Refined Recommendations

Wildlife Crossing System on US Highway 36



DUDEK

ECO-resolutions

WSP

Boulder County Parks & Open Space



September 2026

DRAFT

Refined Recommendations

Wildlife Crossing System on U.S. Highway 36

SEPTEMBER 2026

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Table of Contents

SECTION **PAGE NO.**

Executive Summary v

Acronyms and Abbreviations vii

1 Introduction 1

2 Background 5
2.1 Previous Planning Studies 5
2.1.1 The Study Approach and Findings 5
2.2 Focal Species of Current Analysis 6
2.2.1 Elk 7
2.2.2 Mule Deer 9
2.2.3 Preble's Meadow Jumping Mouse 9

3 U.S. 36 Mortality and Connectivity Considerations 17
3.1 Traffic Impacts on Wildlife Mortality and Connectivity 17
3.2 Recreation Impacts on Wildlife Behavior 17
3.2.1 Elk Hunting Considerations 18

4 Benesch Plan Review 19
4.1 Review of the Benesch U.S. 36 Wildlife Crossings Assessment, Prioritization and Cost Estimation Study 19
4.1.1 Study Review 19
4.1.2 Spacing Considerations 21
4.1.3 Fencing and Supporting Mitigation Measures 21

~~5~~ Dudek Team Recommendation Refinement Approach 23

6 Dudek Team Findings and Recommendations 25
6.1 Refined Wildlife Crossing System Recommendations 25
6.1.1 Milepost 21.8, St Vrain Creek Bridge 27
6.1.2 Milepost 22.6, Badger Underpass 33
6.1.3 Milepost 24.75, Nighthawk Overpass 36
6.1.4 Milepost 25, Hackberry Emperor Underpass 38
6.1.5 Milepost 26.3, Rock Mouse Underpass 40
6.1.6 Milepost 27.95, Left Hand Creek Bridge 42
6.1.7 Crossing Structure Spacing 44
6.2 Wildlife Exclusion Fence 45
6.2.1 South Fence End 45
6.2.2 North Fence End 46

6.2.3 Other Fencing Considerations 46
6.3 Mesofauna and Small Fauna Considerations 48
6.4 Bikeway Considerations 49
6.5 Project Phasing 50
6.6 Other Landscape Connectivity Considerations 50
6.7 Updated Costs Summary 52
6.7.1 Cost Estimate Comparison with the Benesch Study 53
6.7.2 Preliminary Cost Estimate Assumptions and Limitations 54
7 Literature Cited 55

TABLES

1 Summary of Recommended Wildlife Crossing Locations and Considerations 26
2 Cost Estimates for U.S. 36 Boulder to Lyons Wildlife Crossing Structures 52

PHOTOGRAPHS

1 Stakeholders meeting at Left Hand Creek Bridge on February 25, 2026. 24
2 View facing south 31
3 View facing south–southeast. 32
4 View from the interior showing available bench for wildlife to use. 33
5 Photo facing northeast. 35
6 Photo facing southeast 36
7 Photo showing proposed area for the Nighthawk Overpass 37
8 Photo facing northwest 38
9 Photo facing east 39
10 Photo facing west 40
11 Photo facing southeast 41
12 Photo facing southwest 42
13 Photo facing north 43
14 Photo facing northeast 44

FIGURES

1 Project Vicinity 3
2 Elk Collar Data, 2017-2020 11
3 Wildlife-Vehicle Collision Hotspots – (Elk) 13
4 Wildlife-Vehicle Collision Hotspots – (Deer) 15
5 Refined Crossing Structure Recommendations 29

APPENDICES

A Focal Species Habitat
B Extended Focal Species Descriptions
C Effects of Traffic on Wildlife
D Elk Hunting Considerations
E Detailed Review of Benesch (2024) Study
F Response to Agency Concerns Regarding the 2024 U.S. 36 Wildlife Crossing Conceptual Designs
G Conceptual Plans
H Detailed Cost Estimate

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Executive Summary

Boulder County Parks and Open Space commissioned an independent technical review and refinement of the conceptual wildlife crossing and exclusion-fencing system proposed for U.S. Highway 36 between St. Vrain Creek and Left Hand Creek. This corridor is a high-priority area for reducing wildlife-vehicle collisions and maintaining movement between foothills and plains habitats. The review focused on improving motorist safety and long-term wildlife connectivity while addressing concerns raised by the Colorado Department of Transportation and Colorado Parks and Wildlife regarding biological effectiveness, constructability, cost, and project scale. The Dudek team reviewed previous planning studies, wildlife-vehicle collision records, elk movement information, focal-species habitat and movement needs, existing and proposed infrastructure, conceptual designs, and cost assumptions. The team also conducted two multidisciplinary field reviews with Boulder County, state transportation, and wildlife agency staff and considered the effects of traffic, recreation, hunting, fencing, and potential future land use changes, on crossing performance. Elk, mule deer, and Preble's meadow jumping mouse were identified as focal species for designing a system to serve large, medium, and small wildlife and maintain connectivity across a range of upland and riparian habitats.

The review found that a comprehensive crossing and fencing system remains warranted, but that the original concept of three large wildlife overpasses could be refined to improve the system's effectiveness, feasibility and cost-effectiveness. The refined system recommendation consists of enhancements at the existing St. Vrain Creek and Left Hand Creek bridges, one wildlife overpass at milepost 24.75, and three wildlife underpasses at MPs 22.6, 25.0, and 26.3. Continuous wildlife exclusion fencing, escape ramps, deer guards, appropriate fence termini, and targeted accommodations for mesofauna and small fauna are integral to the system. The refined network distributes crossing opportunities across the corridor and responds to documented wildlife movement areas, collision patterns, protected-land connections, site conditions, and species-specific design requirements.

The recommended Nighthawk Overpass at milepost 24.75 would provide the principal crossing for elk and other large wildlife in the corridor's core movement area. The Badger Underpass at milepost 22.6 would preserve permeability in the northern portion of the system, while the Hackberry Emperor and Rock Mouse underpasses at MPs 25.0 and 26.3 would provide additional passage opportunities using structures tailored to local topography and habitat conditions. Existing creek bridges would continue to support riparian and terrestrial movement where dry passage and habitat continuity can be maintained. Final dimensions, approach grading, landowner access, fence alignment, drainage, geotechnical requirements, and species-specific features should be confirmed through preliminary engineering and agency coordination.

Integration with the North Foothills Bikeway, which is being planned by Boulder County along the same corridor, is an essential design consideration. The bikeway footprint at each recommended crossing structure has been accounted for in designs to ensure compatibility of the two projects. Another consideration in the crossing structure designs includes visual screening, vegetation enhancements, or other features where cyclists or pedestrians may be visible to wildlife attempting to utilize the structures.

The refined wildlife crossing system has an estimated project cost of approximately $46.0 million in 2026 dollars. This planning-level estimate is based on conceptual quantities and includes allowances for contingency, mobilization, erosion control, environmental and landscaping improvements, drainage and utilities, traffic control, design engineering, and construction engineering and inspection. It uses site-specific structure dimensions, and applies revised project limits and cost assumptions. The estimate is not a final project budget and should be

updated as design advances; right-of-way, permitting, environmental mitigation, geotechnical work, escalation beyond 2026, utility relocation, and other project-specific costs should be incorporated when better information becomes available.

The next phase should advance the recommended system through preliminary engineering, field verification, geotechnical and drainage investigations, refined wildlife and collision analyses, and landowner and agency coordination. Preliminary engineering should confirm structure types and dimensions, resolve fence termini and access points, refine and define disturbance-reduction measures, refine small fauna accommodations, establish monitoring and adaptive-management objectives, and update costs and implementation priorities.

Acronyms and Abbreviations

Acronym	Definition
BCPOS	Boulder County Parks and Open Space
CDOT	Colorado Department of Transportation
County	Boulder County
CPW	Colorado Parks and Wildlife
MP	milepost
NF	North Foothills
Preble's	Preble’s meadow jumping mouse
SH	State Highway
U.S. 36	U.S. Highway 36
WVC	wildlife-vehicle collision

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1 Introduction

Transportation infrastructure can cause threats to wildlife populations from wildlife-vehicle collisions (WVCs), barrier effects from traffic disturbance and mortality due to WVCs, and disruption of normal migration, wildlife community interactions, and reproductive processes. Recently, a system of wildlife crossings and barrier fencing was proposed for U.S. Highway 36 (U.S. 36) to reduce WVCs from traffic and improve wildlife connectivity between important habitat areas (Benesch and Pinyon Environmental 2024). The intent of the proposed system of crossings and fencing is to improve ecological conditions for elk (*Cervus canadensis*) and deer while also benefiting the myriad other species dwelling near the highway.

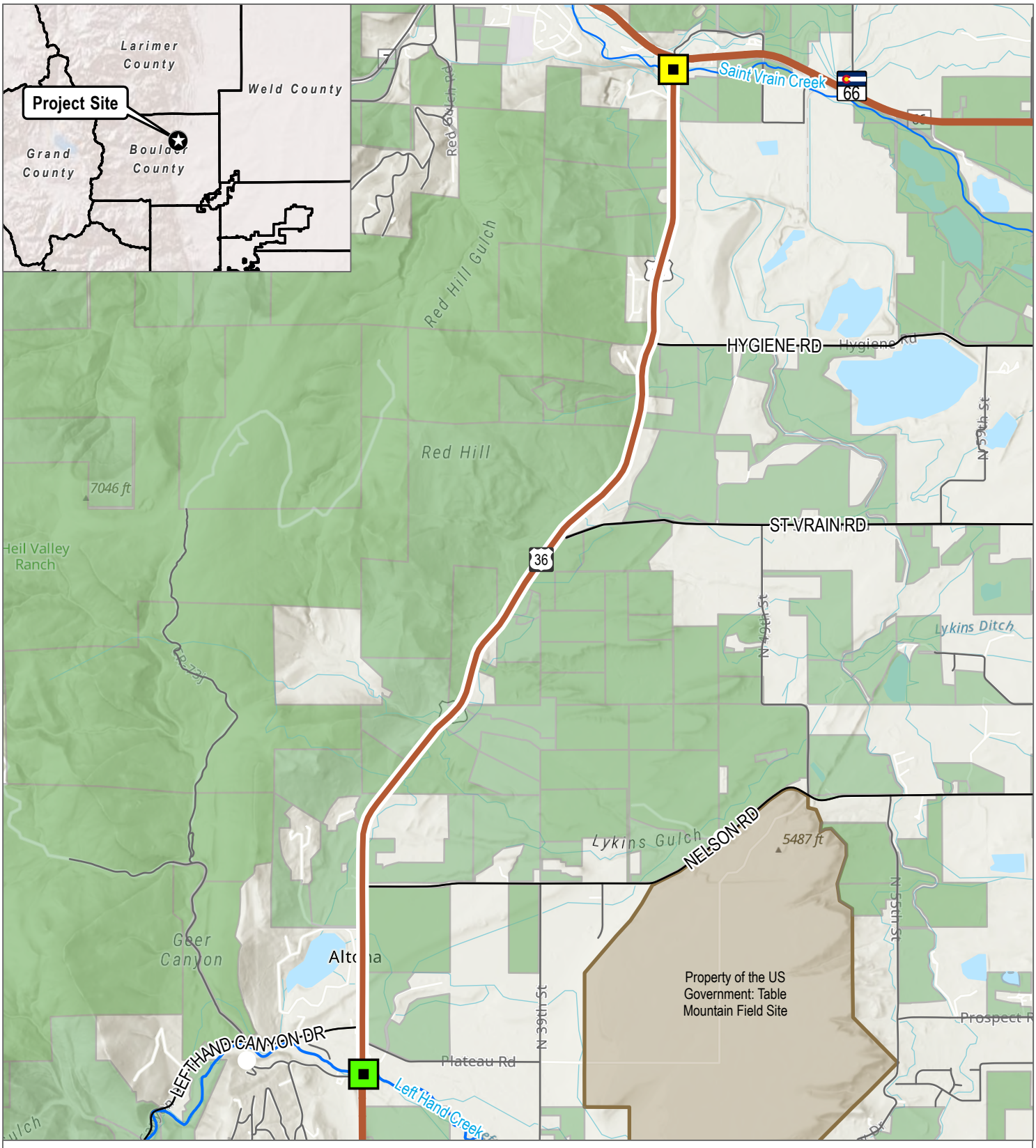


Vehicle versus mule deer near Neva Road on February 25, 2026.

The recommended wildlife crossing design for U.S. 36 extends between the St. Vrain River and Left Hand Creek (Benesch and Pinyon Environmental 2024) (Figure 1, Project Vicinity). Following review of the preliminary crossing and fencing design by Colorado Parks and Wildlife (CPW) and the Colorado Department of Transportation (CDOT), Boulder County Parks and Open Space (BCPOS) initiated an independent third-party review to provide an objective road ecology perspective and additional technical expertise on wildlife connectivity infrastructure. The review was intended to evaluate the proposed crossing and fencing concepts, address comments and concerns raised by CPW and CDOT, and identify opportunities to improve ecological effectiveness and feasibility. The wildlife crossing concepts must also address the concurrent planning efforts for a multi-user shared use path (the North Foothills [NF] Bikeway) within the same corridor. The effort sought to develop integrated recommendations that balance wildlife movement needs, transportation objectives, and long-term corridor functionality.

This report provides an independent, expert review of the U.S. 36 wildlife crossing and fencing plan, including refined, actionable recommendations to improve its effectiveness and practicability. This review evaluates the proposed crossing system with a focus on priority crossing structure locations and types, associated exclusion fencing, and supporting features such as escape ramps (i.e., jumpouts) and drainage structure retrofits. The refined proposal for a crossing system offers an integrated strategy for reducing WVCs and maintaining cross-highway connectivity based on research and best practices implemented in other locations across Colorado and other states. The Dudek Team assessed whether the proposed crossing locations, designs, fencing extents, and other system components function cohesively to provide safe passages under or over U.S. 36 and prevent at-grade wildlife crossings. As a part of the assessment, the Dudek Team evaluated effects from proposed fencing around the Table Mountain area, described how the system would meet the needs of three focal species, and identified gaps, conflicts, and opportunities for optimization. Because both the wildlife crossing and bikeway projects are high priorities for Boulder County (County), a further goal was to ensure coordination of the wildlife crossing system with the planned U.S. 36 NF Bikeway. Coordination requires that the bikeway infrastructure and the presence of cyclists on a separate path parallel to the highway not impact wildlife use of existing and proposed wildlife infrastructure on U.S. 36.

Site visits, field verification, and interested party coordination were conducted to understand local site conditions at proposed crossing locations, observe the landscape, and gather additional input from the County, CDOT, and CPW. These field observations and partner insights were integrated with spatial analysis and the existing study data to support targeted recommendations on crossing type and placement, fencing design and continuity, and potential modifications or phased improvements. The intended outcome of the review process is an updated strategy for a comprehensive wildlife crossing and WVC mitigation system along U.S. 36 with the goal of advancing to preliminary engineering design.



SOURCE: ESRI Topographic, USGS, State of Colorado, City of Boulder (OSMP)

FIGURE 1

Project Vicinity

DUDEK

0 0.5 1 Miles

U.S. 36 Corridor - Safety For All - Wildlife Crossings Conceptual Design Review, Boulder County, Colorado

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2 Background

2.1 Previous Planning Studies

The Eastern Slope and Plains Wildlife Prioritization Study (Kintsch et al. 2022) identified U.S. 36 from St Vrain Road (milepost [MP] 24.3) to Nelson Road (MP 26.9) as a statewide priority segment for wildlife-vehicle conflict reduction in CDOT Region 4. In response, the County commissioned Benesch to evaluate this corridor more broadly—from CO 66 south to Nelson Road—and develop effective mitigation strategies (Benesch and Pinyon Environmental 2024); this evaluation is hereafter referred to as the "Study."

2.1.1 The Study Approach and Findings

The Study's purpose was to assess, screen, and prioritize wildlife crossing locations and infrastructure types for elk, white-tailed deer (*Odocoileus virginianus*), and mule deer (*Odocoileus hemionus*); identify complementary measures such as fencing and accommodations for small animals; and provide cost estimates for the proposed mitigation actions. Ultimately, the Study aimed to provide a strategy for improving human safety and restoring wildlife connectivity through a data-driven and phased implementation approach.

Study Approach

To achieve this goal, the Study employed a structured, multi-step methodology integrating data collection, screening criteria, and quantitative scoring. The Benesch Team first compiled and analyzed available datasets, including long-term WVC records from CDOT (2026) and CPW; elk GPS collar data and species habitat mapping from CPW; and environmental resource information regarding wetlands, threatened and endangered species, and cultural resources. These data focused heavily on elk and deer movement, occurrence, and mortality. These datasets were supplemented with geographic information system mapping, aerial imagery, site reconnaissance, and input from agency staff, allowing the team to identify elk and deer movement areas, collision hotspots, and key ecological and physical constraints.

The Benesch Team identified an initial list of 14 potential wildlife crossing locations based on WVC hotspots, drainage features, topography, and prior regional recommendations. These locations were then screened using a suite of weighted criteria: large animal WVC frequency, elk/deer movement, crossing structure feasibility, right-of-way ownership and potential to leverage public lands, and environmental permitting considerations. Each location was scored and ranked based on the weighted criteria, narrowing the list to a smaller set of feasible, high-potential sites for further analysis.

A second-stage prioritization evaluated the top-ranking sites using a more detailed matrix, comparing WVC reduction potential, connectivity, cost, benefit–cost ratio, environmental considerations, and land ownership advantages. Supporting analyses included smoothing WVC data using a 0.5-mile moving-average technique to reduce milepost-reporting artifacts and better identify collision hotspots, mapping elk/deer collision densities, and developing cost estimates based on conceptual designs. In parallel, the Study assessed complementary strategies such as wildlife fencing, detection systems, and culvert retrofits for smaller species, integrating all elements into a phased implementation framework.

Study Findings and Recommendations

The Benesch Team recommended a coordinated package of structural and non-structural measures, prioritized and phased to reduce WVCs while improving wildlife connectivity across the highway. The recommendations focused on constructing key wildlife crossings, installing fencing to prevent animals from entering the highway, enhancing existing CDOT bridges over creeks, and installing stock passes and other culverts for smaller species. The Benesch Team prioritized the implementation of these mitigation actions based on their relative effectiveness and available funding.

The primary recommendation was the construction of three wildlife overpasses, which were ranked based on priority. The highest-ranking priority was an overpass at MP 24.6, which showed the greatest concentration of elk and/or deer crossings, the highest elk/deer WVC rates, and the strongest benefit–cost performance, making it the most beneficial single investment. The second priority was an overpass at MP 26.4, which also had relatively high elk and deer use and favorable land ownership. The third priority was an overpass at MP 22.4, which ranked lower due to fewer documented elk and deer crossings, higher cost, and less favorable adjacent land ownership.

The Benesch Team also recommended continuous wildlife exclusion fencing along U.S. 36 and targeted fencing on several associated roadways, including State Highway (SH) 119, North 55th Street, and Plateau Road. This fencing was intended to prevent wildlife from accessing roadways, provide access to crossing structures, and included features such as deer guards and escape ramps. A wildlife detection system and driver warning system were also recommended along Nelson Road to alert drivers to the presence of large animals.

To support smaller species, the Benesch Team recommended retrofitting existing drainage culverts with relatively low-cost modifications such as barriers, jumpouts, guide walls, lighting grates, catwalks, natural substrates, and vegetation. These upgrades were anticipated to improve small fauna passage without requiring entirely new structures, although the potential effectiveness and feasibility of these improvements at each culvert location was not assessed.

The Benesch Team recommended phased implementation. Phase 1 focused on the MP 24.6 overpass, U.S. 36 fencing, and culvert upgrades to achieve the greatest immediate reduction in WVCs. Phase 2 expanded mitigation to nearby roads with additional fencing and detection systems, and Phase 3 included construction of the remaining overpasses on U.S. 36. It was noted in the Study that all recommendations were conceptual and would require further design, permitting, funding, and coordination to implement.

2.2 Focal Species of Current Analysis

A focal species approach was employed in the current analysis to help ensure that crossing structures proposed by Benesch were sited and designed to encompass the movement needs of other species of wildlife in the project area (Benesch and Pinyon Environmental 2024). For the U.S. 36 project area, the Dudek Team identified elk, mule deer, and Preble's meadow jumping mouse (*Zapus hudsonius preblei*; Preble's) as focal species suitable for wildlife-highway mitigation planning in this area. A wildlife crossing and



fencing system built to accommodate these species could serve other wildlife with similar habitat preferences, including fox, bobcat (*Lynx rufus*), and other small- and medium-sized fauna. Inclusion of Preble's as a focal species would tend to protect movement of other riparian-preferring species, such as black bear (*Ursus americanus*) and mountain lion (*Puma concolor*), as well as mesofauna and small fauna species that prefer underpasses. The Dudek Team referenced CPW's Species Activity Mapping, which generally characterizes species' seasonal ranges or other occupied and potential habitats (Appendix A, Focal Species Habitat). The following abbreviated focal species descriptions highlight relevant habitat and movement considerations and crossing structure preferences (detailed focal species descriptions are presented in Appendix B).

2.2.1 Elk

Habitat and Connectivity Needs

In the spring, migratory elk descend from the forested mountains to the west down through the foothills and, during the winter months, concentrate on either side of the highway. Notably, a portion of the herd has become resident in recent years, remaining in the area year-round, particularly around the County's Loukonen and Trevarton properties, as well as the federal facility of Table Mountain (National Telecommunications and Information Administration). Figure 2 depicts collar data from several elk between 2017 and 2020. Figure 3 depicts several WVC hot spots for elk, which primarily occur near MPs 23.0, 24.5, 24.9, and 26.0.



Elk image captured by high-elevation drone over Boulder County Haystack Mountain open space. Credit Mike Wussow (May 2023)

Restricting elk access to preferred habitats through development, roads, fencing, and similar features has consistently been shown to alter how elk use the landscape and can have lasting population-level consequences. When access to core habitat is lost, elk are often displaced into less productive or less secure habitats, which can increase crowding and competition in the remaining areas they continue to use. The impacts of diminished access to habitat are relevant in the context of the potential construction of an exclusion fence by the Department of Commerce around their land on Table Mountain, which provides approximately 1,700 acres of preferred habitat for elk in this landscape. While the specific consequences of removing access to habitat on Table Mountain remains uncertain, anticipated effects include localized altered movement patterns, displacement into other open space properties for calving and sheltering, and potential exploration into lands used for agriculture.

Wildlife Crossing Preferences

In western North America, overpasses and large underpass structures with high openness have proven to be the most successful at passing Rocky Mountain elk. Research in both Arizona and Canada has found that elk prefer structures that are open and provide good sight lines, although use can increase over time as animals adapt to the crossing structures. On the Trans-Canada Highway, Clevenger and Barrueto (2014) found passage rates were positively correlated with structure width, height, and openness and negatively correlated with structure length and traffic disturbance. Similarly, on State Route 260 in northern Arizona, wide and tall open span bridges achieved 83% success rates for migratory and resident elk (Gagnon et al. 2011), while Dodd et al. (2007) found that elk passage rates at crossing structures were lower during timeframes with high traffic volumes, such as weekends.

Crossing structure location relative to elk seasonal ranges and movement patterns is also an important consideration. In northern Colorado sagebrush winter range, elk use of crossing structures was primarily influenced by the location of the crossing structures relative to the distribution of elk in the landscape (Kintsch et al. 2021).

Preferred crossing structures for elk include wildlife overpasses, open span bridges (underpasses), and, to some extent, large arch culverts. Effective bridge underpasses for elk generally range from 60 to 100 feet in width and 16 to 25 feet in height, with the most effective underpasses under 100 feet long. As structure length increases, underpasses should be built wider and taller to avoid the feeling of a long, dark tunnel. Because large arch culverts are generally narrower than bridges, these structures may be suitable for elk movements within seasonal home ranges or residential herds but are not recommended where crossing structures must accommodate larger herds of elk during seasonal migrations.

Red Hill Management Plan

The Red Hill elk herd, a sub-herd of the larger St. Vrain elk herd, occupies County open space lands around Red Hill, Heil Valley Ranch, and adjacent foothill properties west of U.S. 36. CPW and BCPOS have been monitoring the herd since the late 1990s to better understand its movements and habitat use. Historically, elk migrated between high-elevation summer ranges near Niwot Ridge and St. Vrain Mountain and lower-elevation winter ranges around Red Hill and Heil Valley Ranch. Over time, however, changes in land management and recreation patterns led elk to shift their distribution to more secluded areas, particularly along the hogbacks near U.S. 36 and other protected open space lands (Boulder County 2020).

A major concern emerged when biologists documented the development of a growing resident elk herd east of U.S. 36. Radio-collar studies conducted by CPW and BCPOS beginning in 2017 showed that some elk were no longer making traditional seasonal migrations and instead remained year-round in the area around Table Mountain and adjacent agricultural lands. This resident herd grew rapidly and is now estimated at approximately 100 to 125 animals. As this resident population increased in number, it increased WVCs, as these elk use areas both east and west of U.S. 36, so more crossings occurred, and they occurred year-round. During the winter, migratory elk join the resident herd, and local numbers can exceed 400 animals, all crossing U.S. 36 (Boulder County 2020).

In response, the County and CPW developed the Red Hill Elk Management Plan in 2020. The plan uses a combination of population management, monitoring, and habitat-based strategies to reduce conflicts while maintaining a healthy elk population (Boulder County 2020). One of the primary management tools is a controlled public hunting program focused on antlerless elk. The herd is closely monitored through radio collars, annual population counts, remote cameras, and drone surveys. This information helps managers track population trends, habitat use, and movement patterns and allows the program to be adjusted as conditions change. The monitoring data have also provided information about where elk are attempting to cross U.S. 36 and where WVCs are most common.

The Red Hill Elk Management Plan recognizes that elk need to move safely between habitats on both sides of U.S. 36 and that restoring habitat connectivity is an important long-term management strategy. While the plan includes a management hunt aimed at reducing conflicts associated with the resident Red Hill elk herd, it also acknowledges the need to maintain wildlife movement across the landscape and avoid further fragmentation of habitat. For this reason, the plan specifically supports evaluating and constructing wildlife crossings along U.S. 36. The County identified wildlife crossings as a key component of its overall strategy to improve highway safety, reduce elk mortality, maintain landscape connectivity, and facilitate safe movement of resident elk between seasonal use areas on either side of the highway. As a result, the Red Hill Elk Management Plan and the U.S. 36 Wildlife Crossings Project have become closely linked and complementary efforts (Boulder County 2020).

