	9.7	9,076	8.3	86	11	3

w/Fencing = wildlife fencing present

With the removal of the Wildcat North cameras in the summer of 2011, three years of monitoring these sites was complete. Wildcat South cameras remained for continued monitoring. Every camera produced thousands of pictures each month, making data analyses time consumptive over the years. These pictures were largely of mule deer, with 8,470 mule deer approaches recorded at Wildcat North, and 10,581 approaches recorded at Wildcat South (see results in Table 15, and Figures 78 through 80). Other mammalian wildlife species were also photographed, see Table 16. Elk photos were captured by the camera on the east side of Wildcat North in 2011. Elk approached the culvert on four occasions from January through June. On one occasion 14 cow and calf elk appeared to be grazing near the entrance, but only two cows looked at the culvert entrance, the rest of the individuals kept their heads to the ground, and then all eventually walked away. Their movements were considered parallel. On four other occasions a single cow elk approached the culvert. On one of those occasions a mule deer doe circled the cow elk, and even went into and back out of the culvert, but the elk did not follow. All four approaches resulted in repelled behavior. These were the only elk presence recorded at the two crossings over the three years.

Table 16. Number of individuals photographed of species of mammals at Wildcat North and South culverts.

Species	Wildcat North	Wildcat South
Badger	0	2
Bobcat	0	9
Coyote	6	68
Red Fox	9	0
Mountain Lion	1	3
Jackrabbit/rabbit	2	15

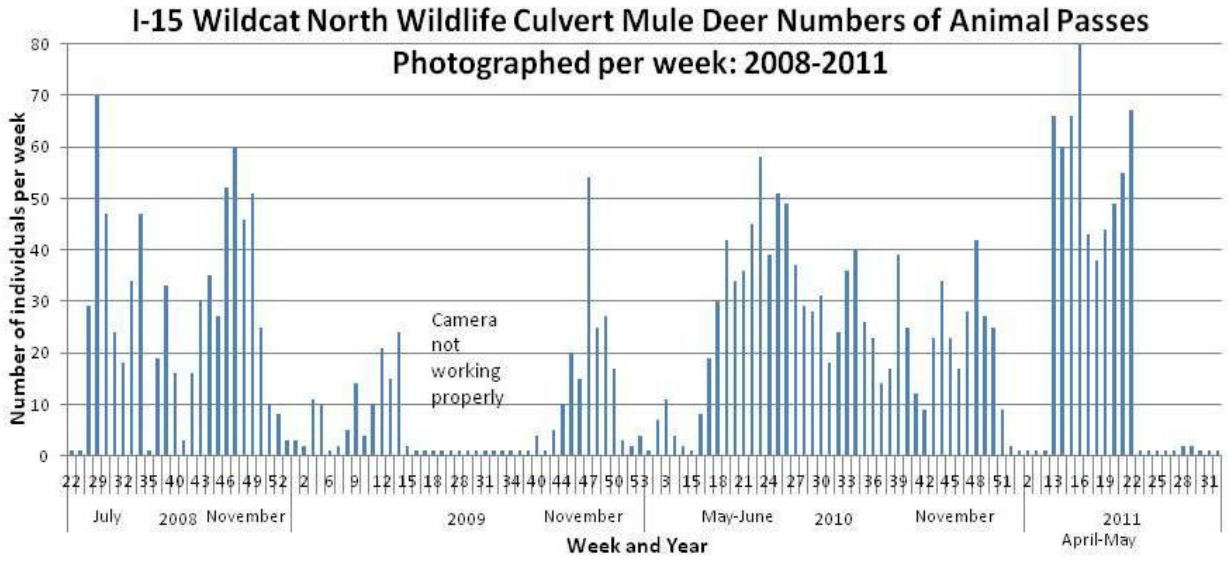

Figure 78. Mule deer use of the I-15 Wildcat North wildlife crossing culverts. Note the Y-axis maximum number of individuals per week scale on this graph (80) is over twice as large as Y-axis maximum of crossings presented in the majority of the report.

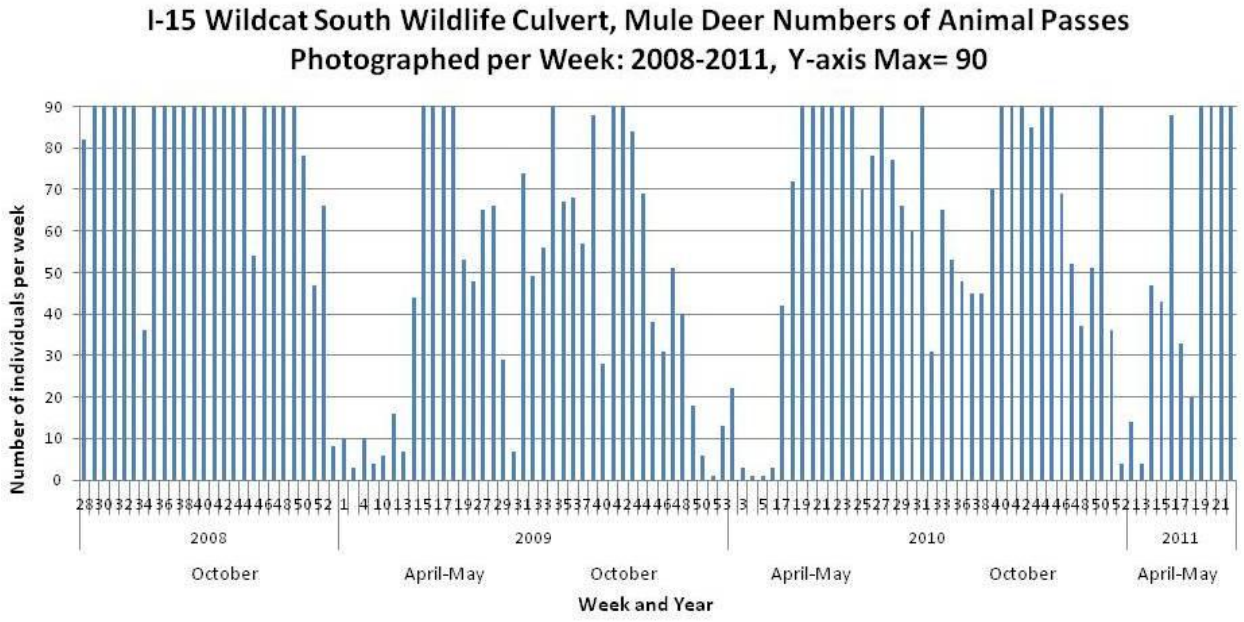

Figure 79. Mule deer use of I-15 Wildcat South wildlife crossing culverts with a y-axis scale of 90 individuals per week, the highest scale among all crossings, yet far below the y-axis scale of 300 per week as used in Figure 80. This axis allows a visual comparison to Wildcat North Scale of 80 individuals per week in Figure 78, while truncating the numbers of individuals in weeks with over 90 individuals photographed per week at Wildcat South.

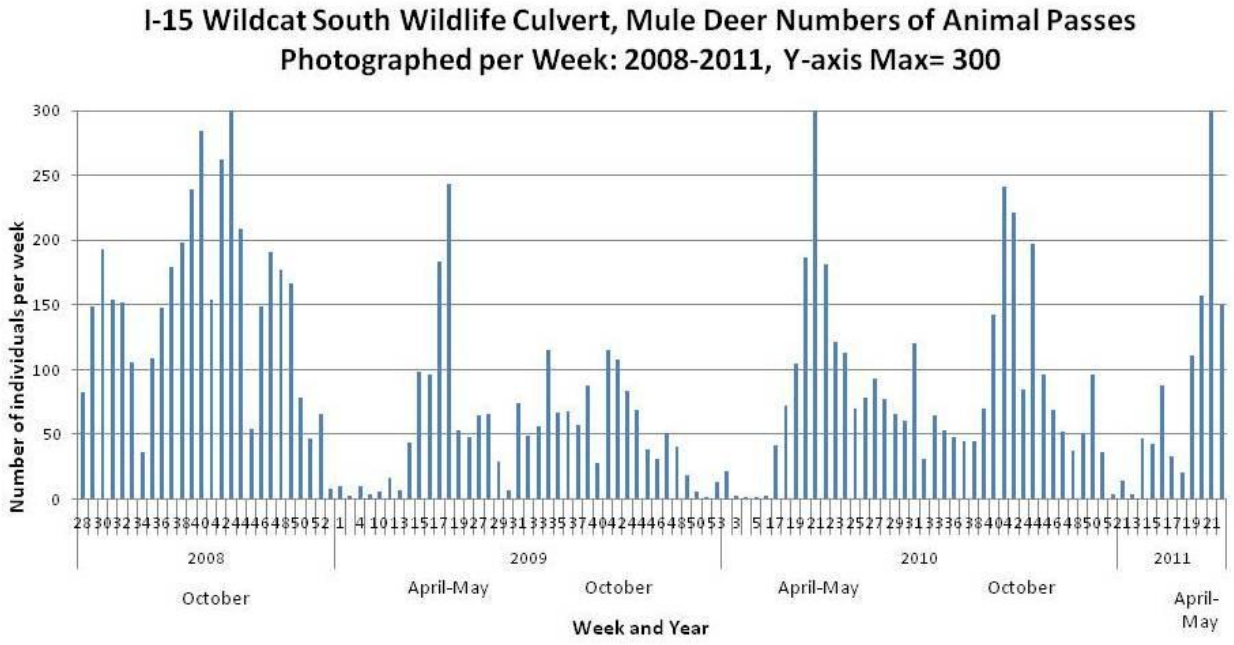

Figure 80. Mule deer use of I-15 Wildcat South wildlife crossing culverts with Y-axis maximum of 300 individuals per week, which is 10 times the scale for most crossings in the report. This maximum value accommodates most weeks in the study.

Mule deer used these culverts on a weekly basis but the trend was for strong migratory movement through the culverts in the fall and spring (Figures 78 through 82). Less mule deer used Wildcat North perhaps in part due to vehicular traffic through the culvert (1,847 vehicle passes recorded). Traffic was heaviest in October and November when migratory movements were highest in Wildcat South. Future wildlife crossings would best serve wildlife if there were no types of roads through them.

