I-70 East Vail Pass Wildlife Crossing Feasibility Study Final Report

August 2020

1. Introduction

The East Vail Pass area provides habitat for resident and migrating wildlife, including one of the few known breeding populations of Canada lynx *(Lynx canadensis)* in this part of Colorado. However, with an average of 22,000 vehicles per day traveling on I-70 over Vail Pass, the interstate and its traffic volumes present a significant barrier to wildlife movement and block genetic connectivity among dispersed wildlife populations.

The I-70 East Vail Pass Wildlife Crossing Feasibility Study builds on previous studies to develop a set of well-defined, constructible, cost-credible wildlife crossing solutions that will leverage partnerships and support future fundraising efforts. This study, a coordinated effort between the National Forest Foundation (NFF), US Forest Service (USFS), Colorado Department of Transportation (CDOT), and Summit County Safe Passages, evaluates the feasibility of wildlife crossings at the three locations recommended by the Summit County Safe Passages Plan (USFS, 2017). The study was funded through wildlife-focused partnerships between the NFF and Vail Resorts, Arapahoe Basin Ski Area, and the Center for Large Landscape Conservation.

2. Project Background

Improving permeability for wildlife across I-70 has been at the heart of agency-led discussions since the late 1990s, when CDOT and the Federal Highway Administration (FHWA) first began work on the Programmatic Environmental Impact Statement (PEIS) for the I-70 Mountain Corridor between Golden and Glenwood Springs (CDOT, 2011a; CDOT, 2011b).

I-70 Mountain Corridor PEIS, ALIVE Memorandum of Understanding, and ALIVE updates. In 2001, an interagency committee formed to study impacts of highway infrastructure on wildlife habitat and movement patterns and to guide the development of mitigation strategies in the PEIS. This committee, called the ALIVE Committee ("A Landscape Level Inventory of Valued Ecosystem" components), included biologists from CDOT, Colorado Parks and Wildlife (CPW), USFS, the US Fish and Wildlife Service (USFWS), and the Bureau of Land Management (BLM). The committee identified 13 Linkage Interference Zones (LIZs) along the I-70 Mountain Corridor as priority areas for wildlife mitigation. Of these, the East Vail Pass and West Vail Pass LIZs were ranked among the highest priorities in the corridor.

In 2008, the ALIVE Committee signed a Memorandum of Understanding (MOU) listing the responsibilities of each agency for improving wildlife movement, addressing wildlife-vehicle collisions, and reducing habitat fragmentation in the I-70 Mountain Corridor. The MOU recommends wildlife crossings on East Vail Pass to mitigate the impacts of highway infrastructure on wildlife habitat and movement patterns and on wildlife-vehicle collisions.

In 2011, the I-70 Eco-Logical study was completed (Kintsch et. al., 2011), for which additional data were compiled and a systematic process developed to update and refine LIZs in the Mountain Corridor. The study provided specific connectivity recommendations and guidelines. On East Vail Pass, there are five large span bridges that can function for wildlife passage under I-70's eastbound lanes; wildlife crossings were recommended across the westbound lanes to provide connectivity for target species such as Canada lynx, elk, and mule deer.

I-70 Wildlife Bridge. In 2013, CDOT assembled a Technical Working Group to guide the site selection process for wildlife overpasses in the I-70 Mountain Corridor. This study identified MP 192.3 in the westbound direction of East Vail Pass as the best location for a wildlife overpass, taking into account biological, safety, and engineering considerations (CDOT, 2013).

Summit County Safe Passages Plan. In 2017, the USFS-led Summit County Safe Passages Plan (USFS, 2017) identified wildlife-highway mitigation needs and priorities across Summit County. The plan identified the east side of Vail Pass as the top priority for wildlife mitigation, based on ecological and safety needs and the opportunity and feasibility of mitigation. Three potential wildlife crossing locations on westbound I-70 were identified at MP 192.3, MP 193.0, and MP 193.5 (Exhibit 1). These recommendations are generally consistent with previous studies—including a USFS/CPW lynx collaring research study (Squires et al., 2011), the 2011 update to the LIZs, and CDOT's 2013 recommendation for an overpass at MP 192.3—and are the foundation for this feasibility study.

3. Scope of Study

This study assesses the feasibility of wildlife crossings and evaluates wildlife crossing concepts at the three locations recommended by the Summit County Safe Passages Plan and illustrated in Exhibits 1 and 2. The feasibility study followed the I-70 Mountain Corridor Context Sensitive Solutions (CSS) process and is consistent with CDOT protocols for project development in the corridor.

The scope comprised conceptual design and preliminary cost estimates for the three crossings; identification of critical issues related to design, construction, and implementation; and development of marketing materials for the project.