2.2.2 Mule Deer



Mule deer occur throughout the U.S. 36 landscape and vehicle collisions involving deer are distributed throughout the corridor (Figure 4, Wildlife-Vehicle Collision Hotspots – [Deer]). WVCs are distributed throughout the project area, with key areas along the MP 22 segment, MP 24 segment, and MP 27 segment (data were primarily collected by milepost historically so precise data are not available currently). Mule deer use of crossing structures is well documented across the western United States and includes box culverts, arch culverts, bridge underpasses, and overpasses. Mule deer are less sensitive to underpass openness than elk. Likelihood and frequency of mule deer use of crossing structures increases with structure width and height and decreases with length (Shilling et al. 2024).

2.2.3 Preble's Meadow Jumping Mouse

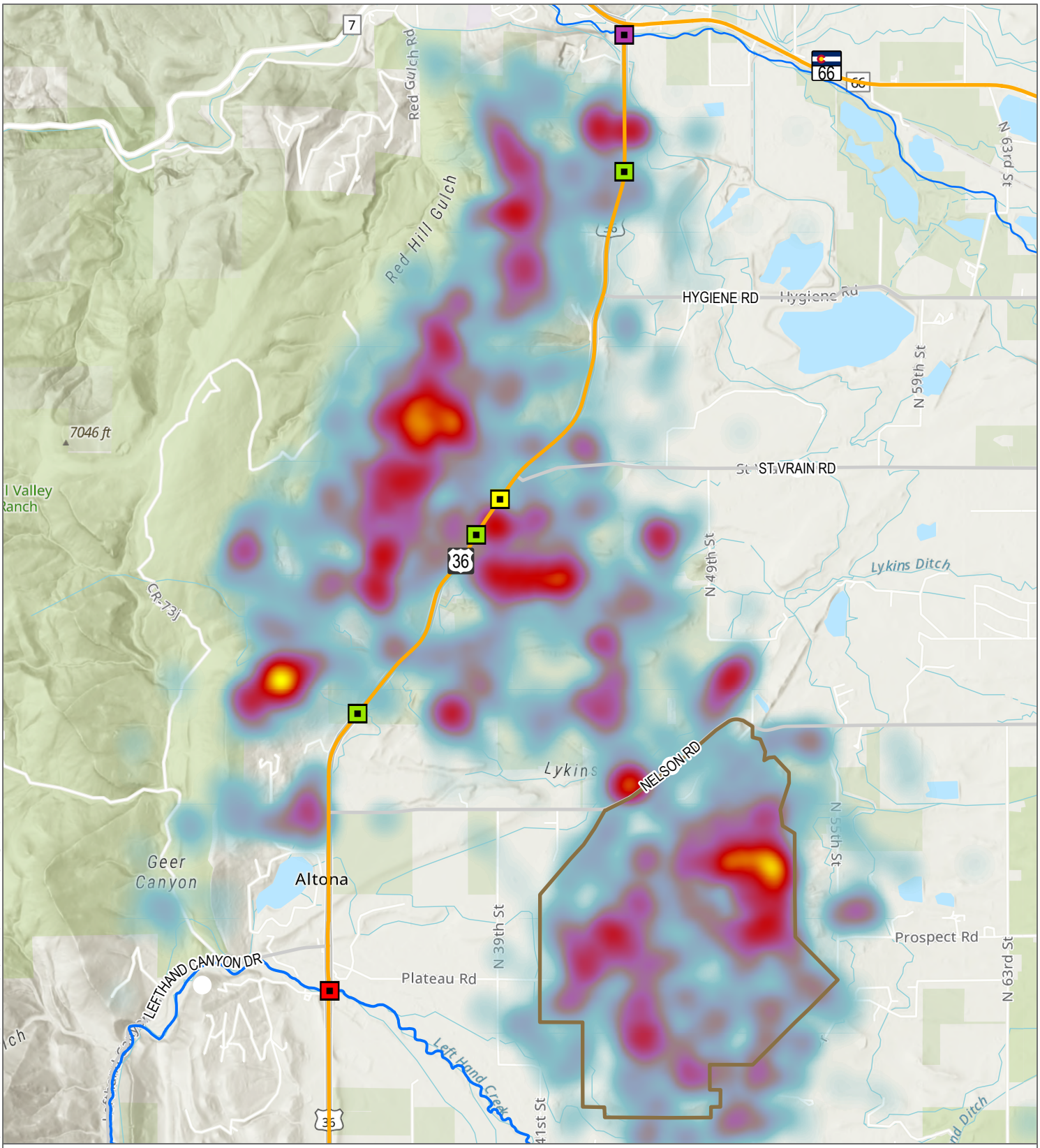


Preble's is a federally Threatened, riparian-dependent subspecies endemic to the Front Range of Colorado and southeastern Wyoming, including riparian systems along the U.S. 36 corridor. BCPOS actively conducts Preble's monitoring and has engaged in riparian restoration efforts at selected locations across the County. Preble's occupancy is recognized as an indicator of healthy riparian ecosystems and, in recent years, management strategies have shifted toward maintaining long-term habitat connectivity and ecological function rather than site-specific protection alone (USFWS 2022; Knight et al. 2025).

Connectivity and Crossing Needs

Movements of Preble's are generally localized and typically constrained to linear riparian corridors, with additional use of adjacent upland areas within approximately 300 feet of the riparian edge. Because movements are largely restricted to areas with dense vegetative cover, the continuity

of riparian habitat plays a critical role in allowing individuals to access foraging areas, breeding habitat, and hibernation sites throughout the year (Trainor et al. 2012). Direct empirical evidence documenting the use of culverts or other crossing structures by Preble's is limited; however, available literature consistently indicates that roads and other linear infrastructure can fragment habitat when they interrupt riparian vegetation or alter hydrologic conditions. Based on the species' movement ecology and observations of other small riparian mammals, transportation structures that preserve riparian continuity and natural channel conditions are considered beneficial for maintaining functional connectivity, even though targeted studies specific to this species remain limited (USFWS 2022; Salo et al. 2020). Notably, Preble's were documented using specially designed small fauna cover features through a large mammal underpass spanning a creek corridor (Kintsch et al. 2025). These features provide consistent woody cover through an otherwise open underpass and connect into the habitat on either side of the crossing. In contrast, long, dry, perched, or lined culverts lacking cover are likely to reduce permeability and serve as partial movement barriers for Preble's.



SOURCE: Colorado Parks and Wildlife; ESRI Topographic

* data from 2017-2020

FIGURE 2

Elk Collar Data, 2017-2020

DUDEK

0 0.5 1 Miles

U.S. 36 Corridor - Safety For All - Wildlife Crossings Conceptual Design Review, Boulder County, Colorado

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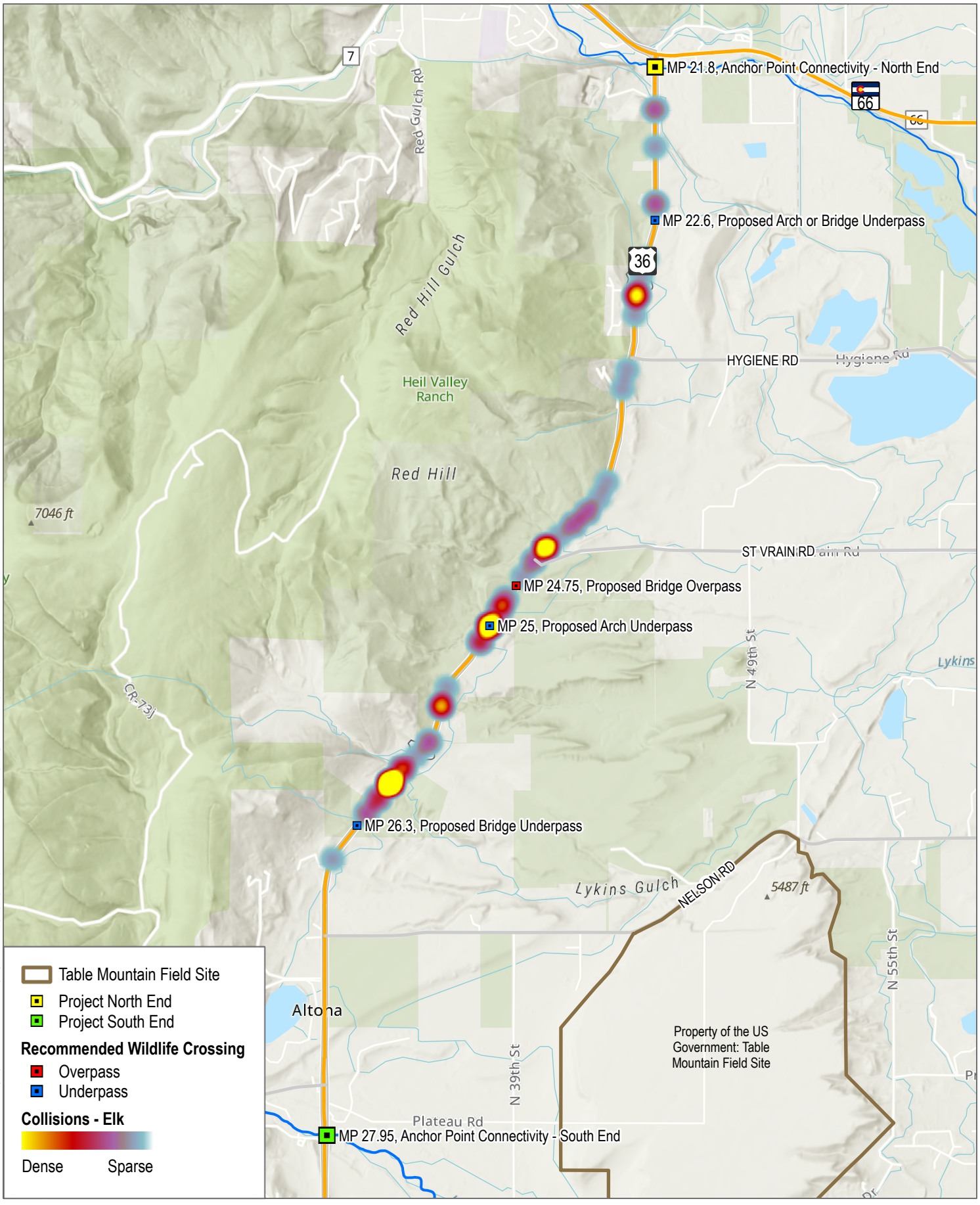

SOURCE: Colorado Parks and Wildlife; CDOT, 2010-2024; ESRI Topographic

* data provided by CDOT (2010-2024)

FIGURE 3

Wildlife-Vehicle Collision Hotspots - (Elk)

DUDEK

0 0.5 1 Miles

U.S. 36 Corridor - Safety For All - Wildlife Crossings Conceptual Design Review, Boulder County, Colorado

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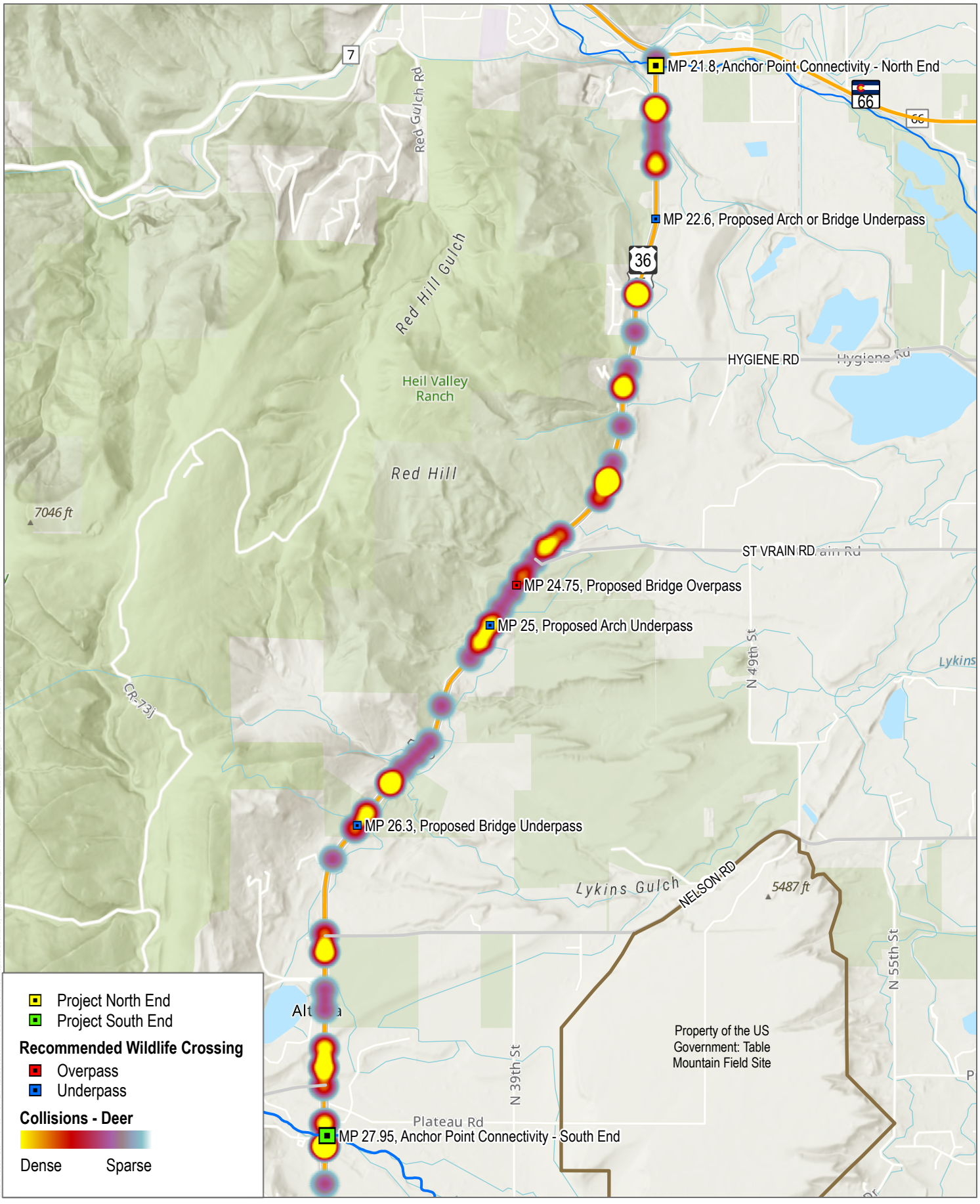

SOURCE: Colorado Parks and Wildlife; CDOT, 2010-2024; ESRI Topographic

* data provided by CDOT (2010-2024)

FIGURE 4

Wildlife-Vehicle Collision Hotspots - (Deer)

DUDEK

0 0.5 1 Miles

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3 U.S. 36 Mortality and Connectivity Considerations

3.1 Traffic Impacts on Wildlife Mortality and Connectivity

Traffic volume strongly influences wildlife movement, mortality, and habitat connectivity by affecting both the likelihood of animals attempting to cross a road and the risk of WVCs. Research indicates that roads with intermediate traffic volumes can pose the greatest risk to certain species of wildlife because animals continue to attempt crossings while experiencing a high probability of collision, whereas very high traffic volumes can create behavioral barriers for some species that reduce crossings but increase habitat fragmentation and isolation, although these effects vary by species (Grilo et al. 2015; Haworth 2026; Jacobson et al. 2016; Riginos et al. 2018; Seiler 2003). Traffic also alters wildlife behavior by increasing vigilance and flight/avoidance behavior and decreasing foraging activity near roads and crossing structures (Collins et al. 2022; Nojoumi et al. 2022).

U.S. 36 project area traffic volumes range from approximately 9,900 to 12,000 average annual daily traffic (CDOT 2026), falling within the transitional range where both mortality risk and barrier effects are expected to be important. Wildlife is likely to continue attempting roadway crossings, resulting in elevated collision risk, while increasing traffic volumes reduce roadway permeability and begin to impede movement across the landscape. Consequently, the project area is expected to experience both wildlife mortality and reduced connectivity, making traffic impacts a significant concern for maintaining wildlife movement and population connectivity. Please see Appendix C, Effects of Traffic on Wildlife, for more information.

3.2 Recreation Impacts on Wildlife Behavior

It is anticipated that cyclist numbers and frequency of use would increase with the successful construction of the bikeway. It is a goal to encourage cyclists of varying abilities to use the new and safer bikeway infrastructure, and a subset of expert cyclists would continue to use the U.S. 36 shoulder, as they currently do. While the recommended wildlife exclusion fencing would physically separate bikeway users from wildlife, the increased visible human presence may influence wildlife behavior. This finding is based on extensive research showing that when people are visible (e.g., as pedestrians or cyclists), wildlife avoid the area (e.g., Boyle and Samson 1985; George and Crooks 2006; Gaynor et al. 2018; Larson et al. 2016; Lenth et al. 2008; Lewis et al. 2021; Reilly et al. 2017; Beaupre et al. 2025). Studies conducted specifically at wildlife crossing infrastructure have also documented behavioral responses to cyclists and pedestrians. For example, Phillips et al. (2001) found that recreational users disrupted migrating mule deer movements near an I-70 underpass in Colorado, demonstrating that recreation can interfere with wildlife use of crossing locations.

These studies collectively point to the importance of understanding the convergence of use in the corridor, including the holistic influence of humans (cyclists, motorists) using U.S. 36, and wildlife behavior. The County is committed to advancing the interests and safety of cyclists, motorists and wildlife. Finding mutually beneficial solutions is important to the success of both projects on this corridor. In Phillips et al. (2001), the addition of an opaque screen blocking visibility of cyclists and pedestrians to wildlife using the underpass significantly improved underpass use, suggesting a mitigation strategy for the U.S. 36 wildlife crossings. These and other mitigations are discussed in

more detail in Section 6, Dudek Team Findings and Recommendations, and would be described in a companion report describing coordination of wildlife crossing and bikeway design.

3.2.1 Elk Hunting Considerations

Hunting can influence elk behavior by increasing perceived predation (by non-human mammals) risk, resulting in greater vigilance, altered movement patterns, and avoidance of areas where human activity is associated with danger. Research consistently shows that hunted elk are more likely to seek security cover, shift habitat use away from areas of concentrated hunting activity, and modify movement behavior compared to elk in non-hunted settings (Ciuti et al. 2012; Proffitt et al. 2013). These responses can affect local habitat use and movement patterns of resident elk, although the timing of the Red Hill elk management is intended to be directed at resident animals and the hunt does not overlap with seasonal migration periods and therefore is not expected to affect migratory animals. As wildlife crossing infrastructure is implemented along U.S. 36, consideration of how local hunting activities may influence resident elk movements near crossing locations would be an important component of adaptive management.

Studies of flight initiation distance, or flushing distance, indicate that elk exposed to hunting pressure often respond to humans at distances of approximately 200–500 meters, although observed distances vary based on hunting intensity, habitat conditions, visibility, and previous exposure to humans (Found 2021; Stankowich and Blumstein 2005). These findings suggest that minimizing concentrated hunting activity within a buffer surrounding crossing structures and associated approach corridors may help maintain crossing effectiveness for resident elk. Given the overlap between portions of the Red Hill elk management area and proposed crossing locations, the County and CPW should consider the influence of hunting on local movement patterns when implementing future crossing infrastructure. If post-construction monitoring indicates changes in elk use of crossing structures or adjacent movement corridors, the County and CPW should evaluate hunting strategies, hunt locations, and available management areas to ensure that wildlife crossings continue to function as intended and support long-term landscape connectivity.

For more detailed information regarding elk hunting considerations, please see Appendix D.

4 Benesch Plan Review

The Dudek Team's review was based on the conceptual wildlife crossing and fencing plan developed by Benesch and Pinyon Environmental (2024) for the U.S. 36 corridor between U.S. 66 and Nelson Road, which includes Dudek's effective project area from St. Vrain Creek Bridge to Lefthand Canyon Drive. The Benesch Study evaluated 14 potential crossing locations and advanced three wildlife overpasses for conceptual design, cost estimating, and prioritization:

- **MP 22.4 overpass**–Selected to provide a crossing opportunity in the northern portion of the project area.
- **MP 24.6 overpass**–Identified as the highest-priority crossing location based on elk movement data, favorable topography, and adjacent open-space ownership.
- **MP 26.4 overpass**–Selected to serve the southern portion of the corridor where wildlife crossing activity and WVC occurrence were elevated.

In addition to the three recommended overpasses, the Study identified several existing drainage structures and potential underpass locations that could support wildlife movement. While these locations were screened out from the final overpass prioritization process, the Study suggested that the MP 25.0 underpass be evaluated further during future design as a potential alternative to the MP 24.6 overpass. The Study also identified the MP 26.3 underpass as a potential backup location should the MP 26.4 overpass prove infeasible during subsequent design.

The plan recommended wildlife exclusion fencing with escape ramps and deer guards along both sides of U.S. 36 from St. Vrain Creek to Lefthand Canyon Drive. Fence termini were designed to direct wildlife toward safe crossing opportunities while minimizing opportunities for animals to access the roadway.

The purpose of this review was to evaluate whether the proposed crossing locations, fencing configuration, and supporting infrastructure function collectively as an effective and implementable wildlife crossing system and to identify opportunities for refinement.

4.1 Review of the Benesch U.S. 36 Wildlife Crossings Assessment, Prioritization and Cost Estimation Study

The following is a summary of an expert review of the Study. This review considers the basis and assumptions of the Study, the wildlife crossing locations identification and screening process, and the resulting findings and recommendations. The intent of this review is to provide additional expertise and review toward highlighting potential gaps and additional considerations to inform status quo, further refinement, or revised recommendations.

4.1.1 Study Review

The primary impetus for the Study was the high rate of WVCs on U.S. 36 particularly involving deer (mule deer and white-tailed deer) and elk, as well as the identification of this segment of U.S. 36 as a top 5% priority corridor in CDOT Region 4 for WVC reduction and wildlife connectivity improvements (Kintsch et al. 2022). Given the strong body of research demonstrating that wildlife crossings used in conjunction with exclusion fencing are among the most effective approaches for reducing WVCs while maintaining wildlife movement (Rytwinski et al. 2016), the Study appropriately focused on evaluating opportunities for these measures.

The Study was tasked with identifying appropriate locations for elk and deer crossings to promote connectivity and an integrated barrier fencing design to reduce WVCs. The Study largely accomplished this, with notable issues and limitations inherent to the modeling approach, the data used, and the likelihood that the proposed crossings would meet the needs of all wildlife species in the area. While the recommended crossing locations are likely to provide benefits to a range of wildlife, the extent of those benefits would depend on the degree to which other species share similar pathways, habitat preferences, and disturbance tolerances.

Prioritization process limitations included the following:

1. The summation method would tend to emphasize places with more data because of biased data collection.
2. WVC data were primarily available for elk and deer, which, when combined with the elk and deer collar data, would tend to prioritize those locations with more data.
3. WVC hotspots were generally co-located with major mileposts (this has been the standard method used to collect data), meaning that WVCs could have occurred anywhere within that mile-long segment. However, spatial data accuracy is purposefully improving and more precise data are now becoming available.
4. Primary use of large mammal data in the prioritization would lead to selection of crossing locations and types that would only benefit medium and small wildlife if they shared habitat preferences with deer and elk. The Study did suggest making sure the prioritized new crossings and existing structures be modified to allow medium and small wildlife passage.

The Study's recommended overpasses and potential underpass alternatives are based on current wildlife crossing guidance and on the habitat, topographic, and ownership conditions present within the corridor. Overpasses are often considered highly effective for facilitating movement of large ungulates and other open-habitat species, particularly when combined with wildlife fencing. However, habitat preferences vary among wildlife species, and the effectiveness of any crossing structure for a broader suite of taxa can depend on factors such as vegetative cover, surrounding habitat connections, structure dimensions, and levels of human disturbance. The Study acknowledged this consideration through its recommendations for small-animal crossing improvements and associated culvert enhancements.

The Study recommends overpasses with a minimum width of 165 feet, presumably based on federal guidance (Clevenger and Huijser 2011). However, advances in wildlife crossing design and monitoring conducted since publication of that guidance suggest that narrower structures can also function effectively for ungulate passage when properly sited and designed. Several successful projects in Colorado, Nevada, and Wyoming have documented substantial use by elk, mule deer, and other large mammals at crossing structures that do not meet this width threshold, indicating that factors such as landscape context, fencing design, approach conditions, and overall connectivity may be as important as structure width alone.

Another important consideration that is not fully addressed in the Study is the influence of disturbance factors on crossing structure performance and wildlife use. Traffic noise, vehicle headlights, recreational activity, and other sources of human disturbance can affect the willingness of wildlife to approach and use both overpasses and underpasses. Consequently, crossing structures should be sited and evaluated with these factors in mind, and where disturbances cannot be avoided, appropriate mitigation measures should be incorporated into the design. Such measures may include vegetation screening, earthen berms, sound walls, visual barriers, or strategic use of natural topography to reduce noise and light intrusion and improve the effectiveness of the crossing opportunity for wildlife.

A more detailed evaluation of the Study is contained in Appendix E.

4.1.2 Spacing Considerations

A notable aspect of the Study's screening methodology is how it addressed spacing between crossings. Section 4.2 of the Study notes that there are no widely accepted wildlife crossing spacing standards and cites examples ranging from approximately 0.9 to 3.8 miles apart. Rather than including spacing as a scored criterion, the Study considered it qualitatively alongside wildlife movement patterns, site conditions, and other screening results.

This approach influenced the screening results in Section 4.3. Because spacing was evaluated outside the scoring matrix, the final recommended crossings were not selected solely based on weighted scores. Instead, spacing helped ensure that crossings would be distributed across the corridor rather than concentrated within a single movement hotspot. The Study ultimately advanced overpass locations at MP 22.4, MP 24.6, and MP 26.4, resulting in crossings spaced roughly 2 miles apart within the range reported in the wildlife crossing literature for mule deer and elk.

The influence of spacing is particularly evident at MP 22.4. Although this location supports fewer elk movements and has had fewer reported WVCs than the central portion of the corridor, the Study specifically cites “good spacing” as one reason for advancing it for further evaluation. Similarly, the MP 25.0 underpass was identified as a potential alternative to the MP 24.6 overpass rather than an additional crossing because both locations serve the same core wildlife movement area. This reflects an effort to avoid clustering multiple large crossing structures within a relatively short distance.