Overall, these crossings were very successful for mule deer based on high numbers of mule deer and the relatively low rates of repellency (less than 12 percent) for mule deer. The Wildcat South structure, the most highly used crossing in Utah, passed approximately 8 mule deer per day, approximating over 3,000 mule deer passes per year. At Wildcat North, mule deer passages approximate 2,500 per year. Combined, there were a minimum of 5,500 mule deer passes annually that were prevented from occurring over Interstate 15 due to these crossings. These two structures were by far UDOT and UDWR's success stories in placing wildlife crossings in the correct places for mule deer migration, and designing crossings with the lower rates of

repellency for mule deer. They are extremely successful for mule deer. If some day elk could be convinced to use these crossings, they would truly be successful for the intended target species.

The Wildcat North cameras were pulled in the summer of 2011, having served their intended purpose. The Wildcat South cameras remained as a control site for mule deer numbers over time for comparison with the new passage on I-70 at MP 5.3. The Wildcat South structure may provide valuable population trend data for the UDWR, in particular after the Twitchell Canyon fire that occurred directly to the east in the fall of 2010. Sound reducing application may also occur at one of these sites in the future.

Pros: Both Wildcat North and South were placed in optimal areas for mule deer use. Placement of crossings has been found to be one of the top important factors in wildlife crossing success (Dodd et al. 2007). The large size of the culverts has encouraged not only high use, but low rates of repellence. These culverts can be models for future wildlife crossings. Lack of human use at Wildcat South has helped mule deer move through this passage in daylight hours just as often as night hours.

Prescription for Improvement: If there is any chance to reduce vehicle use of the county - U.S. Forest Service road through Wildcat North, especially in October and November when mule deer are trying to get to winter habitat, it would help the population as well as individuals.

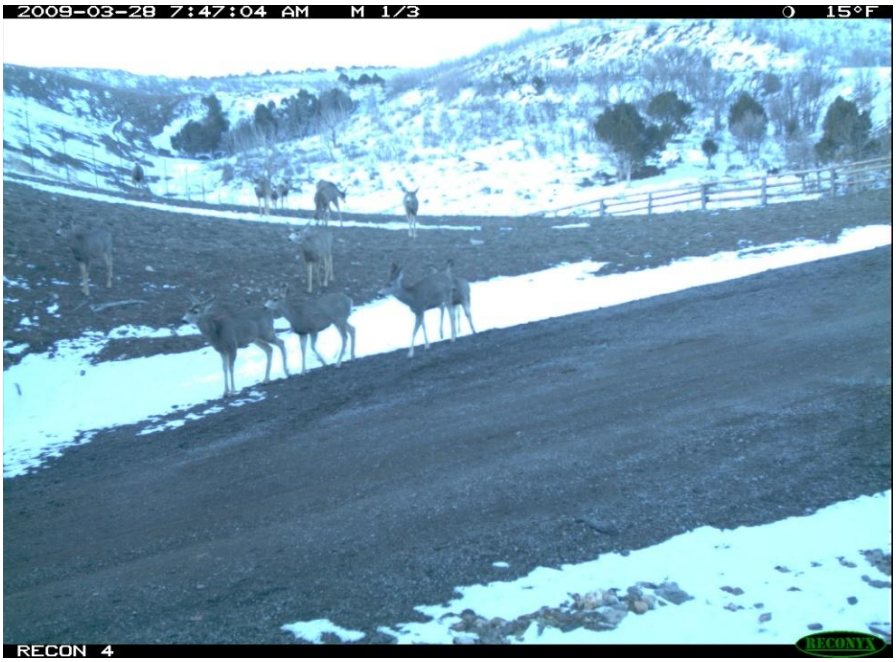

Figure 81. Mule deer approached and used I-15 Wildcat North wildlife crossing culvert.

Figure 82. Mule deer approached I-15 Wildcat south wildlife crossing culvert from the west.

I-15 Beaver Wildlife Overpass – MP 102

A single camera was placed on the median area of the Beaver overpass. This overpass is composed of two narrow (21 feet, 6.4 m wide) bridges over opposing lanes of traffic with a high, natural area in the median. It is accompanied by miles of wildlife fencing north and south of the crossing. See Appendix A for photo of dimensions. The overpass was monitored briefly decades ago, but the data was of limited usefulness. It did show, however, mule deer use similar to the current study, shortly after I-15 construction in 1985 (B. Bonebrake, UDWR personal communication). The objective of monitoring this passage was to see how well North America's first wildlife overpass passed the migratory mule deer and elk in the area. The majority of mule deer movement was in the fall and spring because of heavy mule deer migrations east and west across the highway to summer and winter habitat (Table 17, Figure 83). It was estimated that more than 500 mule deer passes occur on this crossing each year (Figure 84). Nineteen bull elk were photographed using the overpass. No female elk were photographed. This was the most highly used by elk wildlife crossing structure in this study. Other species using the structure included a mountain lion (Figure 85), rabbit, red fox, and coyote. This camera will remain because of the valuable data it provides not only for Utah but for the country, due to the rarity of wildlife overpasses and concurrent monitoring data.

Pros: The overpass was placed in a strategic location to catch migratory mule deer on a ridge that runs the direction of their west-east migrations. Over the decades since it was placed in 1975 for the east half and 1985 for the west half, some vegetation has grown back. The male mule deer passes are 16% of the total passes, which is comparable to the percentage of the males in the population. This lends credit to the idea that the overpass allowed the majority of members of the population of mule deer to access their seasonal habitats.

Prescription for Improvement: While the overpass appears to pass all age cohorts and genders of mule deer, it fails to pass all members of the elk population. If an objective of the overpass is to allow the elk population to move between the east and west sides of the interstate, it fails. If the objective is to allow an occasional bull to move between populations to maintain genetic connectivity and thus diversity, it appears to serve that purpose. It is not known how to encourage cow elk to use this overpass. If panels were placed in the chain link fence along the overpass to block the view and possible noise of traffic, it may create more of a tunnel effect and

discourage elk use. A potential improvement would be to plant sagebrush and juniper on the overpass bridges to provide a more natural "feel" to the area and to provide cover. An additional improvement would be to discourage members of the hunting public from hunting in the area of the overpass and baiting by potential hunters at the entrances, as evidence was found in camera data and field visits.

Table 17. Mule deer camera data tabulated for I-15 Beaver wildlife overpass with wildlife fencing.

Camera Days Analyzed	**Number of Deer Observa-tions at Site**	**Number of deer photo-graphed per day**	**Number of Successful Crossings thru structure**	**Deer thru Structure per day**	**Success Rate (%)**	**Rate of Repellency (%)**	**Parallel Rate (%)** (not known at this location)
738	1,289	1.7	1,206	1.6	94	6	0

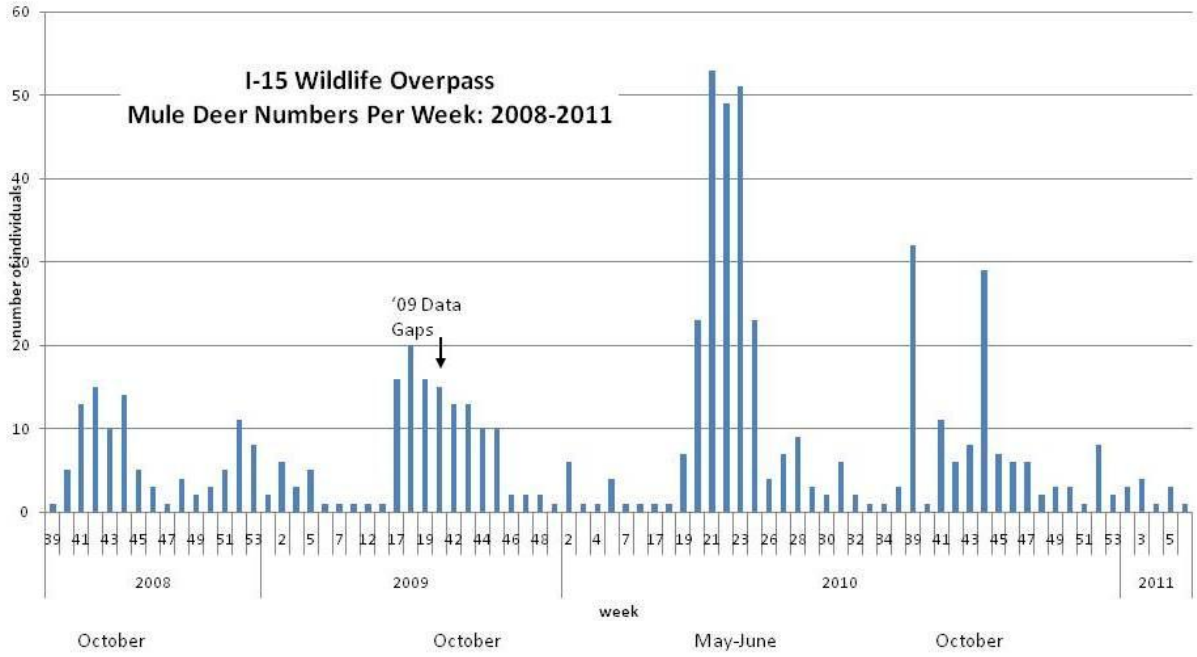

Figure 83. Mule deer use of I-15 Beaver Overpass by week.

Figure 84. Mule deer used the I-15 Beaver Overpass to head west.

Figure 85. Mountain lion (puma) used I-15 Beaver Overpass.

I-15 Long Concrete Box Culverts Without Wildlife Fencing - MP's 36, 42.5, 44

Three long concrete box culverts without wildlife fencing south of Cedar City were monitored for one year as a pre-fencing study (Figure 86). They had very little mule deer use, but high meso-mammal use. The longest culvert in the study, at the Camp Creek South Culvert (MP 42.5), was 9.8 feet (3 meters) high, 11.8 feet (3.6 meters) wide, and 280 feet (84 meters) long. See Appendix A for photo of this culvert's dimensions. All mule deer that approached the site (n=32) were repelled. The Camp Creek North Culvert (MP 44) was 9 feet (2.7 meters) high by 11.5 feet (3.5 meters) wide, by 175 feet (53 meters) long, and had 12 mule deer passes and four repels. The Ash Creek Reservoir culvert (MP 36) was 26 feet (8 meters) high and wide, and 135 feet (41 meters) long. Eleven mule deer approached it and used it, none were repelled. Mule deer use of just the two culverts (Camp Creek South was not used) occurred in the fall migration from September through November, and the spring migration from April through May. In 1,067 camera days, 59 mule deer were photographed at the entrances to these culverts, and just 23 successful crossings were recorded (Table 18). The Camp Creek North and Ash Creek culverts provided a limited amount of connectivity for mule deer in this area. The Camp Creek South culvert provides no connectivity for mule deer (Figure 87) and a limited amount for other mammalian species.