Overall, spacing functioned as a corridor-scale planning consideration rather than a site-specific scoring variable. This helped balance local collision and movement hotspots with broader connectivity objectives and contributed to a network of crossings distributed across multiple movement zones. While wildlife movement and WVC data remained the primary drivers of the screening results, consideration of spacing influenced which locations advanced and helped shape the final recommendations. Because spacing was evaluated qualitatively rather than quantitatively, its effect is not directly visible in the scoring matrix, but it appears to have been an important factor in the selection of the final crossing locations.

4.1.3 Fencing and Supporting Mitigation Measures

The effectiveness of the proposed wildlife crossing system depends not only on the location and design of crossing structures, but also on the performance of the supporting infrastructure intended to reduce WVCs and facilitate safe wildlife movement. The Dudek review evaluated the proposed fencing network and small-animal crossing enhancements to assess whether they are consistent with current road ecology research and likely to achieve the intended project objectives.

Wildlife fencing is a critical component of the overall mitigation strategy with the primary function of preventing wildlife from accessing the roadway and thereby reducing WVCs. The Study states that fencing is intended to guide animals to crossing locations; however, available evidence suggests that wildlife exclusion fencing primarily functions as a barrier that redirects animal movements along the fence line rather than actively guiding animals toward a crossing structure. As a result, fencing effectiveness is largely determined by fence continuity, termination design, maintenance, and the proximity of crossing structures to natural movement pathways.

The proposed herptile barrier enhancements would provide a valuable opportunity to improve permeability for reptiles and amphibians while reducing roadway mortality for these taxa. To maximize effectiveness, barriers should be constructed from opaque materials rather than transparent or translucent materials. Opaque barriers reduce the likelihood that animals would repeatedly attempt to move directly through the structure after visually detecting habitat on the opposite side. Incorporating this design consideration would improve the long-term effectiveness of the barrier and is consistent with recommendations from previous herpetofauna crossing studies. These barriers would be located in areas known to support herpetofauna habitat or movement.

Several recommendations related to culvert enhancements warrant additional evaluation during final design. In particular, the use of lighting grates remains largely experimental and their effectiveness for promoting wildlife passage through culverts has not been conclusively demonstrated. While lighting grates may help maintain moisture, temperature, and atmospheric conditions favorable to some amphibian and reptile species, there is limited evidence that additional illumination within a structure increases crossing use by wildlife. In some situations, unshielded grates may introduce flashing light effects from vehicle headlights that could discourage animal passage. Recent research (Shilling et al. 2024) has further suggested that some small animal species may preferentially use narrower and longer tunnel structures, potentially because such structures provide refuge from predators. Therefore, if lighting grates are incorporated into future designs, their use should be linked to specific biological objectives with verified effects, rather than assuming they would broadly increase wildlife use across species groups.

Collectively, these findings suggest that the supporting mitigation measures identified in the Study provide a strong foundation for improving ungulate permeability and reducing ungulate WVCs along U.S. 36. However, refinement of fencing objectives and the implementation of small fauna enhancements could further improve the biological effectiveness and long-term performance of the overall crossing system for a broader array of wildlife.

5 Dudek Team Recommendation Refinement Approach

After an initial review of the background information, the Dudek Team, BCPOS, CDOT, and CPW conducted a site visit on February 25–26, 2026. The goal of this site visit was to review each of the originally prioritized crossing structure locations, as well as other potential crossing locations based on a preliminary review of the Study. The visit included a comprehensive field review of existing and planned infrastructure (including mapped and unmapped culverts), focused evaluation of three proposed overpass locations and alternatives identified in the Study, evaluation of other potential wildlife crossing locations, and assessment of the Left Hand Creek Bridge area. After the visit, there was general agreement on several preliminary refinements to the siting and/or design of large wildlife crossings. The team also aligned on advancing conceptual design, ongoing roadkill data collection, information synthesis (e.g., fencing, bikeway, and species information), and continued interagency coordination to support further development of crossing concepts, cost estimates, and future field validation of proposed modifications.

A second site visit was conducted on May 4–5, 2026, with BCPOS, CDOT, and CPW to review the updated wildlife crossing locations, proposed structure types and dimensions, modified fence design, and a potential phasing strategy. The visit included field review of five priority crossing locations, evaluation of species-specific use patterns (notably elk, deer, carnivores, and Preble's), and refinement of crossing structure types and fence alignments. The site visit also addressed movement zones, sightline constraints, and roadway safety considerations. Key points of agreement included prioritizing crossings in areas of documented elk movement, potential wildlife exclusion fence alignments along U.S. 36, and eliminating less effective options from further consideration. Site visit participants also generally concurred on optimizing structures for both large and small wildlife, avoiding lighting in crossings, and continuing coordination with CPW and CDOT to refine design assumptions and expected wildlife response in the event of a phased implementation approach.

Both field visits were preceded by conference room meetings to set the stage and were followed by additional meetings to discuss key points and conclusions.

Photograph 1. Stakeholders meeting at Left Hand Creek Bridge on February 25, 2026.



6 Dudek Team Findings and Recommendations

This review process highlighted several notable findings, which informed the Dudek Team's updated recommendations for a comprehensive system of wildlife crossings on U.S. 36. In their review of the original wildlife crossing recommendations, both CDOT and CPW expressed concerns about advancing three wildlife overpasses along a short stretch of highway serving small to moderately sized herds of migratory and resident elk and deer. Agency comments suggested that the proposed level of infrastructure investment should be carefully evaluated relative to the documented WVC patterns, wildlife movement data, anticipated biological benefits, project costs, and competing statewide wildlife crossing priorities. Limited state and federal funding, combined with the viewshed impacts of three overpass structures, potential implementation challenges, and public perceptions regarding the scale of the proposed investment, could have negative repercussions on advancing the project. As a result, this review placed particular emphasis on identifying opportunities to maximize biological effectiveness and motorist safety benefits while improving cost efficiency, constructability, and overall project feasibility.

This review also takes into account ongoing development of the NF Bikeway project and the need to ensure compatibility where the bikeway and wildlife crossing projects overlap. Because both initiatives seek to improve transportation infrastructure within the same corridor, opportunities exist to integrate planning, design, and implementation in ways that support both wildlife connectivity and active transportation objectives. Accordingly, the Dudek Team evaluated how wildlife crossing structures, fencing systems, and supporting infrastructure could be coordinated with bikeway improvements to minimize conflicts, reduce redundancy, and enhance the overall effectiveness of both projects. These findings directly informed the recommendations presented in this report and support an integrated corridor-scale approach to wildlife movement, motorist safety, and recreational access.

6.1 Refined Wildlife Crossing System Recommendations

Based on the review process, site visits, and associated agency coordination, the Dudek Team generally supports the original recommendations for a comprehensive system of wildlife crossings and fencing extending from roughly St Vrain Creek to Left Hand Creek, while recommending refinements to crossing locations, structure types, dimensions, and supporting infrastructure to improve biological effectiveness, constructability, and cost efficiency. The refined wildlife crossing locations are summarized in Table 1, which identifies the recommended crossing structure locations, crossing types, and primary design considerations. Collectively, the revised recommendations include enhancements to existing bridge structures, one wildlife overpass, and three wildlife underpasses intended to provide crossing opportunities for a range of large-, medium-, and small-bodied wildlife species. Additional mitigation components—including wildlife exclusion fencing, escape ramps (jumpouts), deer guards (at driveways and local streets), and other supporting infrastructure—are discussed in the sections that follow, as these elements are critical to the overall effectiveness of the crossing system.

Table 1. Summary of Recommended Wildlife Crossing Locations and Considerations

Location	Recommended Crossing Structures	Implementation Considerations
MP 21.8 St. Vrain Creek Bridge	▪ This location is presumed to have limited function as a wildlife crossing, but is being considered as a tie-in for the north fence end. ▪ Maintain dry bench under existing bridge underpass for terrestrial wildlife passage.	▪ Coordinate with other efforts to maintain low levels of human activity under the bridge. ▪ Coordinate with adjacent landowners to reduce impediments to wildlife movement.
MP 22.6 Badger Underpass	▪ Arch underpass 16 feet H × 40 feet W × 75 feet L	▪ Maximize vertical clearance by raising road grade. ▪ Remove berm on the west side of U.S. 36 to open the approach.
MP 24.75 Nighthawk Overpass	▪ Bridge overpass 100 feet W × 100 feet L, 17 feet H vehicle clearance	▪ Amend the Red Hill Elk Management Plan to create a no-hunting buffer area around the overpass, beyond the state-law-required 50 feet from centerline.
MP 25 Hackberry Emperor Underpass	▪ Arch underpass 16 feet H × 40 feet W × 74 feet L	▪ Amend the Red Hill Elk Management Plan to create a no-hunting buffer area around the overpass ▪ Coordinate with landowner(s) regarding access agreements
MP 26.3 Rock Mouse Underpass	▪ Bridge underpass 16 feet H × 40 feet W × 70 feet L	▪ Coordinate with adjacent landowner(s) ▪ Avoid impacts to nesting raptors
MP 27.95 Left Hand Creek Bridge	▪ Maintain undisturbed riparian corridor under existing bridge to continue supporting terrestrial wildlife passage. ▪ Tie wildlife exclusion fence into north bridge abutments to serve as the south fence end for the wildlife crossing system.	▪ Ongoing coordination with the North Foothills Bikeway project to reinforce need for wildlife use of the Left Hand Creek Bridge. ▪ Work with adjacent landowners to inform them of the importance of not entering the area (Barnes Property), which is designated as closed to the public, due to sensitive wildlife and wildlife connectivity.

Note: MP = milepost; H = height; W = width; L = length; U.S. 36 = U.S. Highway 36.

The refined recommendations were developed in response to concerns raised during agency review and incorporate additional input from CDOT and CPW. Appendix F provides a summary of how agency input was addressed in the refined wildlife crossing system recommendations. The revised approach applies a focal-species framework that considers species-specific movement patterns, habitat associations, and crossing requirements when evaluating crossing locations and spacing. By siting crossing opportunities with respect to the ecological needs of focal wildlife groups, the recommendations seek to improve the likelihood of successful crossing use while maintaining functional connectivity across the corridor. The recommendations also account for foreseeable future changes that may influence wildlife movement patterns and crossing effectiveness, including implementation of the NF Bikeway, potential wildlife exclusion fencing associated with Department of Commerce (National Telecommunications and Information Administration) facilities on Table Mountain, and other future changes in land use, transportation infrastructure, wildlife management, or environmental conditions. Incorporating these considerations at the planning stage increases the likelihood that the crossing system would remain effective over the long term.

Wildlife crossing systems, including wildlife exclusion fencing and associated mitigation components, are a proven strategy for reducing WVCs, particularly with large and medium fauna, while simultaneously maintaining or restoring wildlife connectivity across transportation corridors. Effective systems function by preventing wildlife access to the roadway and providing strategically located crossing opportunities under or over the highway. Within the U.S. 36 corridor, the effectiveness of a wildlife crossing system is enhanced by the extensive network of protected open space, conservation easements, public lands, and undeveloped habitat located both east and west of U.S. 36. Permanent protection of natural habitats and working lands helps ensure the long-term functionality of wildlife infrastructure investments by maintaining habitat quality, reducing future barriers to movement, and preserving landscape connectivity. The relationship between protected lands, habitat connectivity, and the refined crossing structure recommendations is illustrated in Figure 5, Refined Crossing Structure Recommendations, which provides important context for understanding the conservation and safety benefits of the proposed system.

Each of the proposed wildlife crossing locations is discussed in further detail below. Figure 5 shows the location of the recommended crossing structures within the corridor. Conceptual plans for each proposed crossing structure and a rendering of the Nighthawk Overpass are provided in Appendix G.

6.1.1 Milepost 21.8, St Vrain Creek Bridge

The St Vrain Creek Bridge is an existing structure immediately south of the U.S. 36–CO 66 interchange on the outskirts of the Town of Lyons. A floodplain bench under the bridge along the north side of St. Vrain Creek remains dry except under flood conditions. Due to its proximity to the U.S. 36–CO 66 interchange, adjacent development, non-sanctioned recreational use, and other human disturbances, the bridge is likely of limited value for the identified focal species, except for incidental passage by mule deer, white-tailed deer, and other generalist wildlife species that are relatively tolerant of human activity. Although human activity likely reduces the structure's effectiveness for focal wildlife species during peak daytime periods, the bridge may still function as a movement corridor during nighttime hours and other periods of low human use, thereby contributing to local wildlife connectivity. Additionally, the structure has been identified as a potential tie-in (anchor point) for the north fence end.

Alternative northern fence termini should be further evaluated during preliminary engineering (approximately 35% design) and refined during final design to maximize WVC reduction benefits while minimizing conflicts with access points and coordination with adjacent land uses. This evaluation should be led by a qualified road ecologist in coordination with the design team, CDOT, local agencies, and affected landowners to ensure that fencing effectively guides wildlife to crossing opportunities while balancing engineering, operational, and property access considerations. A detailed discussion of fencing and potential alternatives is presented in Section 6.2, Wildlife Exclusion Fence.

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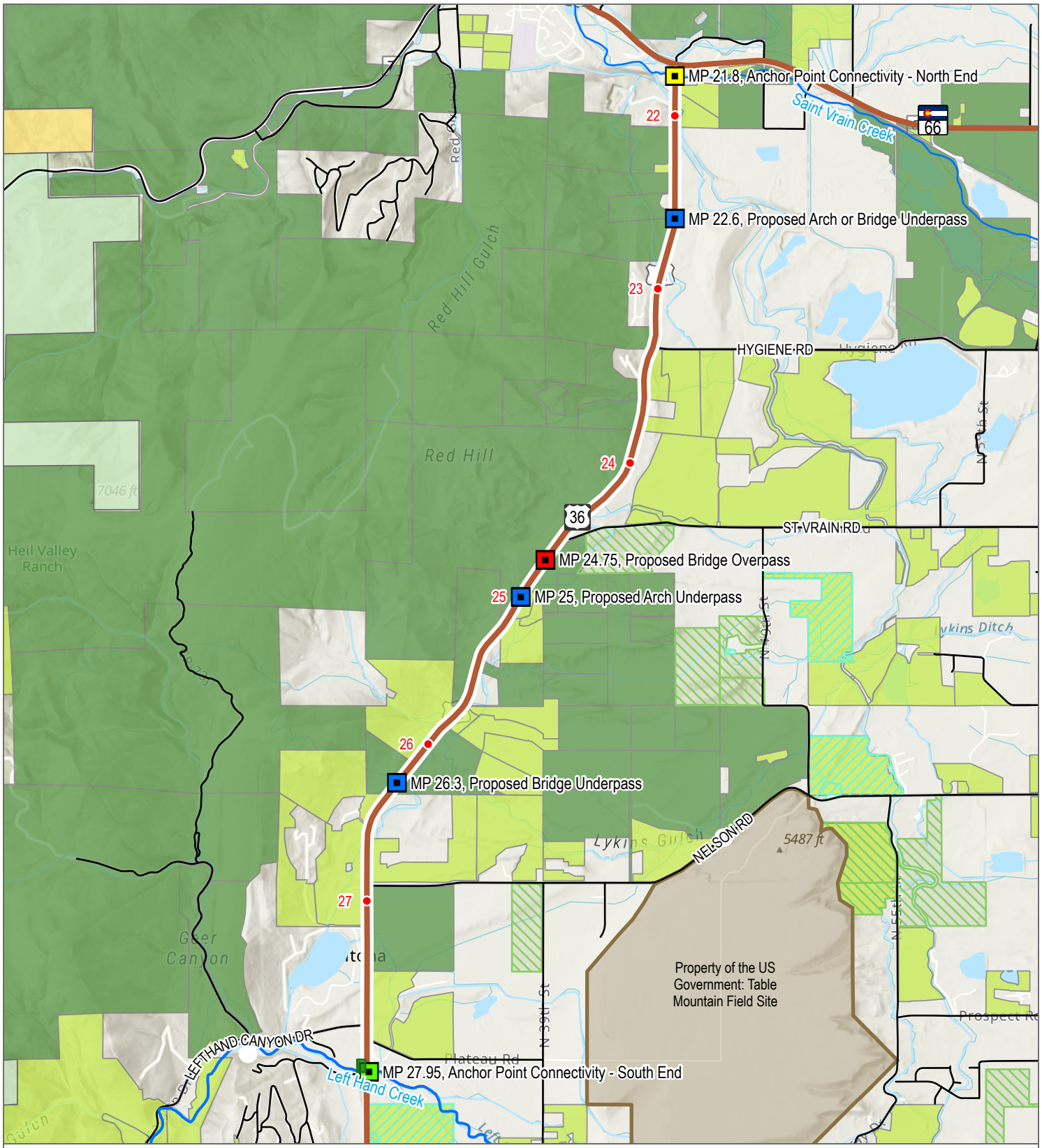

SOURCE: USFS; Boulder County; ESRI Topographic

FIGURE 5

Refined Crossing Structure Recommendations

U.S. 36 Corridor - Safety For All - Wildlife Crossings Conceptual Design Review, Boulder County, Colorado

DUDEK

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Photograph 2. View facing south, showing the St. Vrain Creek bridge on western side of US 36, with gravel company adjacent to the area on south side of bank. This location is in proximity to the SH 66 interchange that provides northern access to US 36.



Photograph 3. View facing south–southeast, showing the St. Vrain Creek Bridge underneath. Rocky and earthen substrate provide a natural corridor for incidental passage of ungulates and other general wildlife species, with bank areas north and south of the bridge including cottonwood trees and willows.



Photograph 4. View from the interior showing available bench for wildlife to use. Interior is generally lacking vegetation, but riparian vegetation occurs on either side of the entrance.



6.1.2 Milepost 22.6, Badger Underpass

The Dudek Team reevaluated the need for extending the wildlife crossings system north of St Vrain Road. This portion of the project area ranked in the 66th percentile in the Eastern Slope and Plains Wildlife Prioritization Study and it experiences lower large wildlife WVC rates than the road segment between St Vrain Road and Left Hand Creek, which ranked in the 95th percentile. However, the top priority Eastern Slope and Plains Wildlife Prioritization Study segments are intended as a starting point for project level planning, and available wildlife data, field observations, and conversations with CPW and the County indicated that a comprehensive wildlife crossing system should extend to U.S. 66 and incorporate a passage suitable for deer, as well as elk and other fauna. In particular, given the uncertainties of ongoing land use changes on wildlife habitat use and movement patterns—including the installation of wildlife exclusion fence around Department of Commerce lands on Table Mountain and the construction of fencing along the highway as a part of the wildlife crossings system—accommodating permeability

for wildlife across U.S. 36 in the northern portion of the project area is important for supporting wildlife connectivity over the long term.

This crossing location is situated at a natural roadway depression, creating an opportunity to raise the road grade, thereby flattening the roadway between the current high points and providing additional vertical clearance beneath the highway. The additional vertical clearance would allow construction of a more open crossing structure suitable for elk passage, which is the primary limiting factor at this location. The recommended structure type at this location is a 75 foot long arch underpass with a wildlife clearance box approximately 16 feet high × 40 feet wide. A bridge structure is also feasible at this location but would add significant cost, although this would be further evaluated during structure selection. This recommendation responds directly to concerns expressed by CDOT and CPW regarding construction of multiple wildlife overpasses in the project area while still providing for long-term wildlife permeability in the northern portion of the project area and maintaining sufficient spacing between crossing structures to support seasonal and population-level movements by the large fauna in this landscape.

Lands to the east of U.S. 36 are owned by Cemex USA. The long-term future of this area depends on decisions made by Cemex, as the owners. Cemex has expressed support for a wildlife crossing at this location. Properties on the west side of U.S. 3.6. at this location are owned by the County and connect to a larger network of protected lands including Heil Valley Ranch and the Arapaho-Roosevelt National Forest.

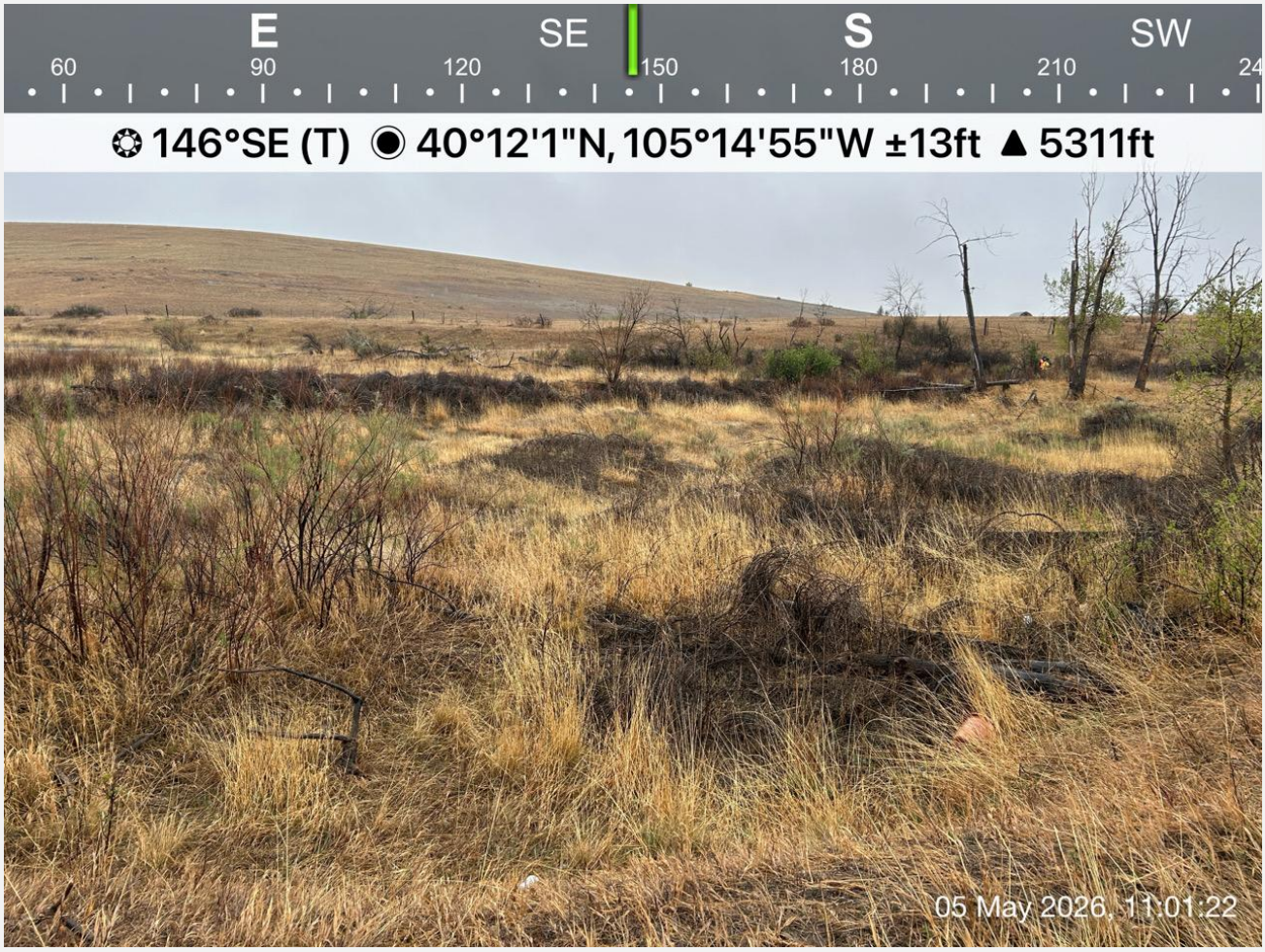
Supplementary recommendations for reducing barriers to wildlife movement and improving access to a crossing structure at this location include the following:

- Coordinate with Cemex to remove potentially unnecessary fence lines on the property and other barriers that may impede wildlife movement. Where fencing is required for livestock containment or property security, or other reasons, replace existing fencing with wildlife-friendly alternatives as needed.
- Remove the large berm on the west side of U.S. 36 on the County's Loukonen Outlots property, which is no longer functional or needed as a pond containment. This would improve visibility and openness at the crossing structure approach. Coordinate with CDOT to evaluate whether excavated material may be repurposed as roadway fill associated with raising the roadway grade.

Photograph 5. Photo facing northeast, showing the proposed area for the Badger Underpass, with a current arch culvert consisting of two openings to the east and west of U.S. 36.



Photograph 6. Photo facing southeast, showing Cemex Cement property to the east of U.S. 36 highway.



6.1.3 Milepost 24.75, Nighthawk Overpass

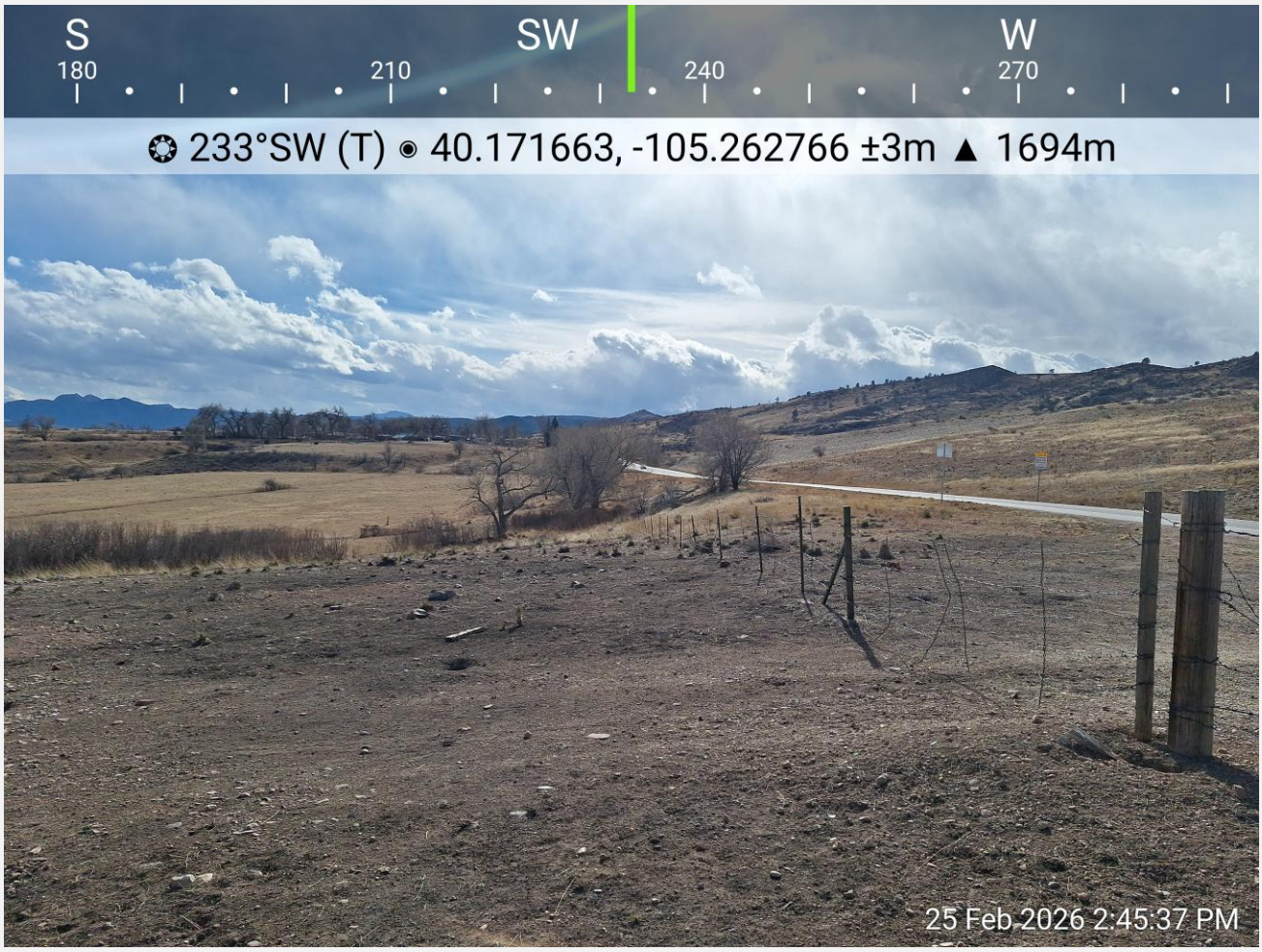
A crossing structure in this area received the highest ranking in the Study. As noted in Table 1, this portion of the corridor is situated within the highest concentration of documented elk highway crossings, based on CPW collar data; experiences elevated WVC rates; and is bordered by BCPOS protected lands on both sides of U.S. 36.

The revised recommendation relocates the wildlife overpass approximately 0.15 miles south of the originally proposed location at milepost 24.6. This updated pass location shifts the overpass farther from the St Vrain Road intersection and associated traffic noise and light impacts. The modified structure location also addresses CDOT and CPW concerns by eliminating obstructions to driver sight lines near the intersection and situates the overpass beyond the turning lanes associated with the intersection. Siting the overpass farther from the interchange is also expected to decrease the likelihood of concentrated elk crossing activity over St Vrain Road relative to the originally proposed location.

The Study proposed hourglass-shaped overpasses, measuring 165 feet at the narrowest point and widening to 210 feet at the approaches. To improve cost efficiency while maintaining biological functionality, the Dudek Team recommends a bridge overpass with straight walls, measuring 100 feet wide for the full span of the bridge and with wing walls opening up to 45° or greater to create open approaches on either side of the overpass. Traffic screening walls designed to reduce noise, light, and visual disturbance are also recommended across the bridge deck and extending along the wing walls for greater than 50 meters beyond the crossing structure. A preliminary concept shown in Appendix G depicts an overpass approximately 100 feet long, spanning the roadway and with accommodations for the future NF Bikeway. A bridge overpass structure is recommended rather than an arch structure because it provides better driver sight distances and operational safety approaching the St Vrain Road interchange.

A no-hunt zone is recommended as a buffer around the proposed overpass and immediate approaches within the Red Hill elk hunt area to encourage consistent wildlife use of the structure.

Photograph 7. Photo showing proposed area for the Nighthawk Overpass, facing southwest, with U.S. 36 corridor.



Photograph 8. Photo facing northwest, showing area where the Nighthawk Overpass would cross U.S. 36 corridor to provide western access for elk and other wildlife species.



6.1.4 Milepost 25, Hackberry Emperor Underpass

This location was identified in the original Study as a potential alternative to the recommended overpass at milepost 24.6. This location is a fill slope situated in a partially constrained drainage and, while the surrounding topography may be somewhat less attractive for elk movement, it is well suited for other wildlife such as black bear, mountain lion, bobcat, and mule deer. In addition, restoring riparian connectivity at this location would support connectivity for the federally Threatened Preble's. Because occupied habitat is present east of U.S. 36, restoring habitat connectivity at this location may provide additional ecological benefits and potentially improve eligibility for supplemental funding opportunities to support the inclusion of this underpass in the U.S. 36 wildlife crossings system.

The recommended structure type at this location is a 74 foot long arch underpass with a wildlife clearance box of 16.5 feet high × 40 feet wide. The structure has a maximum clearance of 21.5 feet at the center of the arch and a

minimum clearance of 10 feet at the edge of the arch. As with the proposed overpass at MP 24.75, a no-hunt zone is recommended as a buffer around the crossing approaches within the Red Hill elk hunt area. As discussed in Section 3.2.1, Elk Hunting Considerations, for elk and other large ungulates, flushing distances of 200–500 meters are commonly reported in hunted landscapes, so a buffer of 500 meters should be the goal.

Photograph 9. Photo facing east, showing fill slope on west side of U.S. 36, which is the proposed area for the Hackberry Emperor Underpass.



Photograph 10. Photo facing west, showing constrained drainage that is on western side of U.S. 36, which provides movement corridor opportunities for other wildlife such as black bears, mountain lions, bobcats, and mule deer.



6.1.5 Milepost 26.3, Rock Mouse Underpass

The Benesch Team originally recommended a wildlife overpass at MP 26.4 where there is a rise in the roadway and roadcuts on either side of the highway. While an overpass structure at this location could be oriented to connect to BCPOS lands on either side of the highway, an adjacent private residence on the east side of U.S. 36 increases the potential for disturbance to wildlife use of the crossing structure from human activity, domestic animals, lighting, and future land use changes. To reduce these potential conflicts while maintaining the desired spacing between large crossing structures, the Dudek Team identified an alternate location for a wildlife underpass at the drainage due north of the road cut. The road fill at this location provides sufficient vertical clearance to accommodate elk passage, and the recommended structure type here is a bridge underpass measuring 16 to 19 feet high × 94 feet wide × 70 feet long. and the wildlife crossing width is 40 feet. Siting a wildlife underpass at this location creates a more direct connection between the natural habitats on County owned lands on either side of the highway, and the recommendation for an underpass structure also meets CPW and CDOT's objective of reducing the number of wildlife overpasses on the corridor.

While collared-elk highway crossing activity is currently lower in this portion of the corridor than areas farther north, the WVC rate is high, largely due to collisions involving deer. In addition, a crossing structure suitable for elk in this portion of the project area supports elk passage needs over the long term, particularly in the context of potential

shifts in elk movement patterns due to the potential construction of wildlife exclusion fencing around Table Mountain Department of Commerce lands.

Available monitoring indicates that the existing cattle culvert near MP 26.3 is used by multiple wildlife species, including larger and smaller fauna. This documented use indicates that the structure currently contributes to wildlife permeability across U.S. 36 and may provide an important component of the broader corridor-scale connectivity network. Its existing function should be maintained during design and construction of the proposed Rock Mouse Underpass and NF Bikeway, and the structure should not be removed, obstructed, or disconnected from wildlife exclusion fencing without further evaluation. Additional monitoring results and recommendations regarding this and other existing cattle culverts and drainage culverts would be presented in the forthcoming bikeway integration report.

Photograph 11. Photo facing southeast, on eastern side of U.S. 36, showing the landscape features that characterize the area, providing ideal movement corridor habitat for wildlife.



Photograph 12. Photo facing southwest, showing the rise in the terrain leading up to U.S. 36 highway, which is the location proposed for the Rock Mouse Underpass. The roadfill at this location would provide sufficient vertical clearance for elk passage.



6.1.6 Milepost 27.95, Left Hand Creek Bridge

The Left Hand Creek Bridge was constructed in 2019 following a major flood event in 2013, which overwhelmed the previous two-chambered box culvert. Recognizing the value of this location for wildlife movement, as well as future flood resilience, CDOT was able to supplement structure replacement funds from the Federal Emergency Management Agency with additional funding from the Federal Highway Administration to install a 150-foot bridge spanning the riparian corridor to support habitat connectivity for the federally Threatened Preble's. To date, BCPOS camera monitoring has documented mule deer, American badger (*Taxidea taxus*), turkeys (*Meleagris gallopavo*), bobcats, striped skunks (*Mephitis mephitis*), bears, mountain lions, white-tailed deer, coyotes, rabbits, and raccoons (*Procyon lotor*) frequently and routinely crossing under the bridge along the creek. This bridge is a critical component of the U.S. 36 wildlife crossing system and currently provides the only functional wildlife crossing opportunity for most wildlife species to move safely under U.S. 36 along the entire corridor. The Left Hand Creek Bridge is also recommended to serve as the southern fence terminus for the U.S. 36 wildlife crossing system.

Coordination with the NF Bikeway planning team has been an ongoing component of this review effort and would continue through future project development. Regular coordination between the Boulder County Transportation

Planning Division and BCPOS has helped ensure that wildlife crossing and bikeway recommendations are developed in a complementary manner rather than as independent efforts. Through this collaborative process, the project teams have identified locations where bikeway infrastructure could influence wildlife movement patterns and have evaluated opportunities to avoid, minimize, or mitigate potential conflicts. A shared objective among the participating agencies is to maintain the functionality of key wildlife movement corridors while also advancing regional transportation and recreation goals. In particular, preserving the effectiveness of high-priority wildlife crossing locations and associated approach habitats has been identified as a critical consideration in bikeway planning. Continued coordination during design and implementation would be important to ensure that bikeway facilities, user access, and associated infrastructure are integrated in a manner that supports both safe recreational use and long-term wildlife connectivity across the U.S. 36 corridor.

Photograph 13. Photo facing north, showing an overview of Left Hand Creek Bridge on the western side of U.S. 36.



Photograph 14. Photo facing northeast, showing the view beneath Left Hand Creek Bridge. Riparian restoration efforts have provided optimal movement corridor habitat for various wildlife species under this structure, which have been documented by camera traps in vicinity of the bridge.



6.1.7 Crossing Structure Spacing

The fence distances between recommended crossing structures, including the two existing bridges that bookend the project area, range from approximately 0.25 to 2.15 miles. The two longest gaps between elk crossing opportunities occur outside the portions of the project area with the highest concentration of documented elk crossing activity. Although spacing between crossings opportunities was an important consideration in identifying suitable elk crossing locations, it was evaluated in the context of a broader set of ecological, engineering, and land use factors. These factors included existing wildlife movement patterns, topography, habitat conditions, roadway geometry, adjacent land ownership and security, constructability, and compatibility with surrounding land uses. Consequently, crossing locations and spacing reflect a balance between providing frequent crossing opportunities for elk and other wildlife and addressing the site-specific constraints and opportunities present along the corridor. As a result, crossing structures were not distributed at uniform intervals but were strategically located where they

are expected to provide the greatest overall safety and connectivity benefits for wildlife while remaining feasible from an engineering and land management perspective.

6.2 Wildlife Exclusion Fence

Wildlife exclusion fencing is an essential component of a wildlife crossing system, preventing wildlife from accessing a roadway, while still allowing them to use existing structures (e.g., cattle box culverts, large culverts) or new wildlife crossings. Long-term monitoring of crossing systems in Banff National Park, Colorado's SH 9 corridor, and other North American projects has shown that use of crossing structures often increases over time, indicating that animals become familiar with crossing locations and incorporate them into regular movement patterns. Species such as elk, mule deer, black bears, wolves (*Canis lupus*), coyotes, and mountain lions have been documented using the same crossing structures over multiple years, demonstrating route fidelity and an ability to locate and reuse predictable crossing opportunities. These findings suggest that wildlife can learn the locations of fence openings and crossing structures and that such locations may become focal movement routes over time. As a result, the effectiveness of wildlife crossing systems depends not only on the crossing structure itself but also on careful control of fence gaps, access points, and other openings that could concentrate wildlife movements at unintended locations (Clevenger and Huijser 2011; Huijser et al. 2015; Kintsch et al. 2020; Rosell et al. 2023).

Fence lines ideally terminate at bridge structures where wildlife can safely pass under the right-of-way or where adjacent developments may help to "push" wildlife back into habitat areas and away from the unfenced highway corridor. A wildlife exclusion fencing system necessarily incorporates additional mitigation components, including deer guards, escape ramps, and access gates. Design considerations for each of these fence components in the context of the U.S. 36 corridor are discussed in Sections 6.2.1 through 6.2.3.

Wildlife Interactions with Fences

Wildlife fencing is installed along a roadway in areas with high amounts of roadkill. The purpose of the fence is to create a barrier to exclude wildlife from road and vehicle traffic. Standard wildlife fencing is 8 feet tall and typically composed of a wire mesh with finer mesh at the bottom to create a barrier for smaller animals. Other design elements (e.g., burying the fence, opaque fencing along the bottom, or outriggers on top) may also be needed to create an effective barrier for specific species.

The fence should extend beyond the length of the collision hotspot and areas where wildlife cross the road, preventing the hotspot from being displaced to the fence-ends (Plante et al. 2019, Hujser and Begley 2022). Well-designed fencing that is long enough in either direction from a crossing structure can both decrease collisions and increase use of the structures (Donaldson and Elliott 2021).

Wildlife fencing works like a levee, it's only as good as its weakest spot. It must be maintained so as not to have holes, and the ends of the fence should be attached to a crossing structure, allowing wildlife to walk along the fenceline until a safe crossing opportunity is encountered (Denneboom et al. 2021). Besides reducing traffic volumes and speeds, it's the only sure way to reduce or eliminate roadkill on a roadway (Rytwinski et al., 2016).

6.2.1 South Fence End

The Benesch Team recommended terminating the south fence end along the west side of U.S. 36 at Lefthand Canyon Drive while extending the fence on the east side of the highway farther south to the Left Hand Creek Bridge at approximately MP 27.95.

The Dudek Team does not recommend offset fence termini because fencing on only one side of the highway south of Lefthand Canyon Drive could create conditions where wildlife movements are redirected toward the roadway,

potentially increasing the likelihood of WVCs and reducing the overall effectiveness of the crossing system. To avoid these potential conflicts, the updated recommendation is to extend wildlife exclusion fencing on both sides of U.S. 36 to Left Hand Creek Bridge (MP 27.95), which also serves as a critical wildlife crossing location within the overall system.

Extending the west-side fence to the bridge would require installation of a deer guard across Lefthand Canyon Drive to maintain fence continuity and prevent wildlife access to the highway right-of-way.

6.2.2 North Fence End

The recommended northern extent of the wildlife exclusion fencing is within the Loukonen Stone Quarry area around MP 21.8 to MP 21.9. The exact northern fence terminus should be evaluated during preliminary engineering and final design to balance wildlife permeability, fencing effectiveness, access requirements, and future bikeway improvements. Current alternatives include the following:

- **Alternative 1 – St. Vrain Creek Bridge Terminus:** Terminate the wildlife fence at the south abutments of the St. Vrain Creek Bridge (MP 21.8). Tying the fence directly into the bridge structure would help reduce the potential for "fence-end run around" behavior because wildlife in this area is likely to continue using the riparian corridor and the existing dry bench beneath the bridge. However, there are five driveway access points within 0.1-mile south of the bridge that would require deer guards or other access-control measures to minimize potential breaches into the fenced highway corridor. This alternative must also account for the future NF Bikeway, which is currently anticipated to cross St. Vrain Creek via a bridge structure on the east side of U.S. 36.
- **Alternative 2 – Quarry Entrance Terminus:** Terminate the wildlife fence near MP 21.85, at the quarry entrance on the west side of U.S. 36 and a private driveway on the east side. This option would remove three driveways from the fenced corridor, thereby reducing infrastructure costs and long-term maintenance obligations. While this alternative does not tie directly into the St. Vrain Creek Bridge structure, it is located within an area characterized by lower vehicle speeds associated with the CO 66 interchange and reduced roadside vegetation that provides improved driver sight distance for wildlife approaching or attempting to cross the highway. Because this alternative creates an open fence end rather than tying into an existing structure, additional safety treatments should be evaluated, including placement of guardrail to protect the fence termination within the roadway clear zone and installation of wildlife-fence-end warning signage to alert motorists to the increased potential for wildlife crossings near the terminus.

6.2.3 Other Fencing Considerations

The wildlife exclusion fence should be integrated into existing stock passes (cattle culverts), drainage culverts, waterway bridges, and arch culverts wherever feasible to preserve below-grade crossing opportunities for mesofauna and small fauna species. These structures may not be sized to support elk or deer use, but other species would benefit. These connections are particularly important in areas where fencing could otherwise create additional movement barriers for non-focal species.

Escape Ramps and Deer Guards

Other components of the wildlife exclusion fencing system include escape ramps, deer guards, and access gates. These elements are essential to the overall effectiveness and function of the wildlife crossings system because

they help prevent wildlife from becoming trapped within the fenced roadway corridor, while maintaining access for landowners and maintenance personnel. The effectiveness of wildlife crossing systems is highly dependent on the integrity of these supporting features, as improperly designed or maintained access points can reduce fence effectiveness and create opportunities for wildlife to gain access to the roadway.

General guidance for these components includes the following:

- Install escape ramps approximately every 0.25 miles (1,320 feet) on alternating sides of the highway. However, a particular consideration for siting escape ramps is to locate ramps near fence ends and road or driveway access points in the fencing, which may result in more variable spacing between ramps. Local topography, adjacent land uses, and maintenance accessibility should also be considered when determining final locations.
- Install deer guards at all road and driveway access points within the fenced segment extending from the northern fence terminus near MP 21.8–21.9 to the Left Hand Creek Bridge at MP 27.95.
- Deer guards in the project area would use a grid pattern, which is more easily traversed by pedestrians and cyclists.
- Guards may be set back from an intersection with U.S. 36 to reduce guard width while preserving turning radii and remaining within the highway right-of way. Precise guard placement at each location would require additional engineering and coordination with affected landowners.
- Install 8-foot-high driveway gates at infrequently used access points, such as agricultural or maintenance access roads, either in lieu of or in combination with deer guards where additional access control is warranted.
- Employ the most current CDOT designs for ramps, guards, and gates.
- Design gates, deer guards, and other access-control features to minimize opportunities for wildlife to bypass or circumvent the fencing system. Special attention should be given to gate closures, hinge conditions, and transitions between fencing and access-control infrastructure, which are common locations for wildlife intrusions.
- Where practicable, locate access points and escape ramps away from wildlife crossing entrances and primary wildlife travel corridors to minimize the potential for wildlife to associate these features with opportunities to enter the roadway corridor. Develop an inspection and maintenance program to ensure that fencing, gates, deer guards, and escape ramps remain fully functional. Regular inspections should occur following storm events, construction activities, vegetation management, or other disturbances that could compromise fence integrity.

Final siting, dimensions, and design specifications for fencing, escape ramps, deer guards, gates, and other supporting infrastructure should be developed during preliminary engineering and final design and should be coordinated with the recommended crossing locations to ensure that all components function as a fully integrated wildlife crossing system. Wildlife exclusion fencing would be sited within the highway right-of-way. Because fencing, crossing structures, escape ramps, deer guards, and access points function as a single system, the performance of the overall mitigation strategy would depend on maintaining the integrity and compatibility of all components throughout the life of the project.

6.3 Mesofauna and Small Fauna Considerations

The Study included general mitigation strategies for small fauna, including barriers, lighting, catwalks, and cover, and provided recommendations for upgrading selected culverts with these types of enhancements for the purpose of cost estimating. Although specific mesofauna and small fauna species—other than the federally Threatened Preble's—are not explicitly identified as primary focal species for the U.S. 36 wildlife crossing system, improving permeability for these species remains an important objective. The recommended crossing network incorporates design features that enhance passage opportunities for mesofauna and small fauna beneath both U.S. 36 and the future NF Bikeway. Specifically, the Dudek Team recommends the following measures:

- Incorporate dedicated cover features within the proposed large mammal crossing structures at MP 22.6 (Badger Underpass), MP 24.75 (Nighthawk Overpass), MP 25.0 (Hackberry Emperor Underpass), and MP 26.3 (Rock Mouse Underpass). Examples include vegetated cover, downed woody material, rock piles, brush windrows, and other refuge features that can substantially increase use by small mammals, reptiles, amphibians, and other cover-dependent species (Connolly-Newman et al. 2013; Kintsch et al. 2025).
- Improve existing drainage culverts, stock passes, and other existing below-grade structures to facilitate mesofauna and small fauna passage and integrate these structures into the wildlife exclusion fencing system. Tying crossing structures into the fencing is essential to ensure that animals can potentially find safe crossing opportunities.
- Evaluate opportunities to retrofit existing drainage culverts located throughout the corridor with species-appropriate enhancements such as small fauna fencing, opaque herptile fencing, guide walls, natural substrate bottoms, small fauna escape features, wildlife shelves, and localized vegetation improvements where site conditions permit.
- Provide visual screening around small fauna crossing locations to reduce impacts from bikeway and vehicle traffic.

The Dudek Team would continue evaluating the NF Bikeway designs and related U.S. 36 transportation infrastructure to ensure that the project minimizes impacts to and enhances wildlife connectivity across the broader landscape combined with targeted enhancements to improve safe passage opportunities. This effort would focus on identifying existing and potential barriers to wildlife movement, assessing opportunities to improve permeability and reduce wildlife mortality risk, and developing recommendations for feasible and appropriate design modifications and mitigation measures. Recommendations may include improvements to existing culverts and drainage structures, wildlife-friendly fencing, trail alignment refinements, lighting and human-use considerations, and other structural measures (e.g., barrier scuppers) that facilitate wildlife movement while ensuring compatibility with the bikeway's recreational and transportation objectives. Body size alone is often a poor predictor of wildlife crossing preferences and crossing-structure performance. Species with similar body sizes may exhibit substantially different responses to crossing structures because of differences in behavior, habitat requirements, predator-avoidance strategies, and movement ecology. Accordingly, the Dudek Team is using the Wildlife Crossing Guilds approach (Kintsch et al. 2015), together with more recent findings from Shilling et al. (2024), to evaluate mesofauna and small fauna passage needs within the U.S. 36 corridor. Shilling et al. (2024) used camera trap evidence of wildlife use of hundreds of structures in 6 U.S. states to develop prediction models for species use (26 species and species groups) of structures based on dimensions, type, and nearby habitat conditions. The Wildlife Crossing Guilds framework categorizes terrestrial wildlife based on how a species responds to crossing structure characteristics and perceived risks. Guild membership is influenced by factors such as anti-predator behaviors, specialized habitat requirements, movement capacity, locomotion mode, preference for cover or openness, and

body size. This framework provides a more ecologically meaningful basis for evaluating crossing suitability than body size alone. Applying the Wildlife Crossing Guilds framework and the Shilling et al. (2024) predictive modeling to the existing infrastructure inventory—including the proposed crossing structures at MP 22.6, MP 24.75, MP 25.0, and MP 26.3 and the existing bridges at MP 21.8 and MP 27.95—helps identify opportunities for targeted enhancements that address the needs of a broader suite of wildlife species. This approach supports the development of a multispecies crossing system that complements the objective of reducing WVCs while improving corridor-scale habitat connectivity for the focal species, as well as mesofauna, small fauna, and other non-target species.

Although the measures discussed above are intended primarily to improve passage for mesofauna and small fauna, available monitoring indicates that some existing culverts also provide movement opportunities for larger species. Existing cattle and drainage culverts, including the structure near MP 26.3, are used by a range of wildlife—including large, medium, and smaller fauna—and therefore may contribute to permeability for multiple wildlife groups. These existing connectivity functions should be considered when evaluating culvert retention, modification, fencing tie-ins, and bikeway improvements. Additional monitoring results and site-specific recommendations would be presented in the forthcoming NF Bikeway integration report.

6.4 Bikeway Considerations

All crossing structures must be designed in anticipation of the 11-mile NF Bikeway project between North Boulder (MP 32.5) and Lyons/CO 66 (MP 21.5). Coordination between the wildlife crossing system and the proposed bikeway is essential to ensure that both projects function effectively over the long term.

Because the bikeway is advancing as a related but separate design effort, the recommendations in this report are intended to identify the primary coordination issues that should be carried forward into subsequent planning and engineering. Detailed bikeway considerations would be addressed during the next phase of work, when the Dudek team would further evaluate alignment, structure integration, user access, screening, and other design measures needed to support the incorporation of wildlife considerations into the NF Bikeway along its entire length.

Specific recommendations include the following:

- At each crossing structure location, the Bikeway alignment should be routed adjacent to the roadway to reduce structure lengths and to minimize Bikeway impacts to wildlife in the vicinity of the crossing structures. The proposed bikeway alignment at each of the crossing structure locations would be separated from vehicle traffic by a barrier as shown in the wildlife crossing concepts presented in Appendix H, Detailed Cost Estimate. Final design for this would be coordinated as the project progresses.
- Crossing structure dimensions at MP 22.6 (Badger Underpass), MP 24.75 (Nighthawk Overpass), MP 25.0 (Hackberry Emperor Underpass), and MP 26.3 (Rock Mouse Underpass) and at the bridge structures at MP 21.8 and MP 27.95 should account for the additional width and footprint associated with the future bikeway. Incorporation of the bikeway would increase the overall span or length required for each crossing structure and should be reflected in preliminary engineering and cost estimates.
- Continued coordination during the design processes for the wildlife crossings system and the NF Bikeway would provide opportunities to streamline permitting and reviews, data sharing, and integrated design considerations assuming that timelines and progress align. The goal is to ensure that wildlife connectivity objectives and active transportation objectives are fully aligned in final engineering plans.

- The bikeway should be located within the wildlife exclusion fence and the CDOT right-of-way. Avoid intersecting the wildlife exclusion fence with the bikeway to minimize opportunities for wildlife to access the roadway corridor and to reduce the need for additional fencing treatments, gates, or access-control structures.
- Avoid new lighting along the bikeway, including in areas already influenced by existing roadway lighting. Limiting light sources would help maintain nighttime habitat conditions and reduce disturbance near the proposed crossing structures at MP 21.8, MP 22.6, MP 24.75, MP 25.0, MP 26.3, and 27.95.