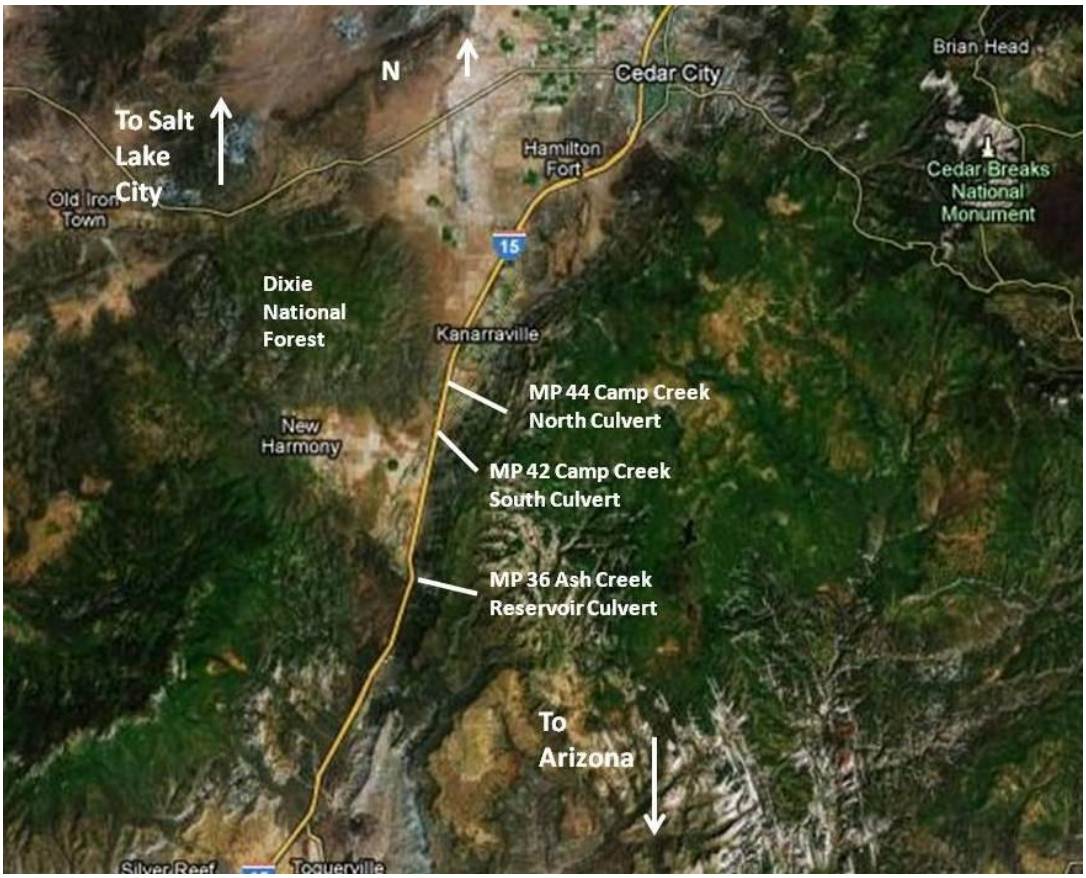

Figure 86. Monitoring sites south of Cedar City along I-15.

Table 18. Mule deer data from three culverts under I-15. No wildlife fencing was present.

Camera Location	Camera Days Ana-lyzed	Number of Deer Observa-tions at Site	Number of deer photo-graphed per day	Number of Success-ful Crossings thru structure	Deer thru Struct-ure per day	Success Rate (%)	Rate of Repel-lency (%)	Parallel Rate (%)
Camp Creek N concrete box culvert MP 44	371	16	0.04	12	0.03	75	25	0
Camp Creek S concrete box culvert MP 42	299	32	0.11	0	0	0	100	0
Ash Creek Reservoir concrete box culvert MP 36	397	11	0.03	11	0.03	100	0	0
Totals	1,067	59	0.05	23	0.02	39	61	0

Figure 87. Mule deer herd repelled from Camp Creek South culvert.

There was a diversity of other wildlife species that used the Ash Creek and Camp Creek South culverts, including: grey fox, bobcat, spotted skunk and striped skunk, ringtail, ground squirrel jackrabbit, cotton-tail rabbit, and raccoon (Figure 88).

Figure 88. Meso mammals (medium mammals) used I-15 box culverts: clockwise from upper left: ground squirrel at Camp Creek North culvert, porcupine at Camp Creek North culvert, Bobcat at Ash Creek culvert, and skunk at Camp Creek North culvert.

In 2011, wildlife fencing was installed along this stretch of I-15. Post-fencing monitoring of the Ash Creek and Camp Creek North culverts began in 2012.

Pros: These culverts, while bordered by private land, still provided limited opportunities for connectivity for a variety of species. Public land is within a mile (1.6 km) of these culverts, including the Bureau of Land Management (BLM) and National Park Service (Zion National

Park) lands. There is also low human use on these culverts. Natural vegetation is close to the entrances to the Camp Creek culverts.

Prescription for Improvements: If sky lights could be punched into the middle of the Camp Creek culverts in the median of I-15, this may improve the conditions of the culverts for wildlife. The Camp Creek North camera recorded a flash flood through the culvert. Upon inspection it was realized that this culvert has two to four feet (0.6-1.2 m) of fill in the bottom. If it could be cleaned out, its size would be increased, thereby making it more attractive to mule deer. Future actions should include conservation easements on the bordering private lands.

I-15 Scipio Crossings and Overpass MP's 182, 184, 186

A set of single span bridges was installed as a wildlife underpass during the construction of I-15 just south of the town of Scipio along public lands (MP 186, See Figure 89). The crossing is free of roads. A set of bridges was also placed along I-15, over a U.S. Forest Service road at MP 182. A two-lane paved overpass bridge was constructed at the Scipio Pass in this area as well at MP 184. UDWR personnel familiar with the construction of this bridge communicated that it was originally designed as a wildlife overpass and ultimately became paved, which allowed the area nearby to become a de facto truck rest stop (B. Bonebrake, UDWR, personal communication). These three structures were monitored in 2007 to better understand if wildlife were using them, and to help plan future enhancements to I-15 that would help wildlife pass under and over the interstate. The sites were monitored with a single camera each. The cameras were older cameras from the Rosa (2006) study on the Wildcat structures.

Figure 89. Monitoring sites along I-15 near Scipio.

The cameras were installed in March, and removed in October of 2007 (Table 19). The study was abbreviated due to vandalism of one camera and the theft of another, and because this part of the study occurred prior to funding, thus no funds were available for new cameras.

Table 19. Mule deer photographed at I-15 Scipio wildlife bridge underpass (MP 186), a U.S. Forest Service road bridge (MP 182) and an overpass paved for vehicles (MP 184).

Camera Location	Camera Days Ana-lyzed	Number of Deer Observa-tions at Site	Number of deer photo-graphed per day	Number of Success-ful Crossings thru structure	Deer thru Struct-ure per day	Success Rate (%)	Rate of Repel-lency (%)	Parallel Rate (%)
Scipio North Bridge Wildlife Crossing MP 186 (w/Fencing)	174	722	4.5	722	4.5	na	na	na
Scipio South Bridge MP 182 (w/Fencing)	214	93	0.4	na	na	na	na	na
Scipio Paved Overpass MP 184 (w/Fencing)	69	0	0	0	0	0	0	0

The Scipio North underpass bridge (MP 186) camera recorded 722 mule deer passes in 174 days of monitoring. This is a rate of 4.5 deer per day. This value is representative of movements from March into October, but even if the mule deer average went to half of this use over the course of a year, this crossing would be one of the top five wildlife crossings in Utah based on numbers of deer. There was a definable herd of 8 does and 3 fawns that were viewed in photos going back and forth almost daily (Figure 90). Bucks occurred in only 5 sets of pictures over this time. Due to the fact that these were the first cameras installed as preliminary cameras for this study, the camera at this site was positioned in the middle of the crossing in the median and did not record repel actions. Overall, the Scipio North passage functioned as a successful wildlife underpass for mule deer. No elk were observed and a casual survey of fecal pellets in the hills east of the crossing found four piles of elk pellets that appeared to be several years old, thus there may not have been elk in the area to use the crossing during monitoring.

Pros: This bridge underpass works well for Utah and should be considered a model crossing design. Although it is placed low in the landscape, thus not allowing for a view through the structure from the approach, it was well used by the mule deer that were willing to use it. It is not known what animals or species of animals did not use the crossing.

Prescription for Improvement: In future upgrades to I-15 and the bridges, every component of their structural dimensions at the time of this writing should be kept as similar as possible.

Scipio South bridges (MP 182) were in an area with little vegetation (Figure 91). This and the fact that a U.S. Forest Service dirt road ran through the area and cameras recorded vehicles all hours of the day and night (there were as few as 12 vehicles in a month, to a high of 334 in May) make it unlikely that mule deer or elk used this area under the bridge. In 214 days of monitoring on the east entrance of this bridged area, 93 deer observations were recorded. The rate of deer observed per day was 0.4. Deer could not be verified using the area under the bridge due to limits of the camera and large extent of the area both in width across and length between opposing lanes of traffic bridges at the site. Rabbits were the only other wildlife recorded at this site. The South Scipio bridges had limited use by deer that are often skittish and on guard. No elk were recorded. A casual count of fecal pellets to the west revealed no mule deer or elk fecal pellets.

Pros: The bridge spans are long and the area is very open for wildlife movement.

Prescription for Improvement: The U.S. Forest Service road running through the structure is used at all hours of the night, the time that would be preferable for wildlife trying to avoid humans and vehicles. If there were restrictions on the use of the road, this would help wildlife. There is no vegetative cover near the entrances or in the median. If there were some juniper or Pinyon pine trees or sagebrush planted in the median and nearby, this may encourage mule deer and elk use.