6.5 Project Phasing

The Dudek Team evaluated a phased implementation approach at the request of CPW and CDOT, with particular consideration given to maintaining long-term elk permeability and connectivity in the northern portion of the project corridor. However, once it became apparent that elk permeability could be addressed at MP 22.6 (Badger Underpass—the northernmost crossing location) and incorporated into the overall project vision from the outset, the advantages of implementing the wildlife crossing system as a single integrated project were determined to outweigh the benefits of a phased approach.

Benefits of implementing the full system include the following:

- Creating cost efficiencies by maintaining a consistent design and construction team through the duration of the project, reducing construction mobilization costs, and minimizing the effects of inflation over time compared to if two separate projects were implemented over an extended time frame.
- Eliminating the potential for exacerbated WVCs in areas immediately adjacent to interim fence termini where wildlife may be redirected around Phase 1 infrastructure while later project phases remain unconstructed.
- Maintaining fundraising momentum and public, political, and agency support while reducing the risk that future project phases could be delayed indefinitely or never implemented due to changing funding priorities or economic conditions.

Despite these benefits, funding availability may ultimately necessitate phased implementation. If phasing becomes necessary, individual phases should be developed with careful consideration of fence termini, crossing spacing, wildlife movement patterns, and long-term system functionality to avoid creating unintended movement bottlenecks or increased collision risks.

6.6 Other Landscape Connectivity Considerations

Several complementary actions are recommended to enhance wildlife connectivity throughout the greater landscape around the U.S. 36 corridor. These recommendations are intended to improve the long-term effectiveness of both the proposed crossing structures and existing bridge structures.

- Establish no-hunt buffer zones around proposed wildlife crossing structures that lie within BCPOS's Red Hill elk hunt area to reduce disturbance and encourage consistent crossing use by elk and other wildlife.
- Coordinate with agricultural lessees and update lease agreements, where appropriate, to reduce barriers to wildlife movement on BCPOS properties. Recommended actions include the following:
  - Removing livestock fencing where practicable or replacing existing fencing with wildlife-permeable alternatives.

  - Avoiding or setting-back livestock fencing in proximity to the wildlife crossing structures and approach zones.
  - Managing pasture rotations to avoid concentrating livestock on pastures adjacent to the wildlife crossings during the seasons when wildlife movements across U.S. 36 are greatest, specifically during elk migration.
  - Removing redundant or double fence lines, including those along Nelson Road adjacent to Table Mountain, where such fencing unnecessarily restricts wildlife movement.
  - Coordinating grazing and land management activities to maintain clear approach corridors to crossing structures and associated wildlife fencing.
- Continue coordination with CPW to proactively address potential elk conflicts because of concentrating wildlife movement at designated crossing structures may alter elk distribution patterns immediately adjacent to the crossings. This concentration is likely to be temporary, as wildlife generally disperses away from a roadway upon making a successful crossing.
- Throughout the U.S. 36 corridor from North Boulder to Lyons, replace existing barbed-wire, woven-wire, buck-and-rail, and other movement-restrictive right-of-way fencing with wildlife-friendly alternatives where safety, operations, and land ownership considerations allow. These actions can improve landscape permeability and strengthen connectivity between the protected lands associated with the recommended crossing locations.



Elk from Boulder County Wolf Run Open Space (Credit Mike Wussow).

6.7 Updated Costs Summary

A planning-level cost estimate was developed for the refined wildlife crossing system described in Section 6.1. The estimate reflects the recommended configuration of one wildlife overpass and three wildlife underpasses, together with wildlife exclusion fencing, escape ramps, deer guards, and associated roadway, drainage, utility, environmental, landscaping, and bikeway improvements. Based on the current conceptual quantities and assumptions, the estimated project cost is approximately $46.10 million in 2026 dollars.

The preliminary quantity-based direct construction subtotal is approximately $21.76 million. Percentage-based allowances were applied to account for conceptual-design uncertainty and additional costs associated with advancing the project through final design and construction. These allowances include contingency, mobilization, erosion control, environmental and landscaping improvements, drainage and utilities, traffic control, design engineering, and construction engineering and inspection. The basis for and application of each allowance are provided in Appendix H.

The estimate is intended for planning purposes and is subject to refinement as design advances. Costs associated with right-of-way acquisition, permitting, environmental mitigation, escalation beyond 2026, and other excluded items are not included unless specifically identified in Appendix H.

The estimate also incorporates improvements associated with the NF Bikeway at each proposed crossing. Approximately $2.19 million in direct bikeway-related construction costs is included in the preliminary quantity-based construction subtotal. This amount represents the estimated incremental cost of accommodating the bikeway through or adjacent to the crossing structures and does not represent the full cost of constructing the bikeway. Costs associated with bikeway pavement, additional retaining walls, related infrastructure, and other features that may be identified as the bikeway design advances are not included unless specifically identified in Appendix H.

Table 2. Cost Estimates for U.S. 36 Boulder to Lyons Wildlife Crossing Structures

Item No.	Description	Unit	Quantity	Unit Price	Cost
607	Fence Deer	LF	63,000	$ 25.00	$ 1,575,000
607	Game Ramp (Special)	EACH	25	$ 15,000.00	$ 375,000
603	Badger Underpass – MP 22.6	EACH	1	$ 5,402,138.89	$ 5,402,139
604	Nighthawk Overpass – MP 24.75	EACH	1	$ 4,983,200.00	$ 4,983,200
603	Emperor Underpass – MP 25.0	EACH	1	$ 2,705,000.00	$ 2,705,000
603	Rock Mouse Underpass - MP 26.3	EACH	1	$ 4,082,400.00	$ 4,082,400
611	24 Foot Deer Guard	EACH	22	$ 90,000.00	$ 1,980,000
611	40 Foot Deer Guard	EACH	6	$ 100,000.00	$ 600,000
		Subtotal	*$21,702,739*		
Total subset cost of including Bikeway (included in total)1			*$2,189,870*		
a)	Contingency	N/A	15%	of a)	$ 3,255,411
b)	Mobilization	N/A	15%	of a) + b)	$ 3,743,722

Table 2. Cost Estimates for U.S. 36 Boulder to Lyons Wildlife Crossing Structures

Item No.	Description	Unit	Quantity	Unit Price	Cost
c)	Erosion Control	N/A	5%	of a) + b)	$ 1,247,907
d)	Environmental/ Landscaping	N/A	10%	of a) + b)	$ 2,495,815
e)	Drainage/Utilities	N/A	15%	of a) + b)	$ 1,049,870
f)	Traffic Control	N/A	10%	of a) + b)	$ 2,495,815
g)	Design (0-100%)	N/A	10%	of a)	$ 2,170,274
h)	Construction Engineering/ Inspection	N/A	22.1%	of a) + b) thru h)	$ 7,954,073
		Total	**$ 46,115,626**		

Notes: LF = linear foot; EACH = each item; MP = milepost; N/A = not applicable.
[1] Bikeway estimate includes accommodation of the bikeway footprint only.

6.7.1 Cost Estimate Comparison with the Benesch Study

The refined estimate was compared with the conceptual costs presented in the previous U.S. 36 Wildlife Crossings Assessment, Prioritization and Cost Estimation Study prepared by Benesch (Benesch Study). The two estimates are not directly equivalent because they address different crossing systems, project limits, supporting improvements, and estimating methodologies.

The Benesch Study evaluated three wildlife overpasses at MPs 22.4, 24.6, and 26.4; wildlife exclusion fencing along U.S. 36; fencing and associated wildlife detection or mitigation improvements east of U.S. 36; and separately identified improvements to existing drainage culverts for smaller wildlife. By comparison, the refined system includes one wildlife overpass, three wildlife underpasses—including an additional crossing at MP 25.0—and wildlife exclusion fencing and supporting improvements within the refined project limits. The refined system replaces two of the three large overpasses with underpasses and generally uses smaller structures tailored to site conditions and wildlife movement requirements. The Benesch Study assumed hourglass-shaped overpasses with an approximately 210-foot-wide opening at the approaches that narrowed to approximately 165 feet at the center, together with 3H:1V approach slopes. The refined system instead includes one 100-foot-wide overpass and three underpasses sized for their respective locations.

The estimates also use different cost-year assumptions. The Benesch Study developed its major quantities and costs in 2024 dollars and then applied 5% annual escalation to an assumed 2027 construction year. The resulting 2027 estimate is not directly comparable with the refined estimate, which is presented in 2026 dollars and does not include a separate escalation allowance beyond that year.

For comparison on a common project-scope and dollar-year basis, the Benesch Study's approximately $69.99 million estimate in 2027 dollars includes approximately $8.73 million for fencing and associated wildlife detection or mitigation improvements east of U.S. 36 and approximately $1.35 million for separately identified small-animal culvert improvements. After removing these scope items and converting the remaining costs to 2026 dollars using the same 5% annual escalation assumption, the comparable Benesch estimate is approximately $57 million. The refined estimated project cost of approximately $46 million is therefore about $11 million, or 19%, lower than the adjusted Benesch estimate.

The refined estimate nevertheless retains substantial costs for roadway reconstruction, earthwork, drainage and utilities, wildlife exclusion fencing and associated features, traffic control, NF Bikeway interfaces, environmental

and landscaping improvements, design engineering, and construction engineering and inspection. Accordingly, the estimated cost difference should not be interpreted as the elimination of these project components. Rather, it primarily reflects a shift to a more targeted crossing system with fewer and smaller overpasses, greater use of underpass configurations, revised project limits, and updated structure-specific quantities and assumptions.

6.7.2 Preliminary Cost Estimate Assumptions and Limitations

The preliminary estimate is intended for conceptual planning and alternatives evaluation and should not be considered a final project budget. It is based on the conceptual layouts, preliminary quantities, and assumptions developed for this Study. The estimate should be refined as the project advances through preliminary and final design and as additional information becomes available.

The bikeway allowances represent the anticipated incremental structural and associated costs required to integrate the NF Bikeway with each proposed wildlife crossing (see NF Bikeway Feasibility Study: Summary Report [Otak 2024]). These allowances do not represent the full cost of constructing the adjacent bikeway. The estimate includes earthwork associated with the assumed bikeway footprint at the crossing locations, based on a 14-foot-wide paved surface plus 2-foot-wide shoulders on each side. It does not include bikeway pavement or additional retaining walls that may be required beyond the quantities specifically identified in Appendix H.

The estimate includes allowances for contingency, mobilization, erosion control, environmental and landscaping improvements, drainage and utilities, traffic control, design engineering, construction engineering and inspection. These allowances account for uncertainty in the conceptual quantities and the anticipated complexity of constructing multiple wildlife crossings within the active U.S. 36 corridor. The basis for each allowance, including the percentage applied and its application to the preliminary quantity-based construction subtotal, is provided in Appendix H.

The estimate does not establish final requirements or costs for right-of-way acquisition, permitting, utility relocation, environmental mitigation, geotechnical investigations or improvements, escalation beyond 2026, or other project-specific items that may be identified during subsequent design and agency coordination, unless specifically identified in Appendix H. These items should be evaluated and incorporated as the project advances.

Overall, the refined concept provides a focused wildlife crossing system with an estimated project cost of approximately $46.0 million in 2026 dollars. The estimate should be updated as the preferred locations and configurations advance to reflect refined design quantities, site investigations, agency coordination, bikeway design requirements, and current construction-market conditions.

7 Literature Cited

Beaupre, C., A. Bevan, J. R. Young, and K. A. Blecha. 2025. "Recreational Trail Traffic Counts and Trail Proximity as a Driver of Ungulate Landscape Utilization." *Ecosphere* 16(6): e70305.

Benesch and Pinyon Environmental. 2024. *Wildlife Crossing Assessment, Prioritization, and Cost Estimation Study: U.S. 36 Wildlife Crossings Project, Boulder, Colorado.*

Boyle, Stephen A., and Fred B. Samson. 1985. "Effects of Nonconsumptive Recreation on Wildlife: A Review." *Wildlife Society Bulletin* 13(2): 110–116.

Boulder County. 2020. *Red Hill Elk Management Plan 2020–2022.* Boulder County Parks and Open Space.

CDOT (Colorado Department of Transportation). 2026. *Online Transportation Information System.* Accessed April 23, 2026. https://dtdapps.coloradodot.info/otis/TrafficData.

Ciuti, S., J.M. Northrup, T.B. Muhly, S. Simi, M. Musiani, J.A. Pitt, and M.S. Boyce. 2012. "Effects of Humans on Behaviour of Wildlife Exceed Those of Natural Predators in a Landscape of Fear." *PLoS ONE* 7(11): e50611.

Clevenger, A.P., and M.P. Huijser. 2011. *Wildlife Crossing Structure Handbook: Design and Evaluation in North America.* FHWA (Federal Highway Administration).

Clevenger, Anthony P., and Marcelo Barrueto, eds. 2014. *Trans-Canada Highway Wildlife and Monitoring Research, Final Report. Part B: Research.* Parks Canada Agency, Radium Hot Springs, British Columbia.

Collins, A.C., T.W. Vickers, and F.M. Shilling. 2022. Behavioral responses to anthropogenic noise at highways vary across temporal scales. *Frontiers in Ecology and Evolution* 10:891595. https://doi.org/10.3389/fevo.2022.891595

Connolly-Newman, H.R., M.P. Huijser, L. Broerg, C.R. Nelson, and W. Camel-Means. 2013. "Effect of Cover on Small Mammal Movements through Wildlife Underpasses along US Highway 93 North Montana, USA." In *Proceedings of the 2013 International Conference on Ecology and Transportation*, Scottsdale, Arizona, June 23–27, 2013.

Dodd, N.L., J.W. Gagnon, S. Boe, A. Manzo, and R.E. Schweinsburg. 2007. *Evaluation of Measures to Minimize Wildlife-Vehicle Collisions and Maintain Wildlife Permeability across Highways: State Route 260, Arizona, USA.* Final Report 540 (2002–2006). Phoenix: Arizona Transportation Research Center and Arizona Department of Transportation.

Found, R. 2021. "Personality and Other Factors Mediating Ungulate Flight Initiation Distances." *Ecology and Evolutionary Biology* 6(4): 125–135.

Gagnon, J.W., Dodd, N.L., Ogren, K.S., and Schweinsburg, R.E. 2011. Factors Associated with Use of Wildlife Underpasses and Importance of Long-Term Monitoring. *Journal of Wildlife Management* 75(6): 1477-1487. https://doi.org/10.1002/jwmg.160

Gaynor, K.M., C.E. Hojnowski, N.H. Carter, and J.S. Brashares. 2018. The influence of human disturbance on wildlife nocturnality. *Science* 360(6394):1232-1235. https://doi.org/10.1126/science.aar7121

George, S.L., and K.R. Crooks. 2006. "Recreation and Large Mammal Activity in an Urban Nature Reserve." *Biological Conservation* 133(1): 107–117.

Grilo, C., F. Z. Ferreira, and E. Revilla. 2015. "No Evidence of a Threshold in Traffic Volume Affecting Road-Kill Mortality at a Large Spatio-Temporal Scale." *Environmental Impact Assessment Review* 55: 54–58. https://doi.org/10.1016/j.eiar.2015.07.003.

Haworth, L. 2026. Median barrier type affects road permeability. MSc Thesis, University of California, Davis. Pp. 59.Huijser, M.P., A.V. Kociolek, T.D.H. Allen, P. McGowen, P.C. Cramer, and M. Venner. 2015. *Construction Guidelines for Wildlife Fencing and Associated Escape and Lateral Access Control Measures.* NCHRP (National Cooperative Highway Research Program).

Jacobson, S.L., L.L. Bliss-Ketchum, C. Elaine de Rivera, and W.P. Smith. 2016. "A Behavior-Based Framework for Assessing Barrier Effects to Wildlife from Vehicle Traffic Volume." *Ecosphere* 7(4): e01345. https://doi.org/10.1002/ecs2.1345.

Kintsch, J., S.L. Jacobson, and P. Cramer. 2015. *The Wildlife Crossing Guilds Decision Framework: A Behavior-Based Approach to Designing Effective Wildlife Crossing Structures.* In *Proceedings of the International Conference on Ecology and Transportation*. Raleigh, NC.

Kintsch, J., P. Basting, T. Smithson, and G. Wooley. 2022. *Eastern Slope and Plains Wildlife Prioritization Study.* CDOT-2022-03. Denver, CO: Colorado Department of Transportation and Colorado Parks and Wildlife.

Kintsch, J., P. Cramer, P. Singer, M. Cowardin, and J. Phelan. 2020. *State Highway 9 Wildlife Crossings Monitoring: Year 4 Progress Report.* Colorado Department of Transportation.

Kintsch, J., P. Cramer, P. Singer, and M. Cowardin. 2021. *State Highway 9 Wildlife Crossings Mitigation Monitoring.* CDOT-2021-01. Denver, CO: Colorado Department of Transportation, Applied Research and Innovation Branch.

Kintsch, J., P. Singer, A. Telander, R. Knoedler, J. Swenson, B. Hanks, and J. Phelan. 2025. *I-25 South Gap Wildlife Monitoring Study.* CDOT-2025-08. Denver, CO: Colorado Department of Transportation, Office of Applied Research.

Knight, H.A.L., C.B. Beebe, C.D. Dick, M. Maiolo-Heath, and R. Schorr. 2025. "A Novel, Community-Based Approach to Endangered Species Recovery: The Case of the Preble's Meadow Jumping Mouse (*Zapus hudsonius preblei*)." *Frontiers in Conservation Science* 6: 1528441. https://doi.org/10.3389/fcosc.2025.1528441.

Larson, C.L., S.E. Reed, A.M. Merenlender, and K.R. Crooks. 2016. Effects of recreation on animals revealed as widespread through a global systematic review. *PLoS ONE* 11(12):e0167259. https://doi.org/10.1371/journal.pone.0167259

Lewis, J.S., S. Spaulding, H. Swanson, W. Keeley, A.R. Gramza, S. VandeWoude, and K.R. Crooks. 2021. Human activity influences wildlife populations and activity patterns: implications for spatial and temporal refuges. *Ecosphere* 12(5):e03487. https://doi.org/10.1002/ecs2.3487

Nojoumi, M., A.P. Clevenger, D.T. Blumstein, and E.S. Abelson. 2022. "Vehicular Traffic Effects on Elk and White-Tailed Deer Behavior Near Wildlife Underpasses." *PLOS ONE* 17(11): e0269587. https://doi.org/10.1371/journal.pone.0269587.

Otak. 2024. *North Foothills Bikeway Feasibility Study: Summary Report*. Prepared for Boulder County, Colorado. Adopted by the Boulder County Board of County Commissioners on August 13, 2024.

Phillips, G.E., W. Alldredge, and W.W. Andree. 2001. *Mitigating Disturbance of Migrating Mule Deer Caused by Cyclists and Pedestrians at a Highway Underpass Near Vail, Colorado.*

Proffitt, K.M., J.L. Grigg, R.A. Garrott, K.L. Hamlin, and J.A. Cunningham. 2013. "Changes in Elk Resource Selection and Distributions Associated with a Late-Season Elk Hunt." *Journal of Wildlife Management* 77: 470–482.

Riginos, C., C. Smith, E.R. Fairbank, E. Hansen, and P. Hallsten. 2018. *Traffic Thresholds in Deer Road-Crossing Behavior*. Wyoming Department of Transportation Research Center, Report WY-18-07F.

Rosell, C., Chrétien, L., Guinard, E., Nowicki, F., Righetti, A., Seiler, A., Trocmé, M., Fernández, L.M., Aliaga, A., Bartels, P., Böttcher, M., Deyrieux, O., Eicher, C., Elstrom, M., Figueras, A., Herold, M., Morand, A., Navàs, F., Paquier, F., Petrovan, S., Schwab, T., Suter, S., and Zumbach, S. 2023. "Chapter 5: Solutions to Mitigate Impacts and Benefit Nature." In: C. Rosell et al., (Eds.) 2023. *IENE Biodiversity and Infrastructure. A Handbook for Action*. https://www.biodiversityinfrastructure.org/

Rytwinski, T., K. Soanes, J.A. Jaeger, L. Fahrig, C.S. Findlay, J. Houlahan, R. van der Ree, and E.A. van der Grift. 2016. "How Effective Is Road Mitigation at Reducing Road-Kill? A Meta-Analysis." *PLoS ONE* 11(11): e0166941.

Salo, J.A., E.P. Gage, G.L. Katz, and J.M. Stoker. 2020. "Assessing Preble's Meadow Jumping Mouse (*Zapus hudsonius preblei*) Habitat and Connectivity for Conservation and Restoration." *Wetlands* 40: 1813–27. https://doi.org/10.1007/s13157-020-01374-6.

Seiler, A. 2003. *The Toll of the Automobile: Wildlife and Roads in Sweden*. Doctoral Dissertation, Swedish University of Agricultural Sciences, Uppsala, Sweden.

Shilling, F., N. Thoron, and D. Waetjen. 2024. *Predicting Wildlife Use of Existing Highway Bridges and Culverts.* UCD-ITS-RR-24-06. Davis, CA: University of California, Davis Road Ecology Center/METRANS Transportation Center.

Stankowich, T., and D.T. Blumstein. 2005. "Fear in Animals: A Meta-Analysis and Review of Risk Assessment." *Proceedings of the Royal Society B* 272: 2627–2634.

Trainor, A.M., T.M. Shenk, K.R. Wilson, and others. 2012. "Spatial, Temporal, and Biological Factors Associated with Preble's Meadow Jumping Mouse (*Zapus hudsonius preblei*) Home Range." *Journal of Mammalogy* 93 (2): 429–38. https://doi.org/10.1644/11-MAMM-A-049.1.

USFWS (U.S. Fish and Wildlife Service). 2022. *Preble's Meadow Jumping Mouse (Zapus hudsonius preblei) Species Profile.* Accessed July 30, 2026. https://www.fws.gov/species/prebles-meadow-jumping-mouse-zapus-hudsonius-preblei.

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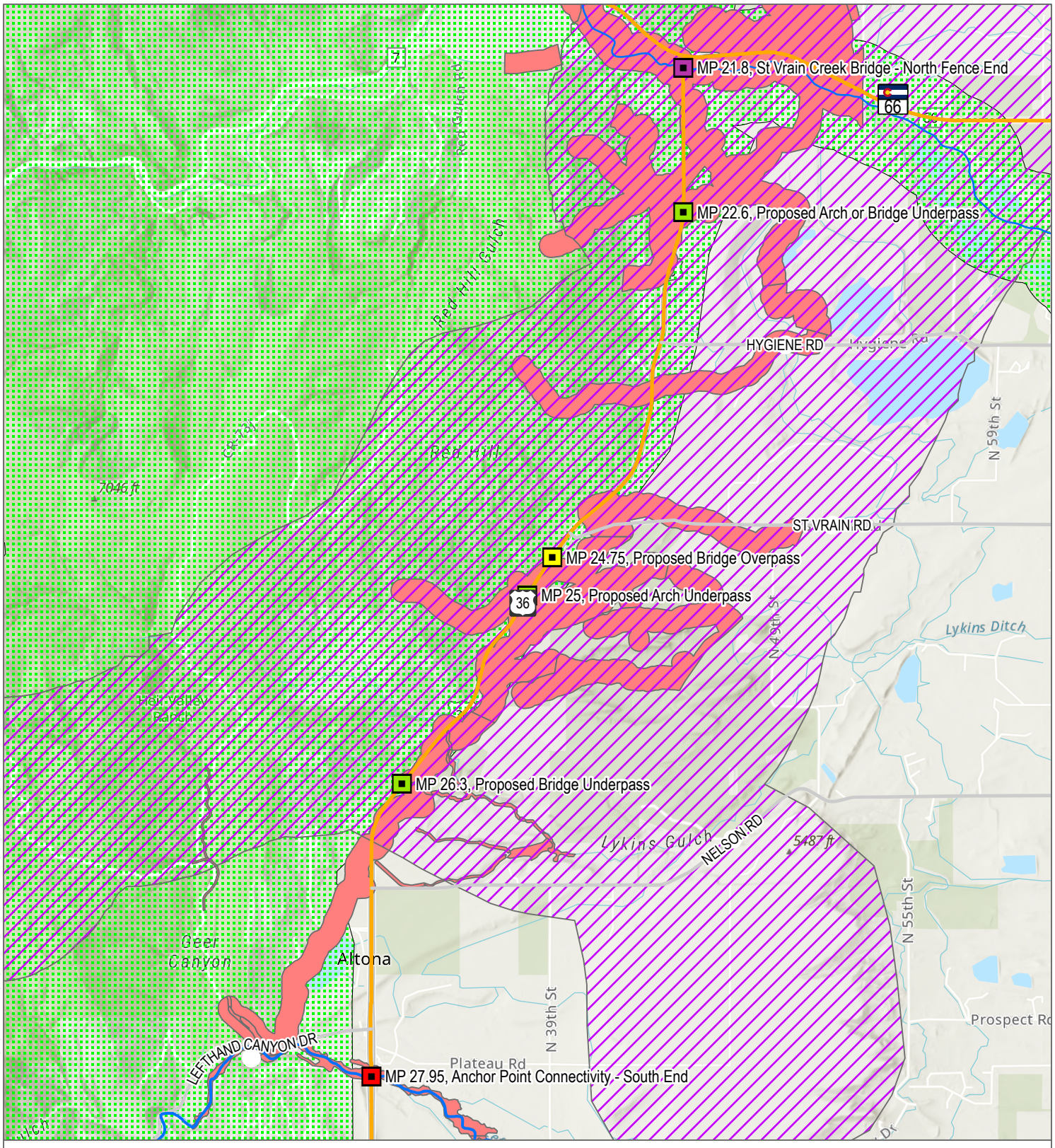
Appendix A
Focal Species Habitat



SOURCE: Colorado Parks and Wildlife; ESRI Topographic

DUDEK

0 0.35 0.7 Miles

Appendix A

Focal Species Habitat

U.S. 36 Corridor - Safety For All - Wildlife Crossings Conceptual Design Review, Boulder County, Colorado

Appendix B

Extended Focal Species Descriptions

B.1 Elk



In the spring, migratory elk (Cervus canadensis) descend from the forested mountains to the west down through the foothills and, during the winter months, concentrate on either side of U.S. Highway 36 (U.S. 36). Notably, a portion of the herd has become residential in recent years, remaining in the area year-round, particularly around Table Mountain. A portion of the U.S. 36 corridor lies within the County's Red Hill elk management area. To address the issue of the increasing elk herd size in recent decades, Boulder County has instituted limited public hunting on the County's lands as a management tool to help control the population size and reduce conflict with agriculture and livestock producers, as well as wildlife-vehicle collisions on U.S. 36.

In the western United States, large structures with high openness have proven to be the most successful at passing Rocky Mountain elk. Research in both Arizona and in Canada found that elk prefer structures with greater openness, although use can increase over time as animals adapt to the crossing structures. On the Trans-Canada Highway, Clevenger and Barrueto (2014) found passage rates were positively correlated with structure width, height, and openness and negatively correlated with structure length and traffic noise. Similarly, on State Route 260 in northern Arizona, wide and tall open span bridges achieved 83% success rates for migratory and resident elk (Gagnon et al. 2011). Dodd et al. (2007) found that elk passage rates at crossing structures were lower during timeframes with high traffic volumes, such as weekends.

Crossing structure location relative to elk seasonal ranges and movement patterns is also an important consideration. In northern Colorado sagebrush winter range, elk use of crossing structures was primarily influenced by the location of the crossing structures relative to the distribution of elk in the landscape (Kintsch et al. 2021).

Preferred crossing structures for elk include wildlife overpasses, open span bridges, and, to some extent, large arch culverts. Effective bridge underpasses for elk generally range from 60 to 100 feet in width and 16 to 25 feet in height, with the most effective underpasses under 100 feet long. Longer underpasses should be built wider and taller to avoid the feeling of a long, dark tunnel. Large arch culverts are generally narrower than bridges. Such structures are generally suitable for elk movements within seasonal home ranges or for residential herds but are not recommended where crossing structures must accommodate larger herds of elk during seasonal migrations.

Restricting elk access to preferred habitats through development, roads, fencing, and similar features has consistently been shown to alter how elk use the landscape and can have lasting population-level consequences. Elk tend to avoid roads, vehicle traffic, and areas of regular human activity, even when those areas provide high-quality forage or cover. As a result, habitat that remains physically intact can become functionally unavailable to elk, effectively shrinking the amount of usable habitat beyond the actual blocking footprint (McCorquodale 2013;

Rowland et al. 2004). When access to core habitat is lost, elk are often displaced into less productive or less secure habitats, which can increase crowding and competition in the remaining areas they continue to use. The impacts of diminished access to habitat is relevant in the context of the planned construction of an exclusion fence around Department of Commerce land on Table Mountain, which is preferred habitat for elk in this landscape. While the specific consequences of removing access to habitat on Table Mountain remain uncertain, anticipated effects include displacement into other open space and agricultural lands and increased human conflict.

Loss of access to preferred foraging areas also has clear energetic costs. Elk exposed to frequent disturbance spend more time moving or remaining vigilant and less time feeding, which reduces overall foraging efficiency. Studies documenting elk responses to roads and vehicle traffic show decreases in foraging and increases in flight or vigilance behavior, patterns that can translate into lower energy intake over time (McCorquodale 2013; Nojoumi et al. 2022). Prolonged avoidance of productive habitats has been linked to reduced body condition and fat reserves, particularly for female elk preceding winter, which can in turn affect pregnancy rates, calf survival, and overall herd productivity (Spitz et al. 2019).

Physical barriers such as highways, dense development, and ungulate-restrictive fencing can further compound these effects by disrupting traditional movement routes and seasonal migrations. Migration allows elk to access seasonally important forage and avoid severe environmental conditions, and barriers that limit this movement can force elk to remain in suboptimal seasonal ranges or alter long-established movement patterns (Watkins 2023). At broader spatial scales, fragmentation and reduced connectivity can isolate elk groups, restrict genetic exchange, and increase vulnerability to local disturbances, contributing to gradual population declines in heavily developed landscapes (Millhouser 2019).

In addition, restricting access to favored habitats can unintentionally increase mortality risk. Displaced elk may shift their movements closer to roads, railways, or human land uses, increasing exposure to vehicle collisions and management removals. Several studies have documented changes in elk distribution and increased mortality following highway construction or fencing that redirected movement rather than maintaining safe, permeable crossings (Harm et al. 2022). Taken together, the literature shows that cutting off access to key elk habitats can lead to cascading behavioral, nutritional, and demographic effects, underscoring the importance of maintaining habitat access, movement corridors, and low-disturbance conditions in landscapes that support elk populations.

B.2 Mule Deer



Mule deer (*Odocoileus hemionus*) occur throughout the U.S. 36 landscape and are among the most frequently observed large mammals in the corridor. Deer-vehicle collisions are distributed throughout much of the highway, reflecting both the widespread distribution of mule deer and their regular movements between foraging areas, bedding habitats, seasonal ranges, and water sources. Unlike elk, which often concentrate in specific wintering areas or migration routes, mule deer movements are generally dispersed across the landscape and occur in a wide variety of habitat types, including foothill shrublands, grasslands, agricultural lands, open space preserves, and low-density residential areas.

Mule deer are highly adaptable and often persist in close proximity to human development. While this adaptability allows them to occupy fragmented landscapes

that may be less suitable for other large ungulates, it also increases their exposure to roads and vehicle traffic. As a result, transportation corridors can be a significant source of mortality while also affecting how deer move through and use the landscape. Numerous studies have shown that roads can reduce habitat connectivity, alter movement patterns, and create behavioral avoidance, particularly where traffic volumes are high (Sawyer et al. 2013; Huijser et al. 2008). Unlike elk, which frequently avoid areas of concentrated human activity, mule deer often continue attempting to cross highways despite the associated risks, contributing to some of the highest wildlife-vehicle collision rates documented in western North America.



Mule deer use of wildlife crossing structures is well documented throughout the western United States and Canada. They have been observed using nearly every major crossing structure type, including wildlife overpasses, open span bridge underpasses, arch culverts, and box culverts. Compared to elk, mule deer appear more willing to use enclosed structures and are generally less sensitive to crossing structure openness. Research conducted across multiple western states indicates that deer use tends to increase as structures become wider and taller and decrease as structures become longer (Shilling et al. 2024). Although openness ratio is commonly used as a design metric, statistical relationships between mule deer passage rates and openness ratio are often weaker than those observed for elk. This likely reflects the fact that deer respond more directly to the physical dimensions of a structure than to openness ratio itself.

Wildlife overpasses have consistently proven to be among the most effective crossing structures for mule deer. Studies along major transportation corridors in Wyoming, Colorado, Utah, Arizona, and Alberta, Canada, have documented high crossing rates and rapid adaptation following construction. In southwest Wyoming, Sawyer et al. (2012) documented more than 49,000 mule deer crossings through a system of wildlife underpasses during a 3year monitoring period. Passage rates increased from approximately 54% during the first year of monitoring to over 90% by the third year, demonstrating that deer may require time to fully adapt to newly installed crossing structures. The same project reduced deer-vehicle collisions by approximately 81% following installation of underpasses and exclusion fencing, highlighting the value of integrating crossing structures with fencing (Sawyer et al. 2012).

As with elk, the location of crossing structures relative to existing movement routes is often as important as the structure design itself. Mule deer exhibit strong fidelity to established movement corridors and migratory pathways and frequently use the same routes across generations. Studies throughout the intermountain west have shown that crossing structures placed directly within established travel corridors receive substantially greater use than structures located outside preferred movement routes (Sawyer et al. 2012; Kauffman et al. 2020). In many cases, deer continue attempting to cross at historic crossing locations even when roads, fences, or development create obstacles to movement. Consequently, understanding where deer already move across the landscape is often one of the most important considerations when identifying effective mitigation opportunities.

Maintaining habitat connectivity is particularly important because many western mule deer populations rely on seasonal migrations to access forage resources across elevational gradients. These migrations allow deer to follow

the progression of spring green-up and access high-quality forage throughout the year. Research has shown that migratory mule deer generally achieve nutritional advantages over resident animals by tracking these seasonal changes in plant productivity, allowing them to accumulate fat reserves necessary for winter survival and reproduction (Middleton et al. 2013). When migration routes become fragmented or disrupted, deer may lose access to important seasonal habitats, resulting in increased energetic costs, reduced nutritional intake, and lower overall population performance.

Even when roads and development do not completely block movement, they can reduce the amount of habitat that deer effectively use. Multiple studies have found that mule deer alter their movements near roads, energy infrastructure, and other forms of human disturbance. In some cases, animals detour around disturbed areas, move more quickly through them, or reduce their use of otherwise suitable habitat (Sawyer et al. 2009; Sawyer et al. 2013). These responses can reduce the functional availability of habitat beyond the actual footprint of the disturbance. As development becomes more extensive, these cumulative effects can contribute to habitat fragmentation, isolation of seasonal ranges, and disruption of long-established movement patterns.

Fencing can play a critical role in reducing wildlife-vehicle collisions, but its effectiveness depends largely on maintaining opportunities for safe passage across the roadway. Wildlife exclusion fencing associated with crossing structures has consistently been shown to reduce collisions while allowing access to designated crossing locations. However, fencing that restricts movement without providing crossing opportunities can create barriers that fragment habitat and alter movement behavior. Although mule deer can jump many conventional livestock fences, repeated encounters with impermeable fencing can redirect movements, increase energetic expenditures, and reduce access to habitat. Studies across western North America have consistently shown that the greatest reductions in deer-vehicle collisions occur when fencing and crossing structures are implemented as an integrated system rather than individually (Huijser et al. 2016; Huijser et al. 2008). However, Rytwinski et al. (2016) have noted that the reduction in collisions is due to the fence-effect and not the crossings themselves.

For the U.S. 36 corridor, maintaining opportunities for mule deer movement would likely require considering both localized crossing locations and broader landscape connectivity. Unlike species that concentrate movement through a relatively small number of migration bottlenecks, mule deer movements in the project area appear to be distributed across much of the landscape. Consequently, successful mitigation measures would likely depend not only on crossing structure design but also on strategic placement within existing movement routes, integration with exclusion fencing, and preservation of habitat connectivity on both sides of the highway. The extensive body of research on mule deer movement ecology and crossing structure use demonstrates that transportation infrastructure can accommodate mule deer movements when permeability is incorporated into project planning and design. At the same time, failure to maintain connectivity can have long-term consequences for habitat access, migration, population resilience, and roadway safety.

B.3 Preble's Meadow Jumping Mouse



Preble's meadow jumping mouse (*Zapus hudsonius preblei*; Preble's) is a federally Threatened, riparian-dependent subspecies endemic to the Front Range of Colorado and southeastern Wyoming, including riparian systems along the U.S. 36 corridor. The species is closely tied to well-developed riparian corridors along streams, creeks, and adjacent wet meadows, generally below approximately 2,300 meters in elevation. Occupied habitat is characterized by dense herbaceous vegetation and shrubs, high plant species diversity, and close proximity to surface water, all of which provide essential foraging resources, protective cover from predators, and favorable microclimatic conditions. During the active season, typically from June through September, individuals forage primarily on seeds, berries, fungi, and invertebrates within riparian vegetation. In late summer and fall, Preble's move to nearby upland or terrace areas with loamy, well-drained soils to hibernate, often remaining underground for 7 to 8 months. This seasonal shift highlights the species' reliance not only on riparian habitat but also on adjacent upland areas, underscoring the importance of maintaining functional connectivity across the broader landscape (USFWS 2022; CPW 2024).

Preble's has been listed as Threatened under the federal Endangered Species Act since 1998. While localized conservation and riparian restoration efforts have resulted in stable or improving conditions in some watersheds, rangewide recovery remains limited, and populations continue to be fragmented. Recent conservation strategies have increasingly emphasized watershed-scale, collaborative approaches that engage landowners, agencies, and local communities. These efforts recognize the species as both a beneficiary and an indicator of healthy riparian ecosystems and, in recent years, management strategies have shifted toward maintaining long-term habitat connectivity and ecological function rather than site-specific protection alone (USFWS 2022; Knight et al. 2025).

The primary threat to Preble's continues to be the loss, degradation, and fragmentation of riparian habitat. Urban and suburban development, flood control and water management projects, agricultural conversion, grazing, and infrastructure expansion have all contributed to reduced habitat extent and simplified vegetation structure, as well as disrupted connections between seasonal habitats. Additional stressors include altered hydrologic regimes, invasive plant species, increased predation pressure in urbanized settings, and the growing influence of climate change, particularly changes in flood frequency, drought intensity, and riparian vegetation dynamics. These cumulative impacts reduce habitat quality and resilience, further challenging population persistence (USFWS 2022).

Movements of Preble's are generally localized and strongly constrained to linear riparian corridors. Radiotelemetry studies have shown that individuals maintain relatively small home ranges, with average 95% kernel home ranges of approximately 0.4 to 0.6 hectares, and males typically occupying larger areas than females. Home range size and movement patterns vary with floodplain width, vegetation complexity, sex, and annual precipitation, with mice occupying wider floodplains tending to use larger areas. Because movements are largely restricted to areas with

dense vegetative cover, the continuity of riparian habitat plays a critical role in allowing individuals to access foraging areas, breeding habitat, and hibernation sites throughout the year (Trainor et al. 2012).

At broader spatial scales, Preble's habitat is often fragmented by urban development, transportation infrastructure, agricultural lands, and altered stream channels. Landscape-scale modeling has shown that although substantial areas of potentially suitable riparian habitat remain, actual connectivity among occupied sites is frequently limited, resulting in population isolation among watersheds. Large expanses of unsuitable land cover can act as effective barriers to dispersal, increasing the species' vulnerability to local extirpation. Because the mouse has limited dispersal ability and relies on continuous vegetation cover, conservation of long, connected stream reaches is generally more important than protection of small, isolated habitat patches (Salo et al. 2020).

Direct empirical evidence documenting the use of culverts or other crossing structures by Preble's is limited; however, available literature consistently indicates that roads and other linear infrastructure can fragment habitat when they interrupt riparian vegetation or alter hydrologic conditions. Based on the species' movement ecology and observations of other small riparian mammals, Preble's may use culverts, bridges, or underpasses opportunistically when these structures maintain natural substrates, moisture, and vegetative cover and function as extensions of the riparian corridor. Notably, Preble's were documented using specially designed small fauna cover features through a large mammal underpass spanning a creek corridor (Kintsch et al. 2025). These features provide consistent woody cover through an otherwise open underpass and connect into the habitat on either side of a crossing. In contrast, long, dry, perched, or smooth-lined culverts lacking cover are likely to reduce permeability and serve as partial movement barriers. Accordingly, transportation structures that preserve riparian continuity and natural channel conditions are considered beneficial for maintaining functional connectivity, even though targeted studies specific to this species remain limited (USFWS 2022; Salo et al. 2020).

B.4 References

Clevenger, A.P., and M. Barrueto, eds. 2014. *Trans-Canada Highway Wildlife and Monitoring Research, Final Report. Part B: Research.* Parks Canada Agency, Radium Hot Springs, British Columbia.

CPW (Colorado Parks and Wildlife). 2024. *Preble's Meadow Jumping Mouse: Assessing Habitat Quality for Priority Wildlife Species in Colorado Wetlands.* Colorado Natural Heritage Program.

Dodd, N.L., J.W. Gagnon, S. Boe, A. Manzo, and R.E. Schweinsburg. 2007. *Evaluation of Measures to Minimize Wildlife-Vehicle Collisions and Maintain Wildlife Permeability across Highways: State Route 260, Arizona, USA.* Final Report 540 (2002–2006). Phoenix: Arizona Transportation Research Center and Arizona Department of Transportation.

Gagnon, J.W., Dodd, N.L., Ogren, K.S., and Schweinsburg, R.E. 2011. Factors Associated with Use of Wildlife Underpasses and Importance of Long-Term Monitoring. *Journal of Wildlife Management* 75(6): 1477-1487.

Hamr, J., D.J. Lieske, C.B. Nickel, J.N. Popp, and M. Martin. 2022. "The Efficacy of Highway Wildlife Collision Mitigation in Preventing Elk Mortality in Central Ontario." *Journal of Wildlife Management* 86 (2): e22184. https://doi.org/10.1002/jwmg.22184.

Huijser, M.P., E.R. Fairbank, W. Camel-Means, J. Graham, V. Watson, P. Basting, and D. Becker. 2016. Effectiveness of short sections of wildlife fencing and crossing structures along highways in reducing wildlife-vehicle collisions and providing safe crossing opportunities for large mammals. *Biological Conservation* 197:61-68. https://doi.org/10.1016/j.biocon.2016.02.002

Huijser, M.P., P. McGowan, J. Fuller, A. Hardy, A.V. Kociolek, A.P. Clevenger, D. Smith, and R. Ament. 2008. *Wildlife-Vehicle Collision Reduction Study: Report to Congress*. Federal Highway Administration, FHWA-HRT-08-034, Washington, D.C.

Kauffman, M.J., J.J. Berg, J.S. Dent, B.J. Hartway, R. Mehringer, J.G. Merkle, W.F. Fagan, and numerous state and federal collaborators. 2020. *Ungulate Migrations of the Western United States, Volume 1*. U.S. Geological Survey Scientific Investigations Report 2020-5101.

Kintsch, J., P. Cramer, P. Singer, and M. Cowardin. 2021. *State Highway 9 Wildlife Crossings Mitigation Monitoring.* CDOT-2021-01. Denver, CO: Colorado Department of Transportation, Applied Research and Innovation Branch.

Kintsch, J., P. Singer, A. Telander, R. Knoedler, J. Swenson, B. Hanks, and J. Phelan. 2025. *I-25 South Gap Wildlife Monitoring Study.* CDOT-2025-08. Denver, CO: Colorado Department of Transportation, Office of Applied Research.

Knight, H.A.L., C.B. Beebe, C.D. Dick, M. Maiolo-Heath, and R. Schorr. 2025. "A Novel, Community-Based Approach to Endangered Species Recovery: The Case of the Preble's Meadow Jumping Mouse (*Zapus hudsonius preblei*)." *Frontiers in Conservation Science* 6: 1528441. https://doi.org/10.3389/fcosc.2025.1528441.

McCorquodale, S.M. 2013. *A Brief Review of the Scientific Literature on Elk, Roads, and Traffic.* Washington Department of Fish and Wildlife.

Middleton, A.D., M.J. Kauffman, D.E. McWhirter, J.G. Cook, R.C. Cook, A.A. Nelson, M.D. Jimenez, and R.W. Klaver. 2013. Animal migration amid shifting patterns of phenology and predation: Lessons from a Yellowstone elk herd. *Ecology* 94(6):1245-1256.

Millhouser, P. 2019. *Evaluating Landscape Connectivity and Habitat Fragmentation Effects on Elk in the Roaring Fork and Eagle Valleys*. Capstone Project Report, Master of Geographic Information Systems, The Pennsylvania State University, University Park, Pennsylvania.

Nojoumi, M., A.P. Clevenger, D.T. Blumstein, and E.S. Abelson. 2022. "Vehicular Traffic Effects on Elk and White-Tailed Deer Behavior Near Wildlife Underpasses." *PLOS ONE* 17(11): e0269587. https://doi.org/10.1371/journal.pone.0269587.

Rowland, M.M., M.J. Wisdom, B.K. Johnson, and M.A. Penninger. 2004. "Effects of Roads on Elk: Implications for Management in Forested Ecosystems." *Transactions of the North American Wildlife and Natural Resources Conference* 69: 491–508.

Rytwinski, T., K. Soanes, J.A. Jaeger, L. Fahrig, C.S. Findlay, J. Houlahan, R. van der Ree, and E.A. van der Grift. 2016. "How Effective Is Road Mitigation at Reducing Road-Kill? A Meta-Analysis." *PLoS ONE* 11(11): e0166941.

Salo, J.A., E.P. Gage, G.L. Katz, and J.M. Stoker. 2020. "Assessing Preble's Meadow Jumping Mouse (*Zapus hudsonius preblei*) Habitat and Connectivity for Conservation and Restoration." *Wetlands* 40: 1813–27. https://doi.org/10.1007/s13157-020-01374-6.

Sawyer, H., M.J. Kauffman, A.D. Middleton, T.A. Morrison, R.M. Nielson, and T.B. Wyckoff. 2013. A framework for understanding semi-permeable barrier effects on migratory ungulates. *Journal of Applied Ecology* 50:68-78.

Sawyer, H., M.J. Kauffman, and R.M. Nielson. 2009. Influence of well pad activity on winter habitat selection patterns of mule deer. *Journal of Wildlife Management* 73(7):1052-1061.

Sawyer, H., C. LeBeau, and T. Hart. 2012. Mitigating roadway impacts to migratory mule deer: A case study with underpasses and continuous fencing. *Wildlife Society Bulletin* 36(3):492-498. https://doi.org/10.1002/wsb.166

Shilling, F., N. Thoron, and D. Waetjen. 2024. *Predicting Wildlife Use of Existing Highway Bridges and Culverts.* UCD-ITS-RR-24-06. Davis, CA: University of California, Davis Road Ecology Center/ METRANS Transportation Center.

Spitz, D.B., M.M. Rowland, D.A. Clark, M.J. Wisdom, J.B. Smith, C.L. Brown, and T. Levi. 2019. "Behavioral Changes and Nutritional Consequences to Elk (*Cervus canadensis*) Avoiding Perceived Risk from Human Hunters." *Ecosphere* 10(9): e02864. https://doi.org/10.1002/ecs2.2864.

Trainor, A.M., T.M. Shenk, K.R. Wilson, and others. 2012. "Spatial, Temporal, and Biological Factors Associated with Preble's Meadow Jumping Mouse (*Zapus hudsonius preblei*) Home Range." *Journal of Mammalogy* 93 (2): 429–38. https://doi.org/10.1644/11-MAMM-A-049.1.

USFWS (U.S. Fish and Wildlife Service). 2022. *Preble's Meadow Jumping Mouse (Zapus hudsonius preblei) Species Profile.* Accessed July 30, 2026. https://www.fws.gov/species/prebles-meadow-jumping-mouse-zapus-hudsonius-preblei.

Watkins, L. 2023. *Migration of Elk (Cervus canadensis) and Barriers to Movement.* Master's thesis, Brigham Young University.

Appendix C
Effects of Traffic on Wildlife

Traffic volume (annual average daily traffic [AADT]) is a key determinant of how wildlife respond to roads, influencing both mortality risk and behavioral avoidance. Roads create a "road-effect zone" where ecological processes are altered through habitat fragmentation, disturbance, and wildlife-vehicle collisions (Forman 2000; Clevenger and Huijser 2011). In general, studies describe a consistent pattern: low traffic volumes allow relatively frequent crossings, intermediate traffic levels tend to produce the highest mortality rates for certain species, and high traffic volumes discourage crossings for certain species altogether, effectively creating movement barriers (Clevenger and Huijser 2011; Seiler 2003).

Field studies support this general pattern, although the relationship between AADT and wildlife mortality is not always straightforward and varies among species. For deer in Europe, mortality often peaks at moderate traffic levels—roughly 10,000 to 20,000 AADT—where animals still attempt to cross but encounter a high likelihood of collision (Clevenger and Huijser 2011; Grilo et al. 2015). In contrast, for mule deer and coyote in California, there is a linear increase in mortality compared with increasing traffic volume (Haworth 2026). At higher volumes (>20,000 AADT), some species may begin to avoid roads entirely, which can reduce mortality rates but also limits movement and connectivity (Grilo et al. 2015). At the same time, more recent work points out that these patterns are not universal; some species show steady increases or even more complex relationships with traffic volume, highlighting the importance of species behavior and local conditions (Denneboom et al. 2024; Haworth 2026).

Lower-volume roads (<5,000 AADT) are now recognized as an important part of the problem as well. Because they remain relatively easy for animals to cross, they can generate substantial mortality over time (Grilo et al. 2015). These effects are closely tied to behavior: wildlife often become more vigilant and spend less time foraging near roads (Collins et al. 2022; Nojoumi et al. 2022), and successful crossings depend on sufficiently large gaps in traffic—approximately 60 seconds for deer under some traffic conditions (Riginos et al. 2018). Taken together, this suggests that traffic volume alone does not determine impact; rather, it interacts with animal behavior and landscape context to shape outcomes. In practice, this creates a trade-off between mortality and connectivity, with lower traffic allowing movement but still causing collisions, and higher traffic reducing collisions while increasing fragmentation.

The AADT range in the corridor (9,200–12,000 vehicles/day) falls within this intermediate range, where both mortality risk and emerging barrier effects are expected. Roads in the approximately 3,000–10,000 AADT range typically show increasing wildlife mortality, with peak impacts for some species occurring between about 10,000 and 20,000 AADT (Clevenger and Huijser 2011; Grilo et al. 2015; but see Haworth 2026 for mule deer and coyote). This suggests that the upper end of the corridor overlaps with conditions where wildlife continue to attempt road crossings but face a relatively high risk of collision. At the same time, traffic volumes at this level may reduce crossing opportunities by limiting the availability of suitable gaps in traffic, thereby introducing partial barrier effects (Riginos et al. 2018). Compared to lower-volume roads, the corridor is therefore expected to experience higher mortality and reduced permeability, although it likely has not yet reached the level of a complete behavioral barrier observed on some higher-volume roadways. Overall, this range represents a transitional condition in which both mortality and fragmentation pressures are likely to be important.

References

Clevenger, A.P., and M.P. Huijser. 2011. *Wildlife Crossing Structure Handbook: Design and Evaluation in North America.* FHWA (Federal Highway Administration).

Collins, A. C., Vickers, T. W., and Shilling, F. M. 2022. "Behavioral responses to anthropogenic noise at highways vary across temporal scales." *Frontiers in Ecology and Evolution* 10.

Denneboom, D., Bar-Massada, A., and Shwartz, A. 2024. "Wildlife mortality risk posed by high and low traffic roads." *Conservation Biology* 38(2): e14159. https://doi.org/10.1111/cobi.14159.

Forman, R. T. T.. 2000. "Estimate of the area affected ecologically by the road system in the United States." *Conservation Biology* 14(1):31–35.

Grilo, C., Ferreira, F. Z., and Revilla, E. 2015. "No evidence of a threshold in traffic volume affecting road-kill mortality at a large spatio-temporal scale." *Environmental Impact Assessment Review* 55:54–58.

Haworth, L. 2026. Median barrier type affects road permeability. MSc Thesis, University of California, Davis. Pp. 59.Nojoumi, M., A.P. Clevenger, D.T. Blumstein, and E.S. Abelson. 2022. "Vehicular Traffic Effects on Elk and White-Tailed Deer Behavior Near Wildlife Underpasses." *PLOS ONE* 17(11): e0269587. https://doi.org/10.1371/journal.pone.0269587.