Figure 90. I-15 Scipio North bridge wildlife crossing being used by seven mule deer.

Figure 91. I-15 Scipio South Bridge over U.S. Forest Service road with mule deer pondering using the area under the structure. It is not known if the mule deer used the passage.

The overpass bridge was monitored for 69 days. No wildlife was viewed in the photographic data other than birds landing on nearby signs. Cows were recorded regularly using the bridge after June 1. Because each month revealed thousands of vehicle photos, only sample periods of time were examined for the number of vehicles. In 30 days from March to April, 454 vehicle passes on the bridge were recorded. In four days in June there were 24 vehicle passes. These samples indicate that there was approximately an average of six to 15 vehicle passes per day on the overpass bridge. The overpass camera revealed this overpass was not used by wildlife for movements over I-15.

Pros: This structure was designed for wildlife and is placed on the very pass where wildlife would prefer to move across the highway. Mule deer use of the overpass near Beaver, Utah indicates local mule deer populations can adapt to such structures.

Prescription for Improvement: The vehicular use of this paved overpass bridge and the day and night parking of tractor trailer trucks prohibit wildlife use. Not only would the bridge need to be closed to vehicular traffic, but the entrance and exit ramps would need to be closed to prevent human use and continued presence of the area.

4.2.6 Interstate 80 Summary

Cameras were placed on the I-80 corridor with the following objectives.

- Two cameras were placed at the Mountain Dell Reservoir (MP 134) interchange and two more at the Lamb's Canyon interchange (MP 137) to determine if wildlife would use these areas under the bridges to access both sides of the interstate (See Figure 92). Three miles of new wildlife fencing was placed along these sites in 2009.
- A camera was placed on the Mountain Dell entrance ramp, southeast side, to help determine if white stripes painted on the road would appear as cattle guards to wildlife and repel them away from the highway.

- A camera was placed at the Lamb's Canyon interchange, at the north side of the highway at the end of a concrete barrier on the side of the road to ascertain if wildlife were accessing the highway at the end of the fence and barrier.
- Two cameras were placed at the Echo Junction Exchange (MP 168) where I-80 joins I-84, at the Weber River Bridge to determine wildlife use of the area pre-construction of the new bridge (See Figure 92).

Figure 92. I-80 camera sites: Mountain Dell Bridge, Lamb's Canyon Bridge, Weber River Bridge.

I-80 Mountain Dell Reservoir and Lamb's Canyon Interchanges – MP's 134 and 137

Two cameras were placed at each of the entrances to the bridge interchanges of Mountain Dell and Lamb's Canyon in October 2009. Cameras were placed to help ascertain if wildlife would traverse under the highway at these local paved road exits which also contain non-paved shoulders. The shoulders were created in 2008 to accommodate wildlife under the bridges. See

Appendix A for photo of Mountain Dell Bridge. In 2009, wildlife-proof fencing was erected from about one-quarter mile west of Mountain Dell interchange to three miles eastward to the Lamb's Canyon interchange where it ended at the bridge west abutment. The monitoring cameras were programmed to come on at dusk and turn off at dawn due to the thousands of vehicles passing by the cameras each month.

At the Mountain Dell Bridge in the first 344 days of monitoring, 43 deer were photographed at the entrances to the bridges, and none could be verified using the structure. During the first 512 days of monitoring analyzed at the Lamb's Canyon Bridge the cameras recorded 86 mule deer at the entrances to the bridge, and six deer traversed under the bridge. See Appendix A for sample photo. Fox and porcupine were recorded at the entrances to the bridges.

Pros: The bridges are at low volume roads in an area important to wildlife migration north and south of I-80. With the placement of wildlife fencing in 2009 it was hoped wildlife would be persuaded to use these underpasses. The bridges are high and wide (long span), thus allowing wildlife ample room to pass underneath.

Prescription for Improvement: The noise under both bridges was in high decibels (not officially measured) as heavy traffic moved over the bridges. The sound was akin to guns being fired. This noise will always cause repels with wildlife until it is mediated. The Mountain Dell interchange had dozens of car passes under the bridge each day, even during the darker hours when the cameras are programmed to come on. That, and the fact that there is a firing range on the south side of the highway, makes this area unlikely to ever function for wildlife. The Lamb's Canyon bridge area had wildlife fencing added on the south side (eastbound) of the highway in 2011. In the future the cameras at this location will help to determine if this helps to better persuade wildlife to use the area under the bridge.

Entrance Ramp at Mountain Dell Interchange MP 134

The white stripes painted as cattle guards for keeping wildlife off of I-80 at the entrance ramp for I-80 at this interchange for east-bound traffic were monitored with a single camera. This camera was mounted from February 16 through June 14, 2010. In 118 days of monitoring, 215 wildlife passes were recorded across the stripes. There were two raccoons, three moose, 95 mule deer,

and 115 elk passes photographed moving across the stripes (Figures 93 and 94). More wildlife was recorded at this site entering and exiting the highway than all the camera nights combined from the four cameras at the Mountain Dell and Lamb's Canyon interchanges. Some mule deer crossed the site on the rocks placed along the sides of the stripes. The camera was removed because results were clear: the painted white stripes did not deter wildlife from entering the highway.

End of Barrier, at North Side of Lamb's Canyon Interchange MP 137

The camera at Lamb's Canyon interchange along the north side of the highway at the end of the concrete barrier was removed after four months. The only wildlife recorded was a fox. The camera box was hit by a vehicle. Tens of thousands of I-80 vehicles were recorded. The risk to the camera negated the need for results.

Figure 93. Elk walked across painted white lines on I-80 entrance ramp at Mountain Dell interchange. Note lights of tractor trailer truck in background.

Figure 94. Moose walked across white stripes on I-80 entrance ramp at Mountain Dell interchange.

Echo Junction Weber River Bridge – MP 168

The two cameras were installed at the Weber River Bridge in August 2009 and recorded mule deer and other wildlife activity for 15.5 months. This bridge was not built for wildlife and did not have wildlife fencing in the area of this convergence of I-80 and I-84. This part of the study was a pre-construction phase because the bridge was replaced in 2011, and the new bridge was designed to pass wildlife. In 543 days of pre-construction monitoring, 361 mule deer used this structure for a value of 0.66 mule deer per day (Table 20 and Figures 95 and 96). A moose was photographed at the entrance, but was repelled. In the first five months the rate of repellency was 4.8%. Local landowners and land users repeatedly placed illegal fencing at the southwest side entrance. Illegal livestock fencing began being tacked up on the bridge in the spring of 2010, and the overall rate of repellency increased to 20.4%. The cameras were removed in December 2010 for new bridge construction, and were reinstalled when the new bridge was completed (See Figure 97 of new bridge in 2012). It is predicted that for the new bridge to be considered successful, it would need to pass at least 0.67 deer per day (244 per year) and occasional moose and elk each year, which are known to be in the area.

Table 20. Mule deer camera data tabulated for I-80 Weber River Bridge.

Camera Days Analyzed	Number of Deer Observa-tions at Site	Number of deer photo-graphed per day	Number of Successful Crossings thru structure	Deer thru Structure per day	Success Rate (%)	Rate of Repel-lency (%)	Parallel Rate (%)
543	496	0.91	361	0.66	72.78	20.36	6.25

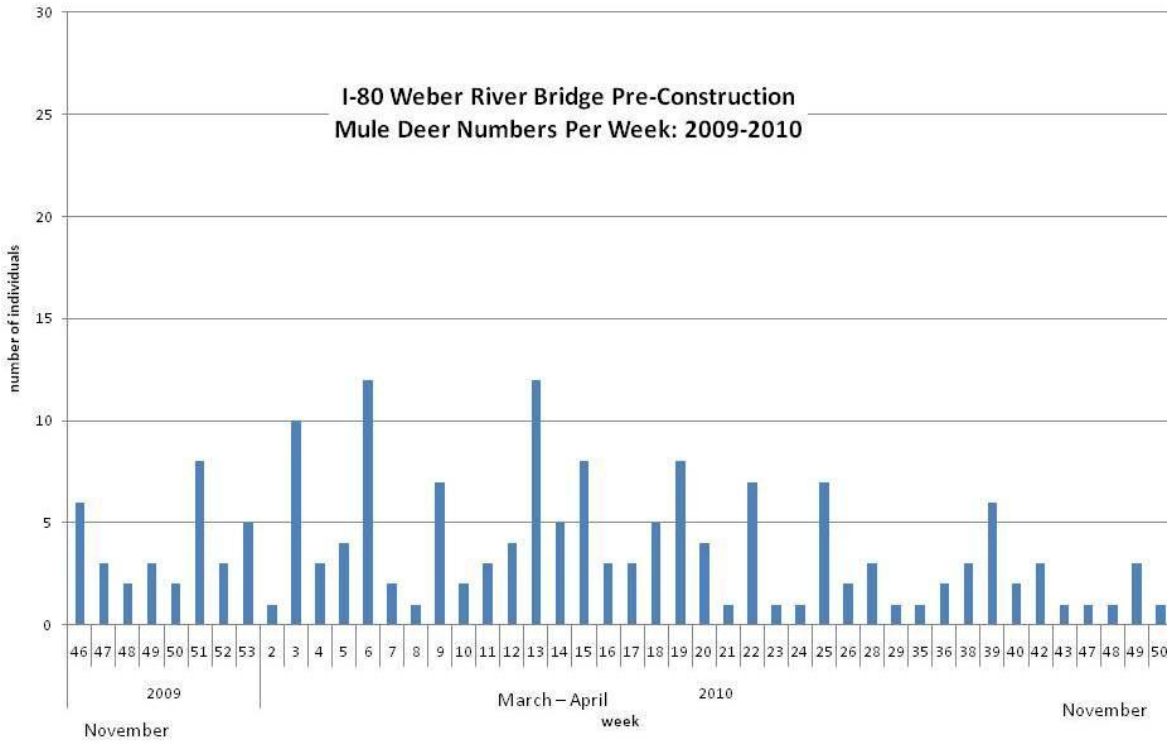

Figure 95. Mule deer use of I-80 Weber River Bridge each week of pre-construction monitoring.

Figure 96. Mule deer buck used the south side of the Weber River Bridge on I-80.

Figure 97. New bridge at Echo Junction, Weber River, near end of construction phase March, 2012.

4.2.7 US Highway 189 Summary

Deer Creek State Park Culvert US 189 MP 20

The culvert and wildlife fencing at Deer Creek State Park were completed in early 2011 (Figure 98). Two cameras were placed at the entrances to this culvert in May of 2011 to help determine the species and their numbers that would use the culvert. Culvert dimensions were 21.7 feet (6.6 m) high, 17 feet (5 m) wide at the base and 22.5 feet (6.9 m) wide at the widest point. The length of the top of the ceiling of the culvert was 143 feet (43 m), and the floor was 204 feet (62 m) long. The wildlife fencing extended for miles in both directions. In the first nine days of monitoring, 12 mule deer observations were recorded. Ten of these animals came through the culvert (Figure 99). Red fox and wild turkey were recorded using the culvert. Elk are in the area and it is hoped they use the culvert in the future. Plans were to monitor this culvert for the full length of the study to determine if mule deer and elk will use the culvert in numbers comparable to their populations in the area.

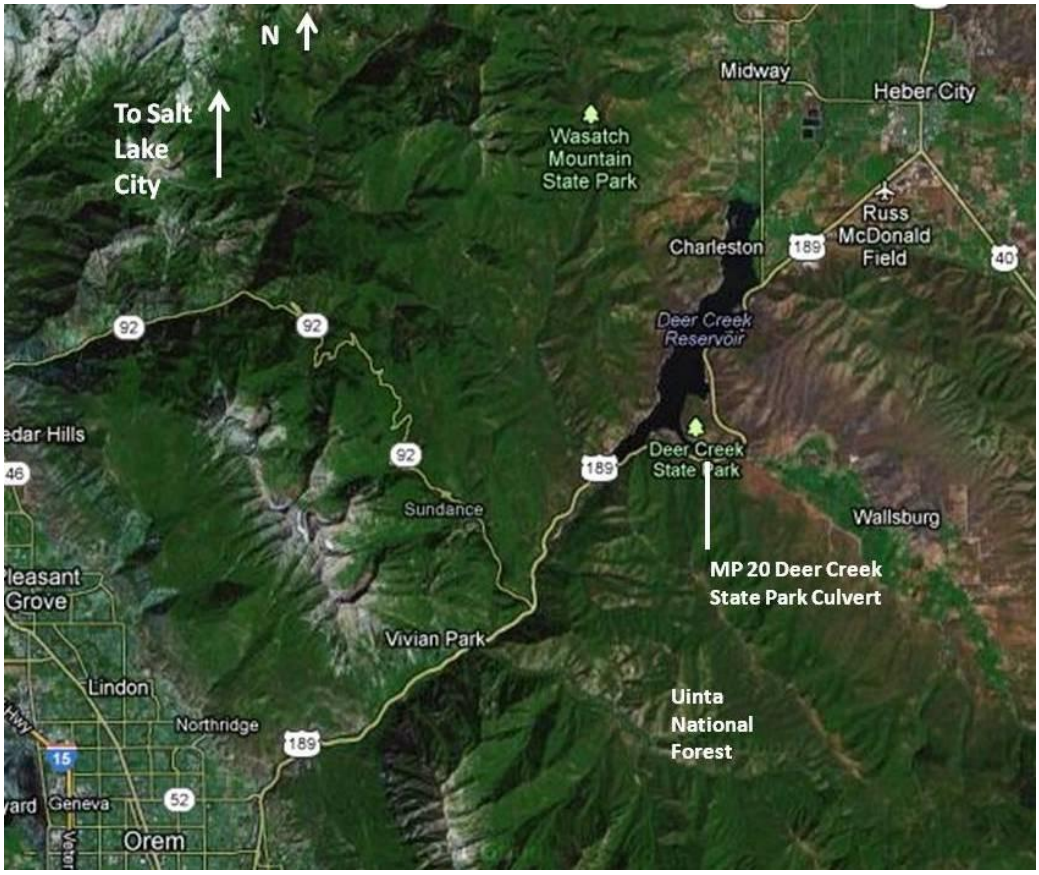

Figure 98. Deer Creek State Park culvert along US 189 in Provo Canyon.

Figure 99. Two mule deer came through the Deer Creek State Park culvert under US 189 in Provo Canyon within several months of its installation.

4.3 Landscape Variables and Fecal Pellet Presence

Vegetation and fecal pellet transects were conducted for all camera sites in the study in 2010 through 2011. Global Positioning System (GPS) points were taken at the new I-70 Arch Crossing (Figure 100). A statistician at Utah State University was consulted on how this data shall be categorized for future statistical analyses. Graduate student Megan Schwender analyzed this data for her master's research, and results will be available by late 2012.

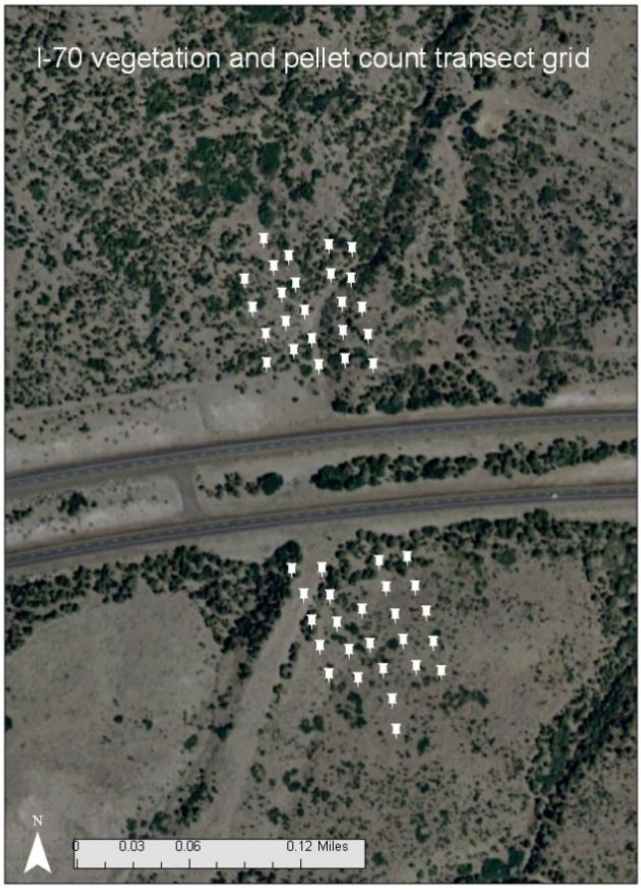

Figure 100. GPS points where vegetation and fecal pellet sampling were conducted at the arch bridge wildlife crossing site along I-70, Utah (photo is of the site before crossing was installed). Photo courtesy of Megan Schwender.

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5.0 CONCLUSIONS

The study demonstrated the success of Utah wildlife crossings in passing mule deer. Over three years (2008-2011), through June 2011, the research documented 25,050 mule deer passages under and over Utah roads in wildlife crossings (23,957 passages) and existing culverts and bridges (1,093 passages) Overall, all monitored wildlife crossing structures created to pass mule deer were documented passing mule deer. At this time the wildlife crossing structures monitored with the highest numbers of deer per day and the lowest rate of repellency are the US Highway 6 Rail Road Bridge at MP 200.7, the sets of culverts at I-15 Wildcat North (MP 126) and Wildcat South (MP 123), and the I-15 Scipio North wildlife underpass bridge (MP 186). The Beaver wildlife overpass above I-15 is also working well at passing mule deer, with over 1,206 mule deer passes in 738 days of monitoring.

Differences in the dimensions of the seven wildlife crossing culverts yield varying wildlife passage success rates. In general, the more open culverts that were shorter in length, wider in width (span), and greater in height had less rates of repellency (under 5%). Five wildlife crossing bridges were monitored. Four were created near the start of this study. The older bridged crossing under I-15 near Scipio (MMP 186) was monitored a short time but it appears to pass mule deer at rates comparable to the US 6 MP 200.7 Bridge and the Wildcat North wildlife crossing culvert. The newer bridges along US Highway 6 all passed mule deer and have increasing rates of mule deer use over time.

Efforts to channel wildlife to existing bridges and culverts on I-80 and I-70 have met with mixed results. The bridges on I-80 in Parley's Canyon, where wildlife fencing was placed for three miles (4.8 kilometers), did not become de facto wildlife passages. White lines painted on the interchanges' exit and entrance ramps along this stretch did nothing to stop over two hundred mule deer, elk, and moose crossings over those lines as they entered and exited the road right-of-way and median. The wildlife fencing placed on I-70 in the fall of 2010 was successful in channeling mule deer and several elk to two existing box culverts and a new arch crossing along the fenced corridor. Approximately one-third of the mule deer and seven percent of the elk that were photographed by monitoring cameras used these structures as of June, 2011. This fencing situation may result in hundreds of mule deer and perhaps dozens of elk crossings at these

structures each year as the animals adapt to them. Continued monitoring will help sort out the details of mule deer and elk acceptance of the new crossing and the two existing culverts.

Existing concrete box culverts under interstates pass few to no ungulates if there is no wildlife fencing present. With wildlife fencing, we see a range of one dozen to ten dozen mule deer passes through each of these culverts over a year, thus providing minimal connectivity for this species, little for elk, and potential connectivity for moose.

The study helped to verify that every wildlife crossing passed mule deer, with a range of dozens to thousands of passes each year. The data helped define successful mitigation efforts and those that need additional adaptive management. Overall this study has greatly increased the state of the science and practice of wildlife crossings in Utah.

6.0 RECOMMENDATIONS AND IMPLEMENTATION

No other state in the U.S. or province in Canada has ever embarked on a study that examines wildlife crossings and other structures across the entire state. This study represents a comprehensive research approach to learn how existing wildlife crossings, new wildlife crossings, and existing structures pass mule deer and other wildlife under and over Utah roads. This study examined 14 wildlife crossings and 21 existing structures in every UDOT region of Utah during the years of 2008 to 2011, through June 2011. The study is being continued with funding from UDWR and conservation organizations until 2013. At that time a full picture of variables that are important to mule deer, elk, moose, and other species of wildlife are hoped to be developed.

Presently, several generalizations can be made and recommendations can be put forth. Since the majority of wildlife-vehicle collisions in Utah occur with mule deer, and since this is the dominant species photographed at all structures, the majority of recommendations pertain to this species. The second important species to reduce wildlife-vehicle collisions with in Utah is elk. Elk-related recommendations follow those for mule deer. Finally, generalizations for passing the highest diversity of species follow.