Riginos, C., Smith, C., Fairbank, E. R., Hansen, E., and Hallsten, P. 2018. "Traffic Thresholds in Deer Road-Crossing Behavior." Wyoming Department of Transportation, Report No. WY-1807F.

Seiler, A. 2003. "The toll of the automobile: Wildlife and roads in Sweden." Doctoral dissertation, Swedish University of Agricultural Sciences, Uppsala. Acta Universitatis Agriculturae Sueciae Silvestria 295. ISBN 91-576-6529-X.

Appendix D

Elk Hunting Considerations

Studies of wildlife flight initiation distance (FID), or flushing distance, consistently show that hunting pressure increases an animal's perception of risk and generally results in animals fleeing at greater distances from people. Animals in hunted landscapes are typically more vigilant, less tolerant of human presence, and more likely to avoid open areas than animals in protected or non-hunted settings (Stankowich and Blumstein 2005; Sreekar et al. 2015).

Among ungulates, hunting-related behavioral responses are particularly well documented. Deer, elk, pronghorn, and other large herbivores commonly increase flushing distances, shift habitat use toward areas with greater cover, become more nocturnal, and reduce use of otherwise preferred habitats during hunting periods (Proffitt et al. 2013; Lone et al. 2015). Hunting pressure frequently creates a "landscape of fear" in which animals alter movement patterns and habitat selection in anticipation of risk rather than in response to direct encounters alone. These behavioral changes can occur rapidly following the onset of hunting seasons and may persist beyond the period of active hunting (Ciuti et al. 2012; Lone et al. 2015).

Research on elk demonstrates that perceived hunting risk can substantially affect movement behavior, space use, and flushing distances. Proffitt et al. (2013) found that elk altered resource selection patterns during hunting seasons by increasing use of areas that provided security cover and reduced hunter access. Similarly, Ciuti et al. (2012) reported that human hunters influenced elk behavior more strongly than natural predators in some landscapes, causing elk to shift habitat use away from areas of elevated hunting risk. Found (2021) further demonstrated that exposure to predation risk was one of the strongest predictors of FID in free-ranging elk, with animals exposed to greater risk exhibiting longer flushing distances.

Similar responses have been documented in other cervids. Lone et al. (2015) found that male red deer rapidly shifted habitat use following the onset of hunting season, moving into areas that reduced hunter encounter rates. Studies of roe deer and moose have also documented increased use of cover, reduced daytime movements, and avoidance of areas with concentrated hunting activity (Sunde et al. 2009; Ericsson and Wallin 1999). Collectively, these studies indicate that hunting affects not only direct mortality but also broader patterns of habitat use, landscape connectivity, and animal movements.

FID is influenced by several factors in addition to hunting pressure. Habitat openness, distance to escape cover, group size, age and sex of individuals, previous exposure to hunters, and individual behavioral tendencies can all affect FID (Stankowich and Blumstein 2005; Found 2021). Elk and many other ungulates often favor areas that provide a combination of visibility and escape opportunities, allowing them to detect and respond to threats before close encounters occur.

Reported FIDs in ungulates vary widely among species and settings. Studies have documented average flushing distances ranging from less than 100 meters in habituated populations within protected areas to several hundred meters in heavily hunted populations. For elk and other large ungulates, flushing distances of 200–500 meters are commonly reported in hunted landscapes, while animals exposed to repeated non-threatening human activity often tolerate substantially closer approaches. This variability reflects differences in hunting pressure, habitat conditions, and local behavioral adaptation (Found 2021; Stankowich and Blumstein 2005).

From a management perspective, the literature suggests that hunting can influence wildlife movement patterns well beyond direct mortality effects. Increased wariness may alter habitat use, movement corridors, and willingness to use wildlife crossing structures. Consequently, minimizing human disturbance near key movement routes, maintaining secure habitat connections, and providing vegetation screening or other refuge features near crossings are often considered important design considerations for risk-sensitive species such as elk and other ungulates (Kintsch et al. 2020; Ciuti et al. 2012; Proffitt et al. 2013).

References

Ciuti, S., J.M. Northrup, T.B. Muhly, S. Simi, M. Musiani, J.A. Pitt, and M.S. Boyce. 2012. "Effects of Humans on Behaviour of Wildlife Exceed Those of Natural Predators in a Landscape of Fear." *PLoS ONE* 7(11): e50611.

Ericsson, G., and K. Wallin. 1999. "Hunter Observations as an Index of Moose (*Alces alces*) Population Parameters." *Wildlife Biology* 5:177–185.

Found, R. 2021. "Personality and Other Factors Mediating Ungulate Flight Initiation Distances." *Ecology and Evolutionary Biology* 6(4): 125–135.

Kintsch, J., P. Cramer, P. Singer, M. Cowardin, and J. Phelan. 2020. *State Highway 9 Wildlife Crossings Monitoring: Year 4 Progress Report.* Colorado Department of Transportation.

Lone, K., L. Egil Loe, E.L. Meisingset, I. Stamnes, and A. Mysterud. 2015. "An Adaptive Behavioural Response to Hunting: Surviving Male Red Deer Shift Habitat at the Onset of Hunting Season." *Animal Behaviour* 102: 127–138.

Proffitt, K.M., J.L. Grigg, R.A. Garrott, K.L. Hamlin, and J.A. Cunningham. 2013. "Changes in Elk Resource Selection and Distributions Associated with a Late-Season Elk Hunt." *Journal of Wildlife Management* 77: 470–482.

Sreekar, R., E. Goodale, and R.D. Harrison. 2015. "Flight Initiation Distance as a Behavioral Indicator of Hunting Pressure." *Tropical Conservation Science* 8: 505–512.

Stankowich, T., and D.T. Blumstein. 2005. "Fear in Animals: A Meta-Analysis and Review of Risk Assessment." *Proceedings of the Royal Society B* 272: 2627–2634.

Sunde, P., C.R. Olesen, J.D. Møller, and L. Haugaard. 2009. "Behavioral Responses of Roe Deer to Hunting Disturbance." *European Journal of Wildlife Research* 55: 551–557.

Appendix E

Detailed Review of Benesch (2024) Study

The Study's screening and prioritization process was primarily driven by available quantitative data for deer and elk, including wildlife-vehicle collision (WVC) records, elk collar data, and movement patterns. While other wildlife species are known to occur within the corridor and may also experience roadway mortality and connectivity constraints, comparable movement datasets were generally not available for many of these species. As a result, they were not a primary factor in the crossing-location prioritization process. Importantly, the Study did recognize the presence of smaller mammals, birds, reptiles, amphibians, and federally listed species such as Preble's meadow jumping mouse, and included recommendations for culvert enhancements and other mitigation measures intended to improve connectivity for smaller wildlife. Future phases of design could further evaluate how crossing structure location and design may support a broader range of species with differing habitat preferences and movement behaviors.

Prioritization Process

The prioritization process used in the Study was effective for identifying locations that would benefit elk and deer, but understanding how the underlying datasets and evaluation framework influenced the resulting recommendations helps to explain why certain crossing locations emerged as priorities and where opportunities may exist to broaden future planning efforts to encompass a wider range of wildlife species.

As with many prioritization processes, the availability and quality of wildlife data strongly influenced the prioritization outcomes. Spatially explicit data for elk and deer were substantially more robust than data available for most other wildlife species due to extensive GPS collaring efforts, documented WVC records, and more detailed habitat mapping. In contrast, information available for species such as mountain lions, black bears, meso-carnivores, reptiles, amphibians, and small mammals was generally more limited in both quantity and spatial resolution. The screening and prioritization process relied heavily on datasets that represented ungulate movement patterns and WVC hotspots, providing a strong empirical basis for identifying locations that would benefit elk and deer. This approach is consistent with the Study's stated objectives and reflects the reality that conservation planning is often guided by the species for which the most reliable information is available. At the same time, the resulting crossing recommendations provide the greatest level of confidence for addressing the movement and mortality concerns of elk and deer, while the extent to which they optimize benefits for other wildlife taxa is less certain and would likely require additional species-specific information to evaluate. The influence of taxonomic bias on ecological studies and conservation decision-making is a well-recognized and common problem (Troudet et al. 2017).

The Study explicitly identified elk as the focal species for crossing design, based on their size and the assumption that structures suitable for elk passage could also serve many other wildlife species. This approach is consistent with common wildlife crossing planning practices, as structures designed for large-bodied ungulates often provide connectivity benefits for a variety of taxa. However, elk crossing preferences are influenced not only by body size, but also by anti-predator behaviors and a preference for open conditions around crossing structures (Kintsch et al. 2015). Successful use of crossing structures by non-target species often depends on additional design considerations beyond structure dimensions alone, including vegetation composition, proximity to suitable habitat, adjacent land uses, levels of human and traffic disturbance, and long-term habitat management. Consequently, the effectiveness of the proposed overpasses for the broader wildlife community would depend not only on their location, but also on how habitat features and disturbance-reduction measures are incorporated during final design, implementation, and long-term management.

Elk WVC data and elk collar data were both incorporated into the scoring framework, providing complementary datasets that capture both wildlife mortality patterns and movement behavior. At the same time, this approach places greater emphasis on elk than on species for which similarly comprehensive movement and mortality

datasets are not available. Given the Study's objectives of improving motorist safety and maintaining ungulate connectivity, this emphasis is appropriate; however, it also highlights an opportunity for future planning efforts to incorporate additional species-specific datasets where available to further evaluate benefits across the broader wildlife community.

The Study includes environmental permitting considerations as a screening criterion, while also acknowledging that environmental clearances are manageable through planning, coordination, and mitigation. At the same time, many environmentally sensitive resources, including wetlands, riparian corridors, and habitats supporting threatened and endangered species, often function as important movement corridors and connectivity features within the landscape. As projects advance into design and environmental review, there may be opportunities to further integrate habitat connectivity objectives with transportation safety goals by considering how crossing infrastructure can enhance connectivity among these ecologically important areas.

Finally, the additive scoring framework used in the screening process represents a practical, transparent, and commonly applied method for comparing alternatives across multiple evaluation criteria. Such approaches are particularly useful during early planning stages because they provide a consistent framework for comparing diverse project objectives. However, additive scoring methods also have inherent limitations. Closely related variables can sometimes reinforce one another, highly weighted criteria can strongly influence overall rankings, and tradeoffs among competing objectives may not always be fully apparent within a cumulative score. More advanced structured decision-making approaches can, in some cases, provide additional insight into uncertainty and the relative importance of competing objectives. Nevertheless, the Study's approach successfully identified locations that address its primary goals of reducing ungulate-related WVCs and maintaining landscape connectivity for ungulates, while also providing a foundation for incorporating broader biodiversity considerations during future design, environmental review, and implementation phases.

References

Kintsch, J., S.L. Jacobson, and P. Cramer. 2015. *The Wildlife Crossing Guilds Decision Framework: A Behavior-Based Approach to Designing Effective Wildlife Crossing Structures.* In *Proceedings of the International Conference on Ecology and Transportation*. Raleigh, NC.

Troudet, J., P. Grandcolas, A. Blin, R. Vignes-Lebbe, and F. Legendre. 2017. "Taxonomic Bias in Biodiversity Data and Societal Preferences." *Scientific Reports* 7(1): 9132.

Appendix F

Response to Agency Concerns Regarding the 2024 U.S. 36 Wildlife Crossing Conceptual Designs

The following table summarizes how agency concerns regarding the U.S. 36 Wildlife Crossing Conceptual Designs (Benesch and Pinyon Environmental 2024) have been addressed in the refined wildlife crossing system recommendations.

Location	Issue of Concern	Response	Addressed?
Corridor-wide	Review project extents and fence length (from Left Hand Creek to St Vrain Creek).	The Dudek Team reevaluated the need for extending the project north of St Vrain Road, beyond the 95th percentile segment identified in the Eastern Slope and Plains Wildlife Prioritization Study. This review upheld the rationale for the recommended project extent from Left Hand Creek to St Vrain Creek.	✓
Corridor-wide	More underpasses and fewer overpasses would be more appropriate for this segment.	The refined recommendations call for one overpass and three underpasses.	✓
Corridor-wide	Fencing distances between some proposed crossings are too long for elk.	The fence distances between recommended crossing structures (including the two existing bridges that bookend the project area) range from 0.25 to 2.15 miles. The two portions of the project area with the longest distances between elk crossing opportunities lie outside of the area with the greatest concentration of elk crossing activity. While spacing between crossings was a factor in determining suitable elk crossing locations, other factors including local terrain conditions, adjacent land security, and land use also influenced crossing structure site selection and spacing.	✓
Proposed Phase 2 Segment (north of St Vrain Road)	If the project were phased, the St Vrain Rd overpass (MP 24.6) would be built first and the fence would run all the way north to CO 66, creating an extensive fence barrier until the northern overpass is built in Phase 2.	The Dudek Team does not recommend phasing the project due to the cost efficiencies of a single project, concerns about exacerbating WVC conflict in an unfenced Phase 2 segment, and the risk of a Phase 2 being delayed or never completed.	✓
St Vrain Intersection	Distance between the intersection and the proposed overpass at MP 24.6 may limit driver sight lines.	Overpass location moved farther south (from MP 24.6 to MP 24.75), increasing the distance from the intersection.	✓
St Vrain Road	An overpass at MP 24.6 in close proximity to St Vrain Road may increase elk crossing activity over the County Road.	Overpass location moved farther south (from MP 24.6 to MP 24.75), increasing the distance from St Vrain Road and the likelihood that animals will disperse, consistent with current movement patterns	✓

Location	Issue of Concern	Response	Addressed?
		(e.g., elk tend to cross in this area and then head east and southeast toward Table Mountain).	
MP 25.0	Assess potential underpass at MP 25.0 as an alternative or in addition to the overpass at MP 24.6.	The refined recommendations call for an underpass at MP 25.0 to complement an overpass at MP 24.75. The primary targeted species for the overpass is elk, while the underpass is expected to provide safe passage for species such as black bear, mountain lion, bobcat, and mule deer.	✓
Proposed Fence Ends	Reevaluate proposed fence end designs at Left Hand Creek and St Vrain Creek.	The refined recommendations support terminating the south fence end at Left Hand Creek Bridge on both the east and west sides of U.S. 36 (instead of terminating the west side fence at Lefthand Canyon Drive). The Dudek Team offered two alternatives for the north fence: tying into the St Vrain Creek Bridge or terminating the fence at the stone quarry entrance. The final selection of the north fence end terminus will depend on further investigation into access requirements and bikeway improvements.	✓
Corridor-wide	Deer guards at major intersections are necessary but require careful consideration.	The refined recommendations emphasize the need for deer guards at all intersections and driveway access points in the fenced segment. High-level guidance includes setting guards farther back from major intersections to minimize guard width while preserving turning radii and remaining within the road rights-of-way.	✓

References

Benesch and Pinyon Environmental. 2024. *Wildlife Crossing Assessment, Prioritization, and Cost Estimation Study: U.S. 36 Wildlife Crossings Project, Boulder, Colorado.*

Kintsch, J.A., P. Basting, T. Smithson, G. Woolley, Jacobs Engineering Group, and ECO-resolutions LLC. 2022. Eastern Slope and Plains Wildlife Prioritization Study. Prepared for Colorado Department of Transportation (CDOT) and Colorado Parks and Wildlife (CPW), Denver, Colorado. CDOT Report No. 2022-03.

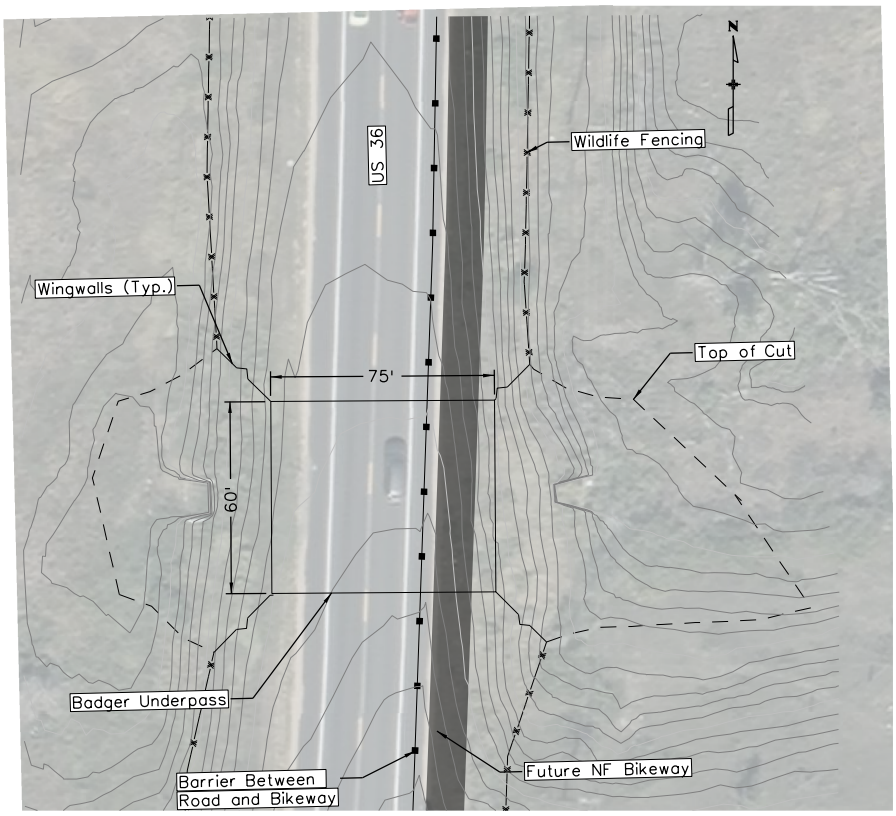
Appendix G
Conceptual Plans

Nighthawk Conceptual Rendering of the Overcrossing



Badger Underpass, MP 22.6

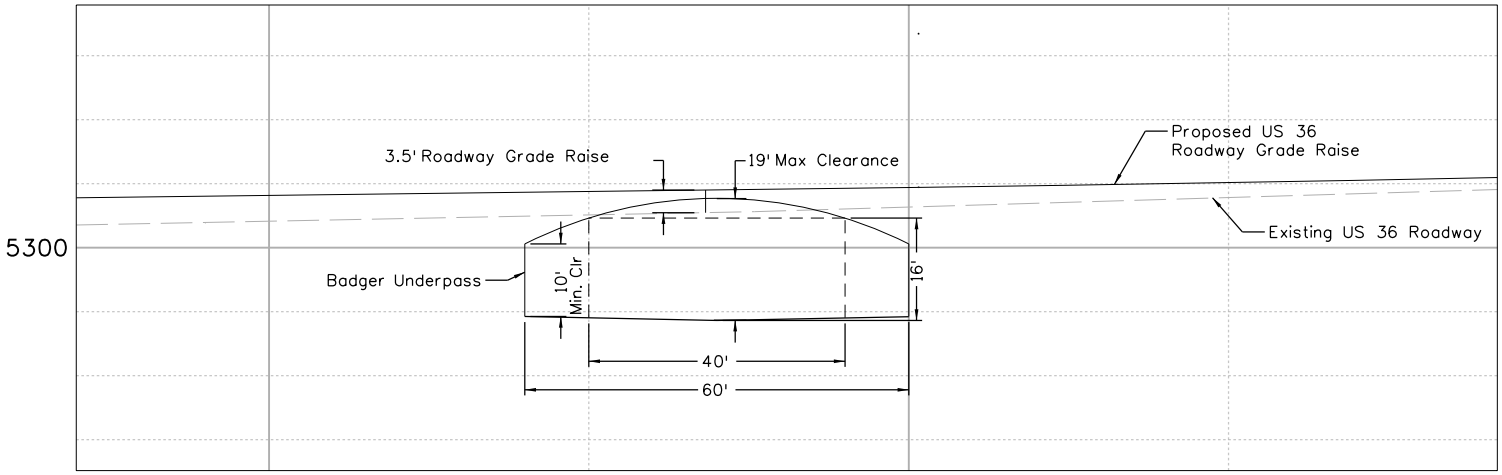
Badger Underpass, MP 22.6



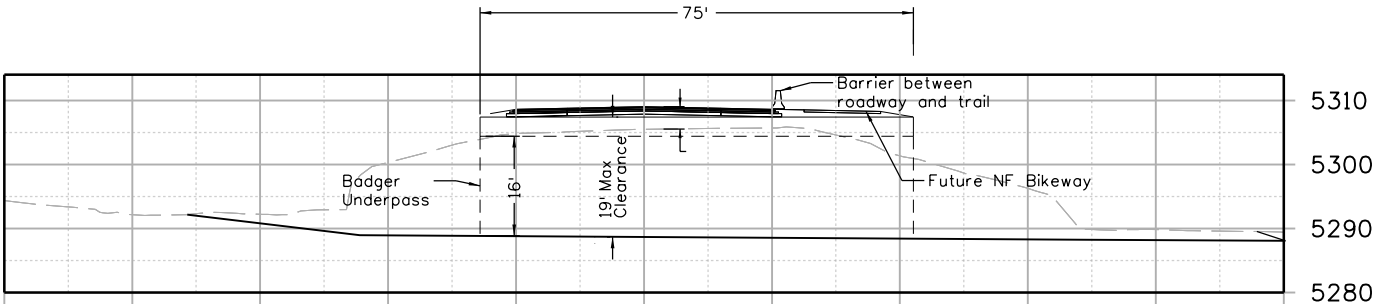
Underpass Plan View

Notes

1. Arch Underpass with 40'W x 16'H x 75'L clearance box for wildlife.
2. Minimum clearance for wildlife = 10'
3. Roadway Grade Raise of 3.5 feet to allow for wildlife to use Underpass comfortably
4. Design accommodates future North Foothills (NF) Bikeway
5. A bridge underpass design was also considered but it was determined an arch is much more cost effective.
6. Approximate MP 22.6



Underpass Section



Underpass Profile

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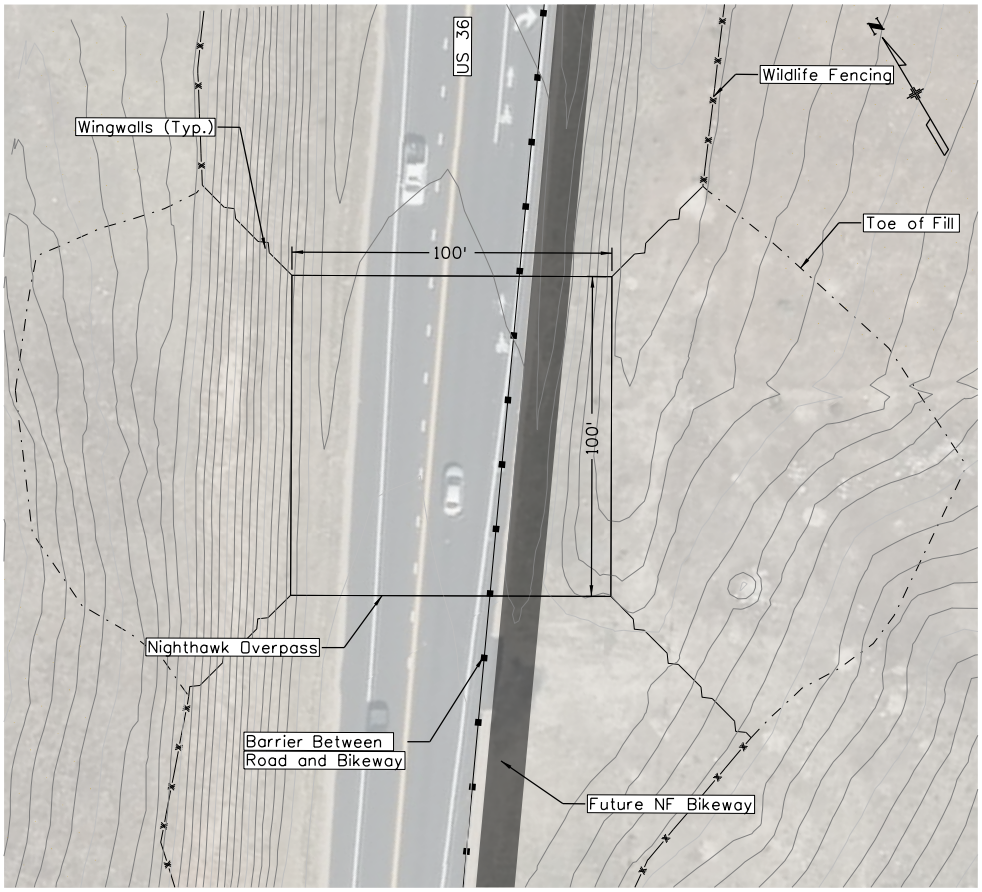
Nighthawk Overpass, MP 24.75

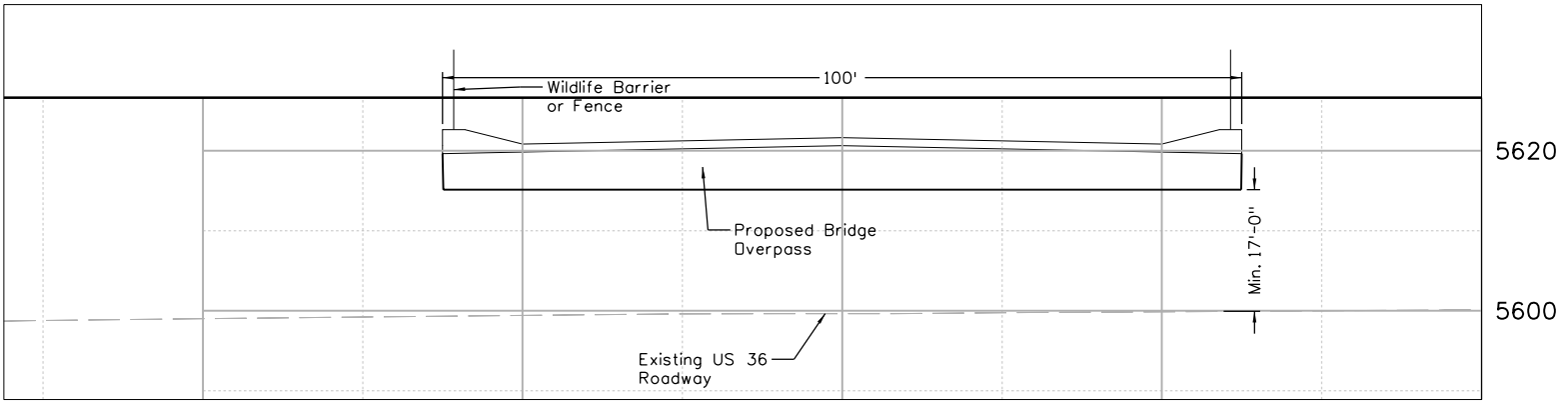
Nighthawk Overpass, MP 24.75



Overpass Plan View

Notes

1. 100' W x 100' L Bridge Overpass
2. Minimum clearance for vehicles = 17'
2. Approximate MP 24.75
3. Design accommodates future North Foothills (NF) Bikeway



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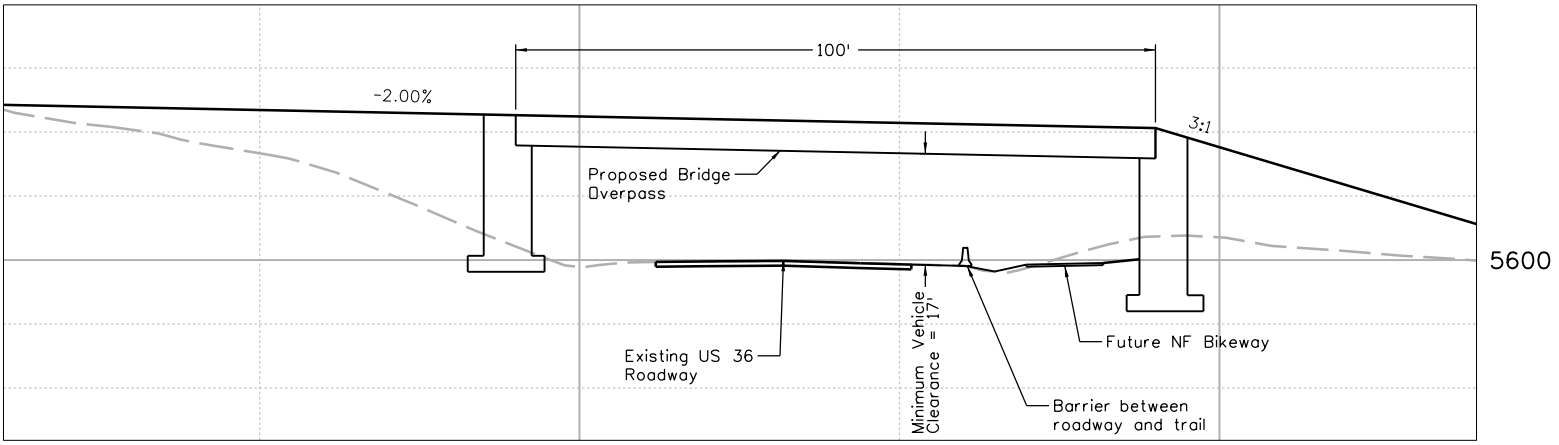

Overpass Profile

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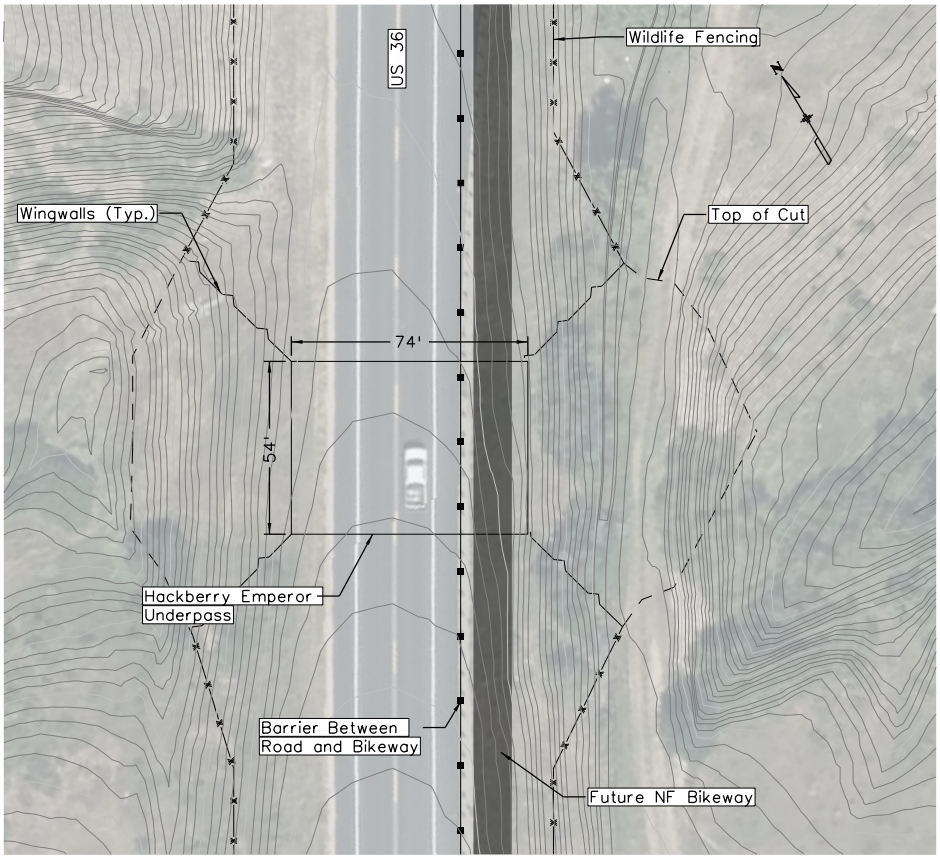
Hackberry Emperor Underpass, MP 25.0

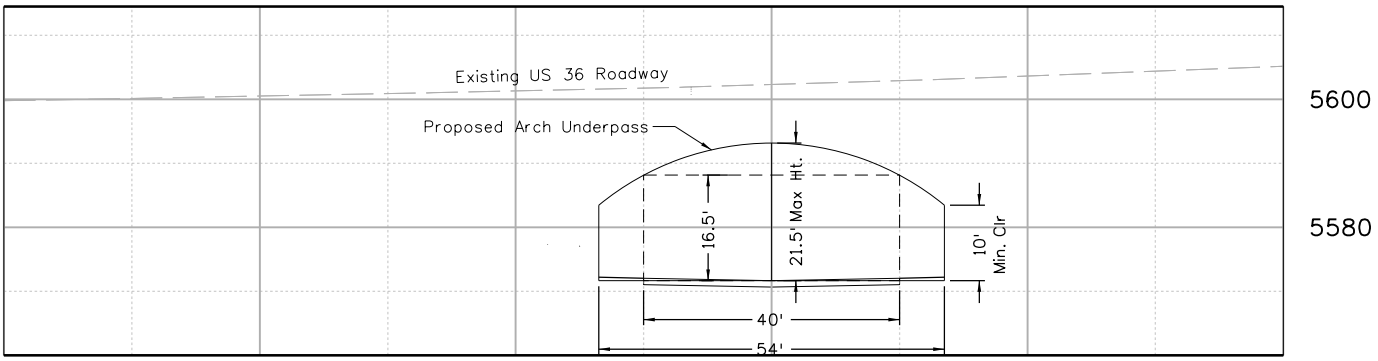
Hackberry Emperor Underpass, MP 25.0



Underpass Plan View

Notes

1. Arch Underpass with 40' W x 16.5' H clearance box for wildlife
2. Minimum clearance for wildlife = 10'
3. Design accommodates future North Foothills (NF) Bikeway
4. Approximate MP 25.0
5. Maximum structure height = 21.5'



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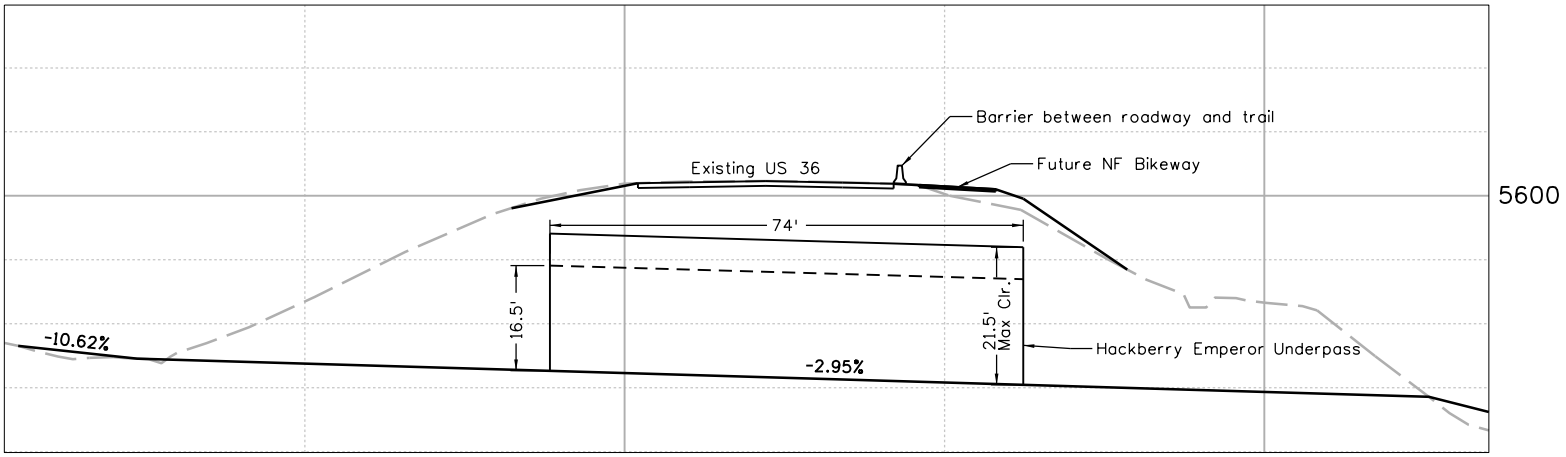

Underpass Profile

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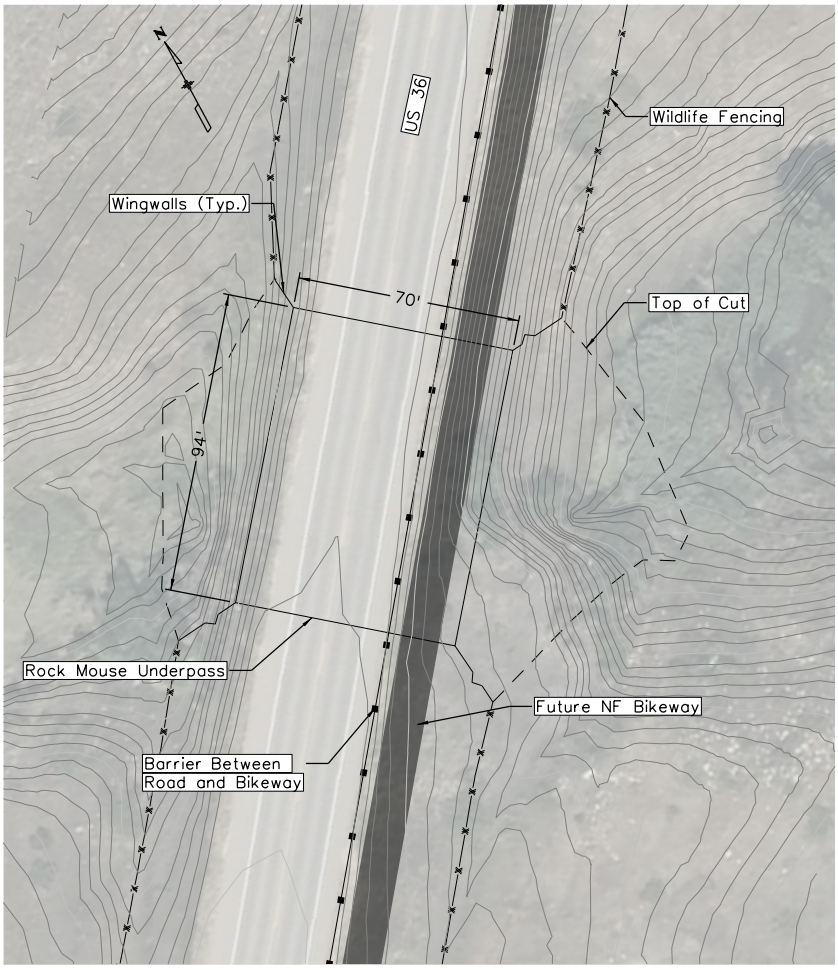
Rock Mouse Underpass, MP 26.3

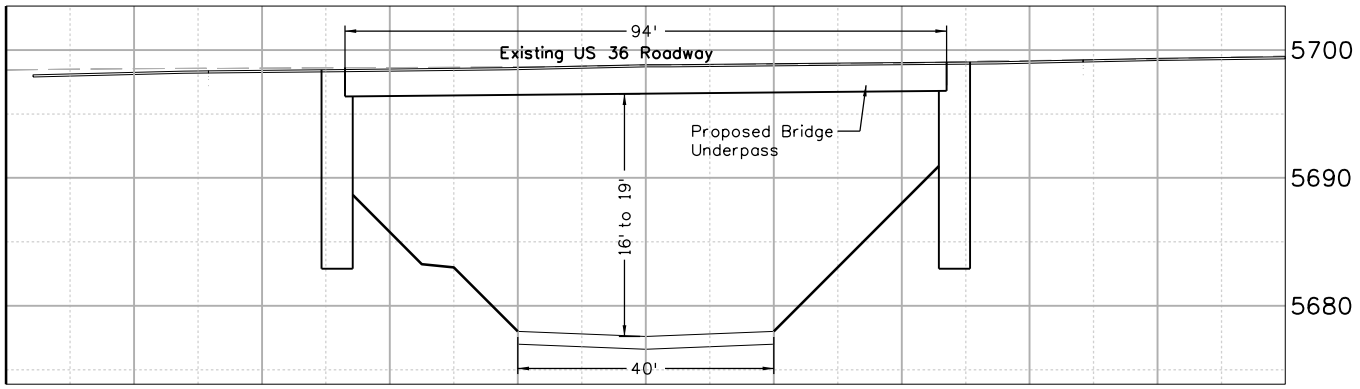
Rock Mouse Underpass, MP 26.3



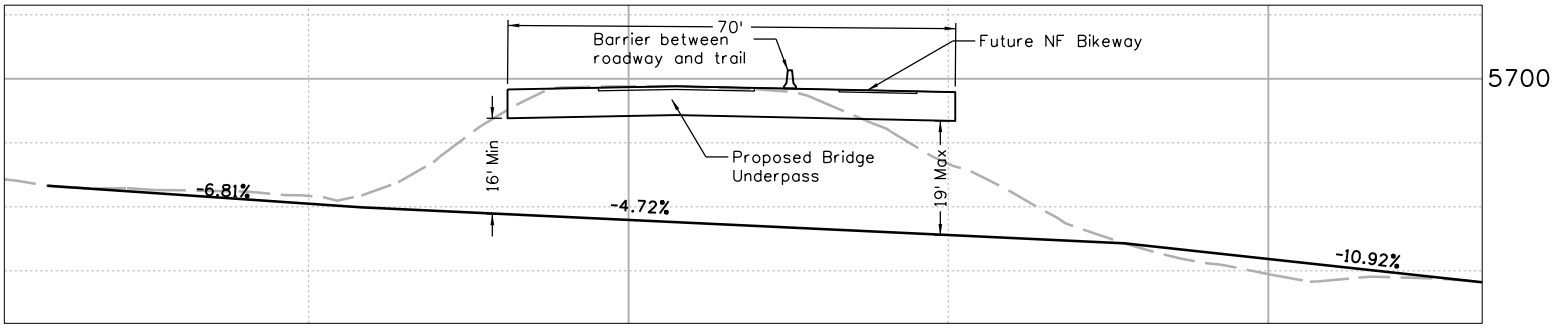
Underpass Plan View

Notes

1. Bridge Underpass with 16' minimum clearance for wildlife
2. Design accommodates future North Foothills (NF) Bikeway
3. Bench grading in underpass to tie into existing slopes
4. Approximate MP 26.3



Underpass Section



Underpass Profile

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Appendix H
Detailed Cost Estimate

Cost Estimate
Refined Recommendations for Wildlife Crossings on US36

ITEM NO.	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	COST
607	Fence Deer	LF	63,000	$ 25.00	$ 1,575,000
607	Escape Ramp (Special)	EACH	25	$ 15,000.00	$ 375,000
603	Badger Underpass - MP 22.6	EACH	1	$ 5,402,138.89	$ 5,402,139
604	Nighthawk Overpass - MP 24.75	EACH	1	$ 4,983,200.00	$ 4,983,200
603	Emperor Underpass - MP 25.0	EACH	1	$ 2,705,000.00	$ 2,705,000
603	Rock Mouse Underpass - MP 26.3	EACH	1	$ 4,082,400.00	$ 4,082,400
611	24 Foot Deer Guard	EACH	22	$ 90,000.00	$ 1,980,000
611	40 Foot Deer Guard	EACH	6	$ 100,000.00	$ 600,000
	Total subset cost of including Bikeway (included in total)*				$ 2,189,870
a)	**SUBTOTAL OF PRELIMINARY QUANTITIES**				**$ 21,702,739**
b)	Contingency		15%	of a)	$ 3,255,411
c)	Mobilization		15%	of a) + b)	$ 3,743,722
d)	Erosion Control		5%	of a) + b)	$ 1,247,907
e)	Environmental / Landscaping		10%	of a) + b)	$ 2,495,815
f)	Drainage / Utilities		15%	of a) + b)	$ 1,049,870
g)	Traffic Control		10%	of a) + b)	$ 2,495,815
h)	Design (0-100%)		10%	of a)	$ 2,170,274
i)	Construction Engineering / Inspection		22.1%	of a) + b) thru h)	$ 7,954,073
			.		
	2026 TOTAL PROJECT COST				**$ 46,115,626**

Cost Estimate
Refined Recommendations for Wildlife Crossings on US36
Badger Underpass - MP 22.6

ITEM NO.	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	COST
202	Removal of Asphalt Mat	SY	4,444	$ 15.00	$ 66,667
203	Embankment Material (Complete In Place)	CY	17,700	$ 45.00	$ 796,500
203	Unclassified Excavation (Complete In Place)	CY	14,700	$ 40.00	$ 588,000
304	Aggregate Base Course (Class 6)	CY	1,650	$ 95.00	$ 156,750
403	Hot Mix Asphalt (Grading S) (100)	TON	681	$ 150.00	$ 102,222
411	Raise Roadway Grade	LS	1	$ 1,300,000.00	$ 1,300,000
603	Arch Underpass (60' x 70')	EACH	4,200	$ 350.00	$ 1,470,000
601	Concrete Class D (Wall)	CY	40	$ 1,200.00	$ 48,000
504	Walls	SF	1,500	$ 400.00	$ 600,000
504	Temporary Retaining Wall	SF	800	$ 250.00	$ 200,000
606	Guardrail Type 3 (31 Inch Midwest Guardrail Syster	LF	1,000	$ 50.00	$ 50,000
606	End Anchorage (Flared)	EACH	4	$ 6,000.00	$ 24,000
	Total subset cost of including Bikeway (included in total)*				$ 390,250
a)	**SUBTOTAL OF PRELIMINARY QUANTITIES**				**$ 5,402,139**
b)	Contingency		15%	of a)	$ 810,321
c)	Mobilization		15%	of a) + b)	$ 931,869
d)	Erosion Control		5%	of a) + b)	$ 310,623
e)	Environmental / Landscaping		10%	of a) + b)	$ 621,246
f)	Drainage / Utilities		15%	of a) + b)	$ 261,328
g)	Traffic Control		10%	of a) + b)	$ 621,246
h)	Design (0-100%)		10%	of a)	$ 540,214
i)	Construction Engineering / Inspection		22.1%	of a) + b) thru h)	$ 1,979,889
			.		
	2026 TOTAL PROJECT COST				**$ 11,478,875**

Cost Estimate
Refined Recommendations for Wildlife Crossings on US36
Nighthawk Overpass - MP 24.75

ITEM NO.	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	COST
203	Embankment Material (Complete In Place)	CY	6,800	$ 45.00	$ 306,000
604	Wildlife Overpass (100' x 100')	EACH	10,000	$ 400.00	$ 4,000,000
601	Concrete Class D (Wall)	CY	36	$ 1,200.00	$ 43,200
504	Walls	SF	1,400	$ 400.00	$ 560,000
606	Guardrail Type 3 (31 Inch Midwest Guardrail Syster	LF	1,000	$ 50.00	$ 50,000
606	End Anchorage (Flared)	EACH	4	$ 6,000.00	$ 24,000
	Total subset cost of including Bikeway (included in total)*				$ 705,500
a)	**SUBTOTAL OF PRELIMINARY QUANTITIES**				**$ 4,983,200**
b)	Contingency		15%	of a)	$ 747,480
c)	Mobilization		15%	of a) + b)	$ 859,602
d)	Erosion Control		5%	of a) + b)	$ 286,534
e)	Environmental / Landscaping		10%	of a) + b)	$ 573,068
f)	Drainage / Utilities		15%	of a) + b)	$ 241,062
g)	Traffic Control		10%	of a) + b)	$ 573,068
h)	Design		10%	of a)	$ 498,320
i)	Construction Engineering / Inspection		22.1%	of a) + b) thru h)	$ 1,826,347
			.		
	2026 TOTAL PROJECT COST				**$ 10,588,681**

Cost Estimate
Refined Recommendations for Wildlife Crossings on US36
Emperor Underpass MP 25.0

ITEM NO.	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	COST
203	Unclassified Excavation (Complete In Place)	CY	8,200	$ 40.00	$ 328,000
603	Medium Culvert Underpass (54' x 74')	EACH	3,996	$ 350.00	$ 1,398,600
601	Concrete Class D (Wall)	CY	12	$ 1,200.00	$ 14,400
504	Walls	SF	1,600	$ 400.00	$ 640,000
504	Temporary Retaining Wall	SF	1,000	$ 250.00	$ 250,000
606	Guardrail Type 3 (31 Inch Midwest Guardrail Syster	LF	1,000	$ 50.00	$ 50,000
606	End Anchorage (Flared)	EACH	4	$ 6,000.00	$ 24,000
	Total subset cost of including Bikeway (included in total)*				$ 340,520
a)	**SUBTOTAL OF PRELIMINARY QUANTITIES**				**$ 2,705,000**
b)	Contingency		15%	of a)	$ 405,750
c)	Mobilization		15%	of a) + b)	$ 466,613
d)	Erosion Control		5%	of a) + b)	$ 155,538
e)	Environmental / Landscaping		10%	of a) + b)	$ 311,075
f)	Drainage / Utilities		15%	of a) + b)	$ 130,854
g)	Traffic Control		10%	of a) + b)	$ 311,075
h)	Design		10%	of a)	$ 270,500
i)	Construction Engineering / Inspection		22.1%	of a) + b) thru h)	$ 991,385
			.		
	2026 TOTAL PROJECT COST				**$ 5,747,789**

Cost Estimate
Refined Recommendations for Wildlife Crossings on US36
Rock Mouse Underpass MP 26.3

ITEM NO.	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	COST
203	Unclassified Excavation (Complete In Place)	CY	5,300	$ 40.00	$ 212,000
603	Bridge Uderpass (70' x 94')	EACH	6,580	$ 400.00	$ 2,632,000
601	Concrete Class D (Wall)	CY	37	$ 1,200.00	$ 44,400
504	Walls	SF	1,600	$ 400.00	$ 640,000
504	Temporary Retaining Wall	SF	1,200	$ 400.00	$ 480,000
606	Guardrail Type 3 (31 Inch Midwest Guardrail Syster	LF	1,000	$ 50.00	$ 50,000
606	End Anchorage (Flared)	EACH	4	$ 6,000.00	$ 24,000
	Total subset cost of including Bikeway (included in total)*				$ 753,600
a)	**SUBTOTAL OF PRELIMINARY QUANTITIES**				**$ 4,082,400**
b)	Contingency		15%	of a)	$ 612,360
c)	Mobilization		15%	of a) + b)	$ 704,214
d)	Erosion Control		5%	of a) + b)	$ 234,738
e)	Environmental / Landscaping		10%	of a) + b)	$ 469,476
f)	Drainage / Utilities		15%	of a) + b)	$ 197,486
g)	Traffic Control		10%	of a) + b)	$ 469,476
h)	Design		10%	of a)	$ 408,240
i)	Construction Engineering / Inspection		22.1%	of a) + b) thru h)	$ 1,496,203
	.				
	2026 TOTAL PROJECT COST				**$ 8,674,593**

Cost Estimate Assumptions and Allowances

- The estimate is a planning-level estimate intended to support comparison of the wildlife crossing alternatives and development of a preferred concept. It is not intended to represent and final construction budget.
- Costs are based on the recommended crossing configuration and conceptual design developed in this study, including the proposed wildlife structures, associated roadway improvements, fencing, wildlife treatments and integration with the North Front Range Bikeway.
- The estimate assumes that major right-of-way acquisition will not be required. Potential property access or easement needs should be evaluated during preliminary engineering.
- The estimate is based on conceptual quantities and preliminary site information. Geotechnical conditions, utility conflicts, drainage requirements, environmental mitigation, construction staging and other site-specific conditions will require further investigation and refinement.
- The estimate assumes construction will occur while maintaining traffic on U.S. 36.
- Costs are presented in 2026 dollars and do not include additional future escalation. Unit price costs were assumed looking at CDOT historical bid tab data and recent project bids.
- The estimate assumes that the project can be delivered using conventional construction methods and currently anticipated construction practices. Actual costs may vary based on final design, construction phasing, market conditions, contractor pricing, and project delivery method.
- The estimate includes allowances appropriate for the conceptual level of design and anticipated project complexity.
- Contingency – 15% is applied to the preliminary quantity subtotal to account for uncertainty in conceptual quantities, site conditions, design development, and other project elements that will be refined during subsequent design.
- Mobilization – 15% to account for contractor mobilization, project setup, temporary facilities, and related startup activities.
- Erosion Control – 5% for temporary erosion and sediment control measures associated with construction and earthwork.
- Environmental / Landscaping – 10% for revegetation, restoration, landscaping, and other environmental improvements associated with the project.
- Drainage / Utilities – 15% to account for drainage modifications, utility conflicts, and other subsurface infrastructure that cannot be fully quantified at the conceptual level.
- Traffic Control – 10% for temporary traffic control, staging, traffic control devices, and related construction requirements along U.S. 36.
- Design (0–100%) – 10% for engineering and design services from preliminary through final design (0-100%).
- Construction Engineering / Inspection – 22.1% applied to the preliminary construction costs and applicable project allowances for construction administration, inspection, field engineering, and related construction-phase services.

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