1. Mule deer will readily use short culverts as well as all studied bridges to move under Utah roads.
2. In order to ensure high mule deer successful passage, culverts should be designed with the shortest possible length, tallest height, and widest width as possible. Length is most important, width is second in importance, and height is least important.
3. All bridge designs monitored in this study were successful in passing mule deer, with success rates of 89 to 98%. Bridges are a very viable option for passing mule deer under and over roads and are recommended as the top design for wildlife crossings. Factors that reduce a bridge's accessibility for mule deer, and thus increase the rate of repellence, are: illegal fencing tacked to the abutments of bridges (I-80 Weber River), large boulders along the creek where the mule deer approach the bridge combined with high water levels (US 6 Starvation Creek), rail lines throughout the structure (US 6 Gilluly), large boulders that block the passage (I-70 Ivy Creek), and loud popping sounds from the bridge as traffic passes over (I-80 Mountain Dell and Lamb's Canyon). These impediments should

be avoided in future wildlife crossing bridges or areas where it is a goal to funnel wildlife to existing structures.

4. Wildlife crossings should include wildlife exclusion fencing 8 feet (2.4 m) high to guide animals to the structures and encourage them to use them.
5. Double cattle guards or wildlife guards need to be used on entrance and exit ramps and other ingress-egress drives when wildlife fencing is placed along a road and used to encourage wildlife use of structures. The experiment on I-80 with painted white lines can attest to the ability of wildlife to adapt to using these open areas to access roads.
6. Mule deer move day and night. In structures where mule deer do not have to share the space with humans, meaning low human use, I-15 Wildcat South, US 91 MP 14, US 6 Beaver Creek for examples, mule deer use the structures 50% of the time in daylight. If an area is being considered for wildlife crossings, its usefulness for wildlife is diminished with roads or recreational trails through the structure.
7. Elk will not use culverts regularly in Utah. All wildlife crossing structures in elk habitat should be designed as bridges with fencing to ensure some degree of use by all elk age classes and genders.
8. Stream crossings are excellent conduits for increasing wildlife crossing use by all species of wildlife. Wildlife crossing placement should consider inclusion of streams through the structure. This offers both an opportunity to restore aquatic connectivity and to increase the diversity of species of wildlife using the crossing. It can also allow for use of the structure by anglers who can avoid going up over the road to traverse a stream or river.
9. There should be continued research of wildlife crossings. For less than 2% of the total cost of a structure, it can be monitored for three years to verify if it is serving the intended purposes of passing wildlife, especially mule deer. In a period of time during smaller budgets for state agencies, UDOT can show the cost effectiveness of structures and their success with such research, as well as learn of the most cost-effective designs. All new wildlife crossing structures should be monitored for at least three years post-mitigation to best gauge if the wildlife species the mitigation was designed for do use the structure in numbers comparable to pre-construction monitoring (Clevenger et al. 2002, Clevenger 2011, Dodd et al. 2007, Gagnon 2011). Another important part of research is collecting enough data across time and space to be able to scientifically and statistically make sound predictions on what structures mule deer and elk are willing to use to keep

them off the roadway. For instance, concrete box culverts over 200 feet (61 meters) in length without wildlife fencing had seven replicates for this study, making a strong case that this type of structure without fencing does not work at passing more than a handful of mule deer. If we could monitor several replicates of bridge and culvert types, as we did with the corrugated steel culverts, we can begin to tease out dimension differences that most influence wildlife use. Utah has become a leader in wildlife crossing design and research with this statewide study.

10. Continued collaboration and communication among state and federal agencies should continue. These continued dialogues can help identify areas of problems with wildlife and vehicle collisions, wildlife migration routes, maintenance fixes, and the successes of wildlife crossings, fencing, and existing structures in keeping wildlife off Utah roads. The US 6 Wildlife Advisory Committee that evolved into a statewide Wildlife Coordinating Committee is a perfect venue for these kinds of dialogues.

The results of this study can assist UDOT personnel in designing the most cost-effective wildlife crossing structures that work for mule deer and other wildlife. Implementation of this research will be the continued design of crossings that are proven to pass mule deer and other species, and the maintenance of crossings and fencing. UDOT engineers can become more confident in the knowledge that most recent designs are working. This may free some designers to be more creative with design considerations. This study validated the basic wildlife crossing designs UDOT created and allows future research and designs to focus more on the most economical means to provide functional wildlife connectivity across roads while also reducing wildlife-vehicle collisions.

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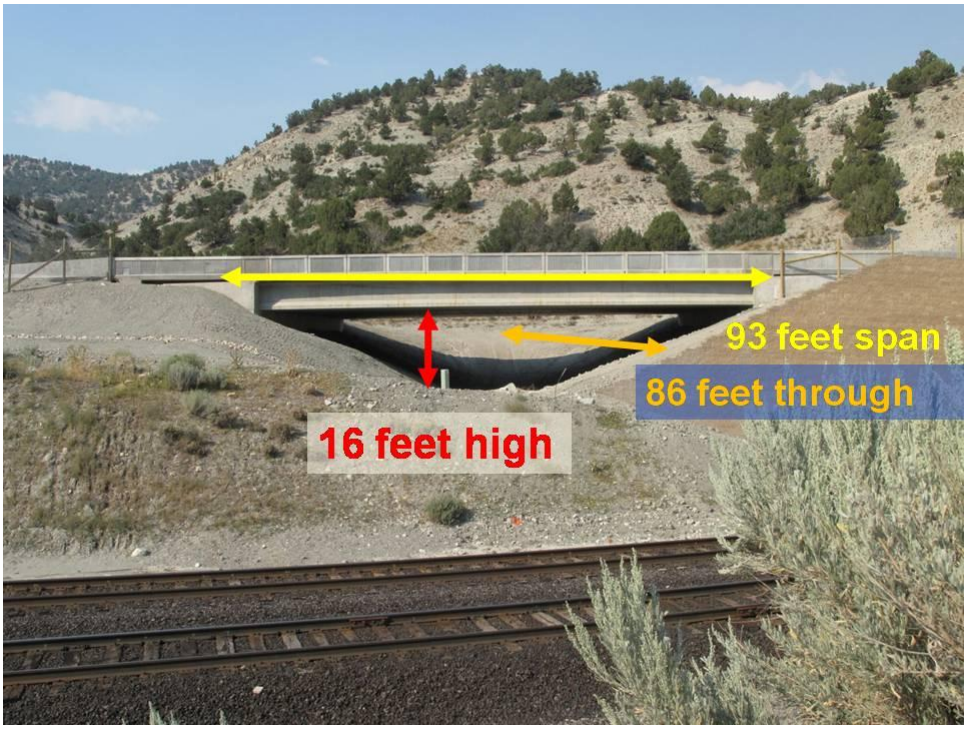
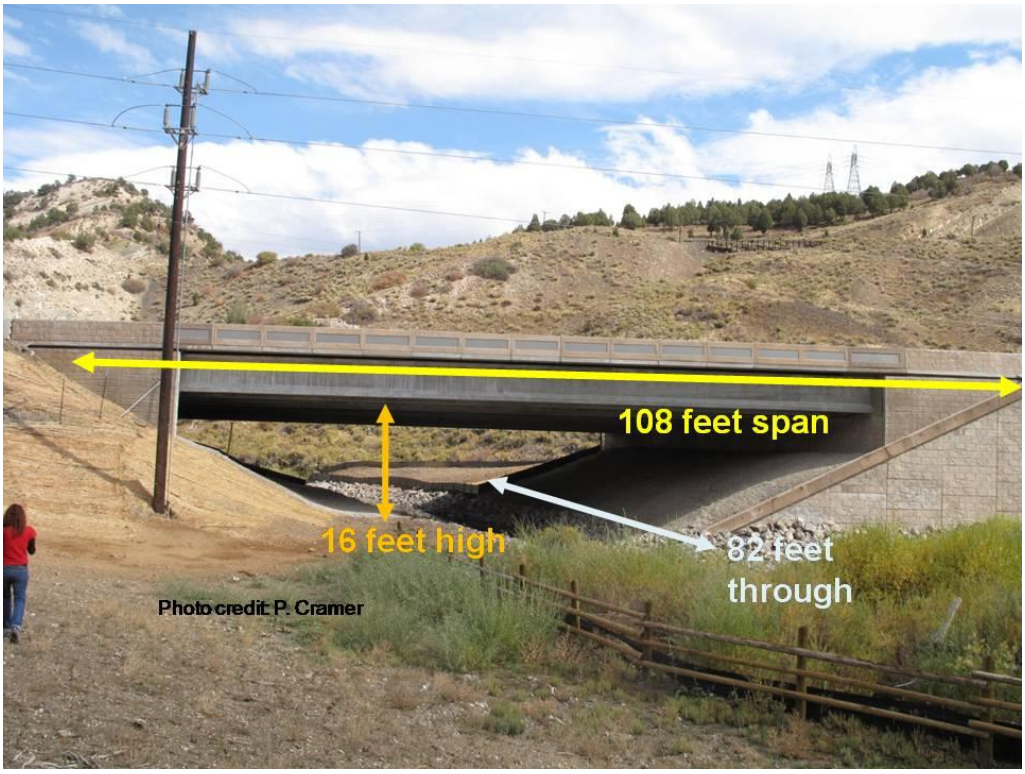
APPENDIX A
SELECT WILDLIFE CROSSING BRIDGE AND CULVERT PHOTOS

This appendix contains select photos of most of the wildlife crossing bridges and culverts and existing culverts monitored in the study. Dimensions are provided for most structures. The appendix was created to better elucidate the configurations of the bridges and culverts, and to provide further evidence of wildlife use of the different structures and mitigation. Photos are organized by roads in the order presented in the text.

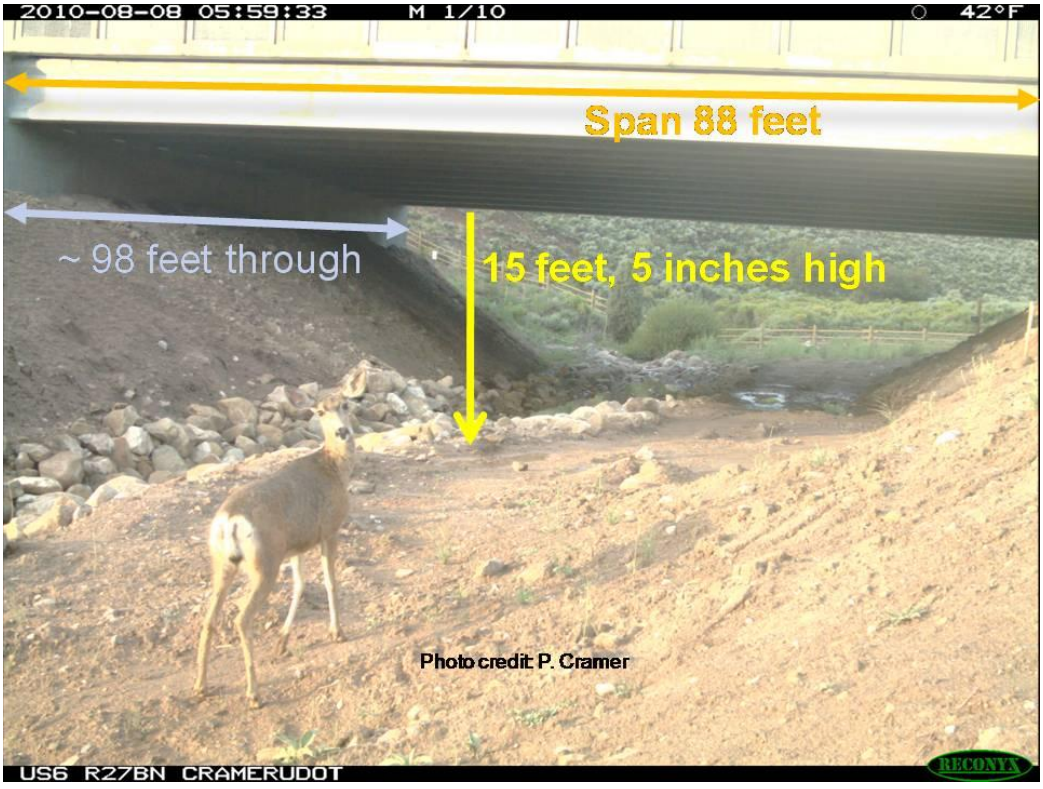
US 6



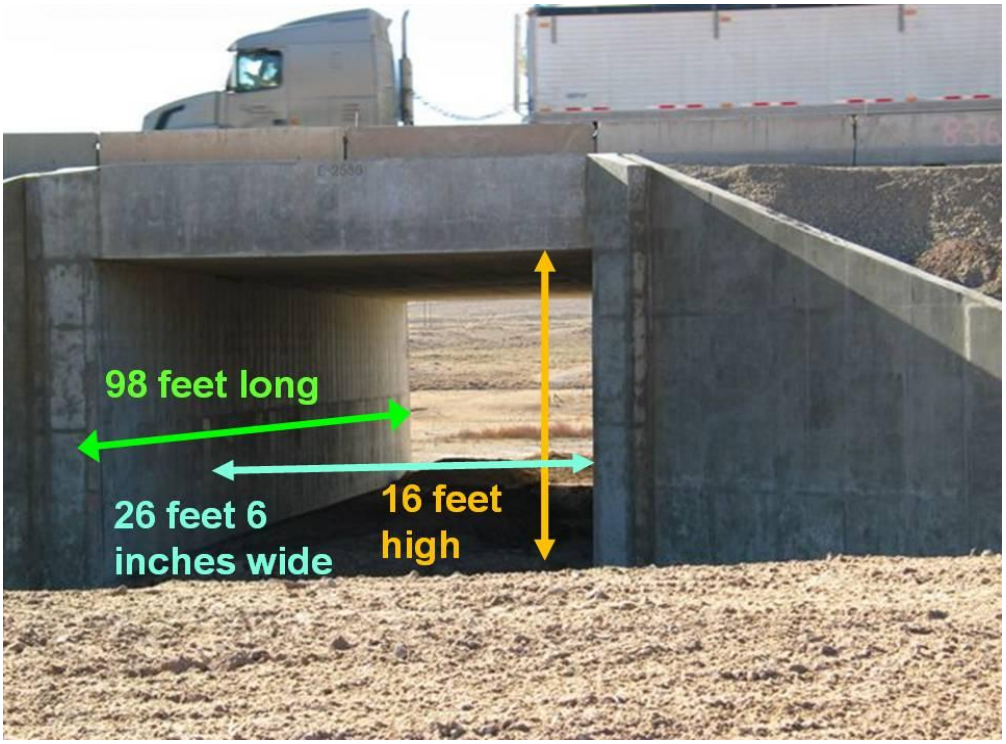
US 6 RxR Bridge wildlife crossing at MP 200.7.



US 6 Starvation Creek Bridge wildlife crossing, MP 204.



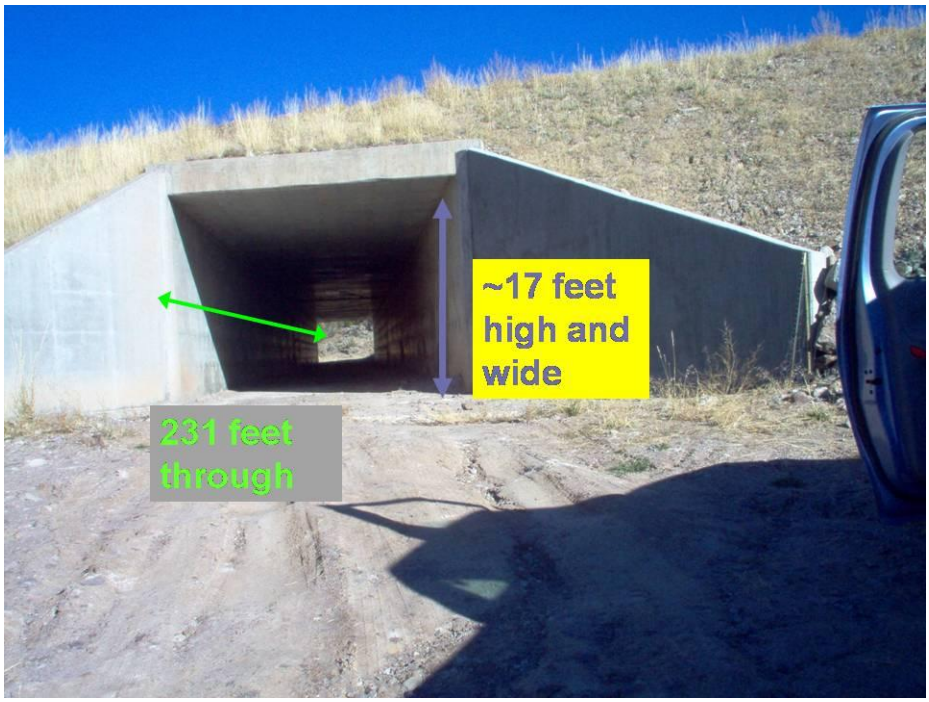
US 6 Beaver Creek Bridge wildlife crossing at MP 220.



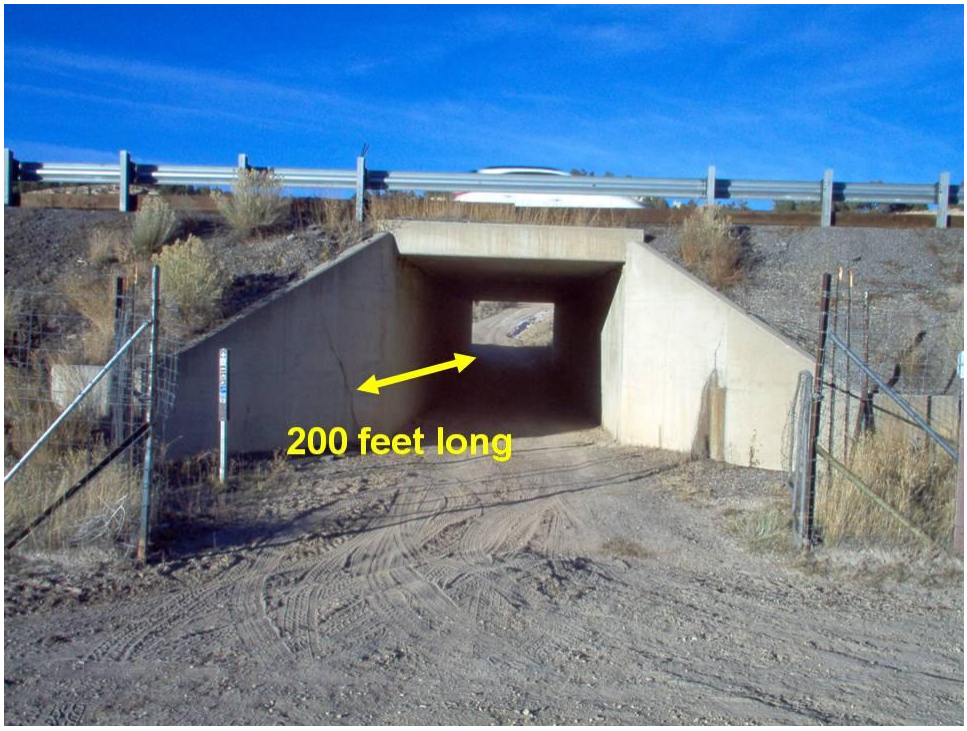
US 6 Colton Culvert wildlife crossing at MP 217.

US 6 Gilluly Bridge MP 205 elk grazing in snow storm.

I-70



I-70 box culvert at MP 6, not a wildlife crossing and no wildlife fencing. Received wildlife fencing with construction of new crossing at MP 5.3 in Fall 2010.



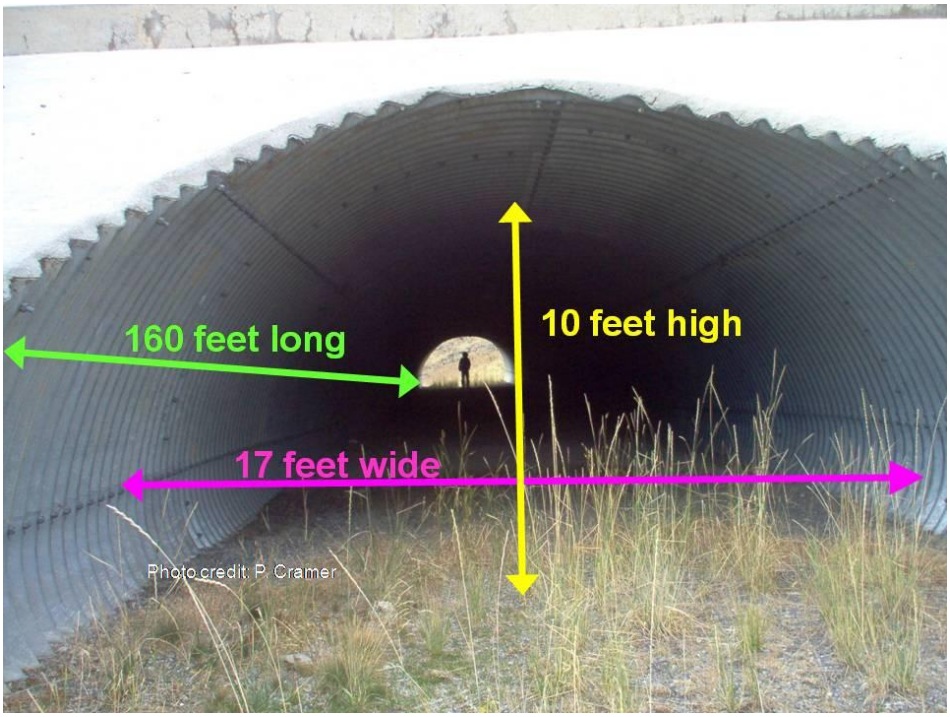
I-70 box culvert at MP 64 called Gooseberry culvert. Wildlife fencing accompanies the culvert.

I-70 Arch bridge wildlife crossing at MP 5.3. Under construction. Completed November, 2010.

I-70 New Arch crossing first deer photographed through (approach from north).

I-70 New Arch crossing first deer herd through (approach from south).

US 89/91

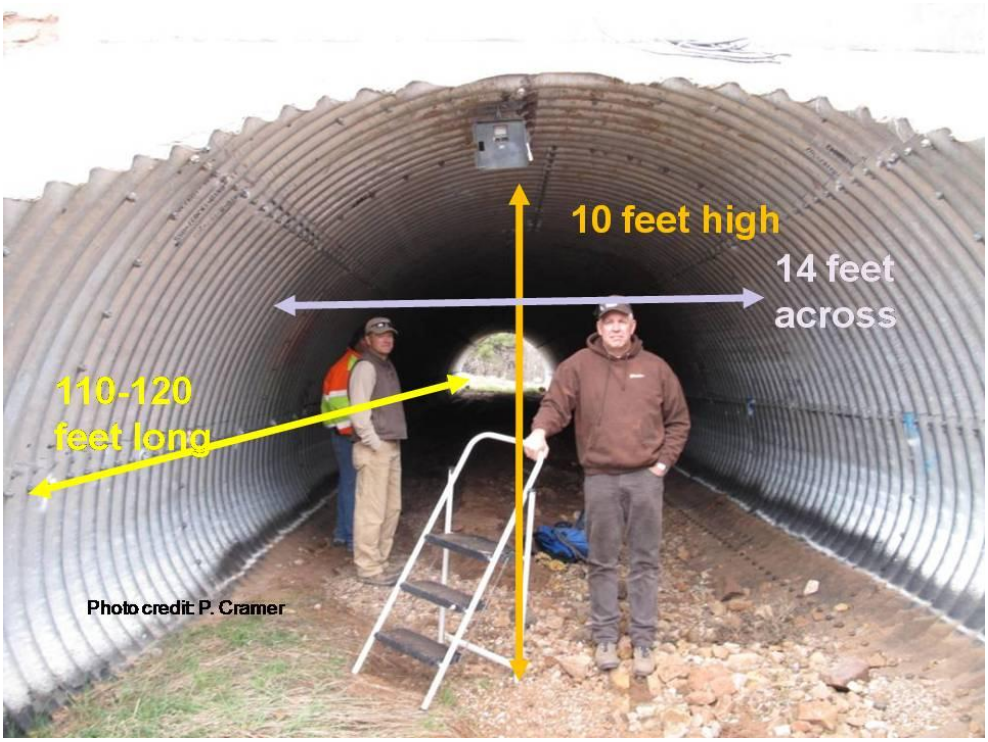


US 89/91 wildlife crossing culvert at MP 14 in the Wellsville Mountains.

Mule deer used US 91 wildlife crossing culvert at MP 8 in the Wellsville Mountains.

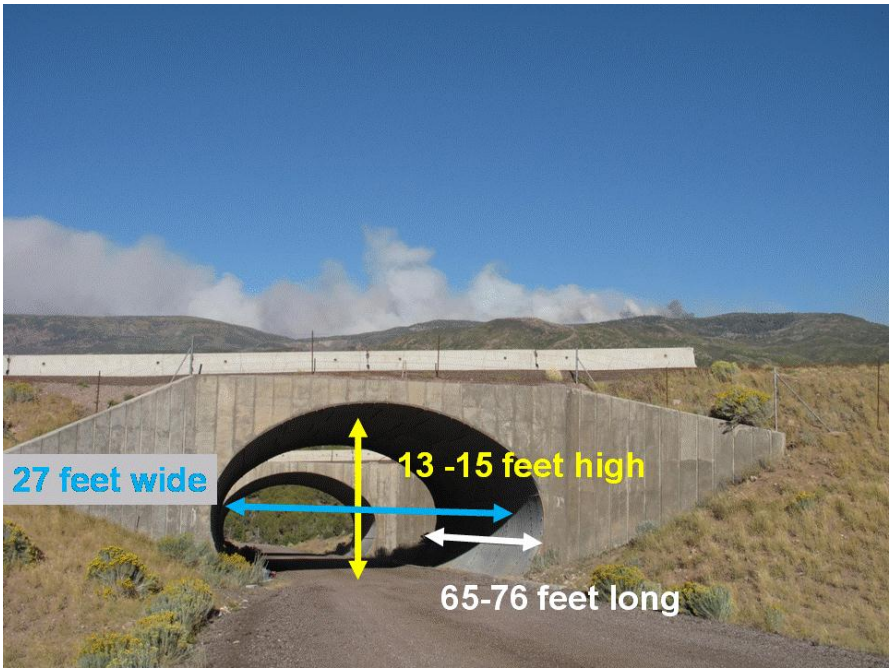
Female moose used wildlife crossing culvert under US 89/91 in Wellsville Mountains, MP 14.

US 191

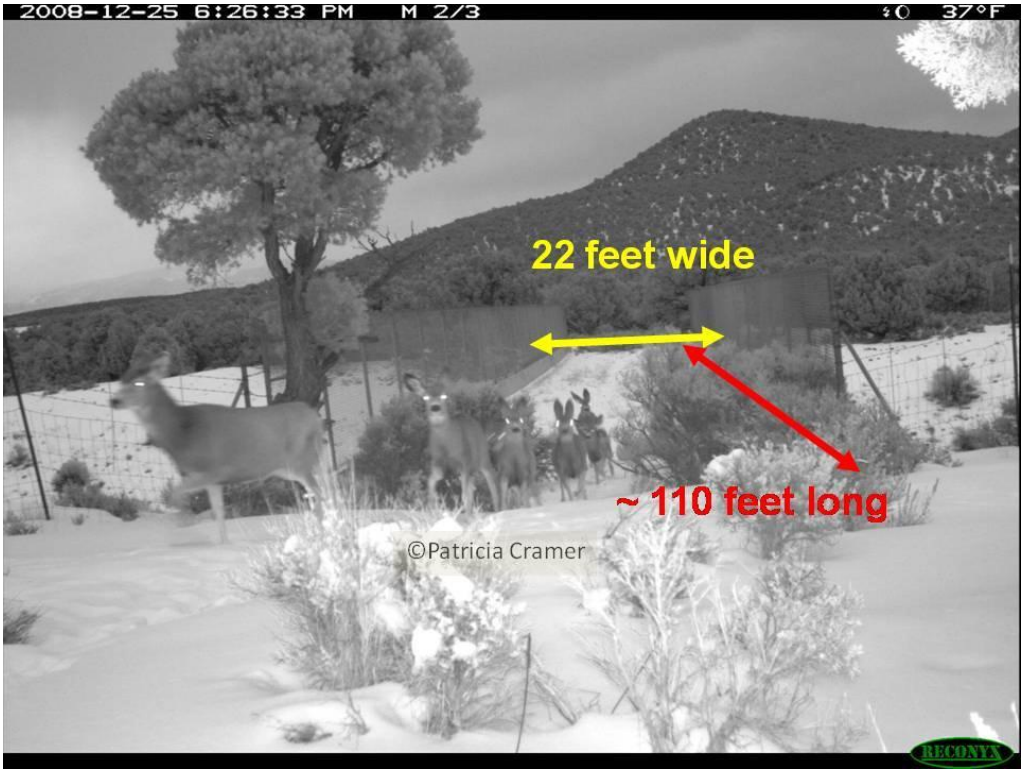


US 191 Monticello wildlife crossing, Devil's Canyon area.

I-15



I-15 Wildcat North MP 126 wildlife crossing, similar to Wildcat South. Note Twitchell Canyon fire in background.



I-15 Wildlife Overpass at MP 102, north bound lanes.

I-15 Camp Creek South culvert. No deer were caught on camera using this culvert.

I-15 Scipio North Wildlife Crossing Bruce Bonebrake (UDWR) with wildlife-friendly fence. Camera was placed in median, between the two bridges.

I-15 Scipio Overpass, as viewed from west side hill. Randall Taylor (UDOT) and Bruce Bonebrake (UDWR) stand in foreground. Camera was positioned on east and north side of overpass, in the background.

The I-15 Scipio South Bridge over U.S. Forest Service road.

I-80

I-80 Mountain Dell Bridge MP 134 and unpaved wildlife path to the left of lanes.

I-80 Lamb's Canyon bridge and interchange MP 137, mule deer at entrance, this animal did not use the area under bridge.

Elk came off of I-80 across painted stripes at Mountain Dell Reservoir exit, MP 134, eastbound entrance ramp.