Exhibit 1. Wildlife Crossing Overview Map

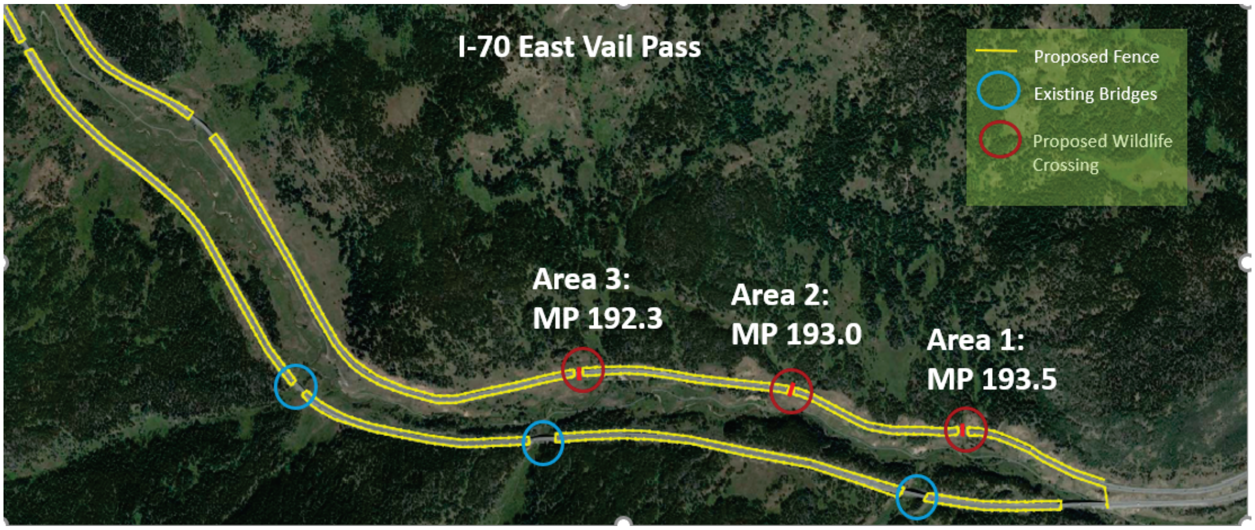
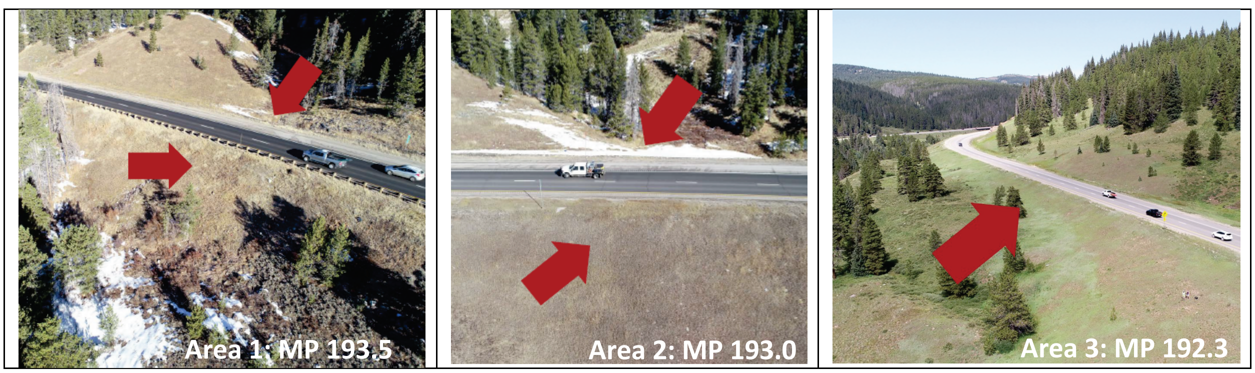


Exhibit 2. Wildlife Crossing Locations



Conceptual Design and Preliminary Cost Estimates. The project team, consisting of the NFF, USFS, CDOT, and the consultant team, prepared conceptual designs for each crossing location that consider wildlife needs and the feasibility of each crossing relative to cost, traffic and environmental impacts, and constructability. The preliminary structural selections (e.g., bridge, buried bridge, etc.) and conceptual design adhere to the design criteria developed for successful wildlife passage, accommodate CDOT future planning (including an additional lane on I-70), and account for geotechnical, hydrologic, and environmental conditions as well as maintenance of traffic. The project team conducted wetland and geotechnical investigations to confirm the conditions at each crossing location and collected drone photography to support the three-dimensional modeling that was used to validate and communicate the crossing concepts.

Cost estimates were based on conceptual design, construction phasing, and constructability considerations.

Key Elements for Future Success. Through the conceptual design process, the project team documented design, construction, and implementation issues that will require consideration or resolution during preliminary and final design and/or construction. These issues are discussed in Section 7.2.

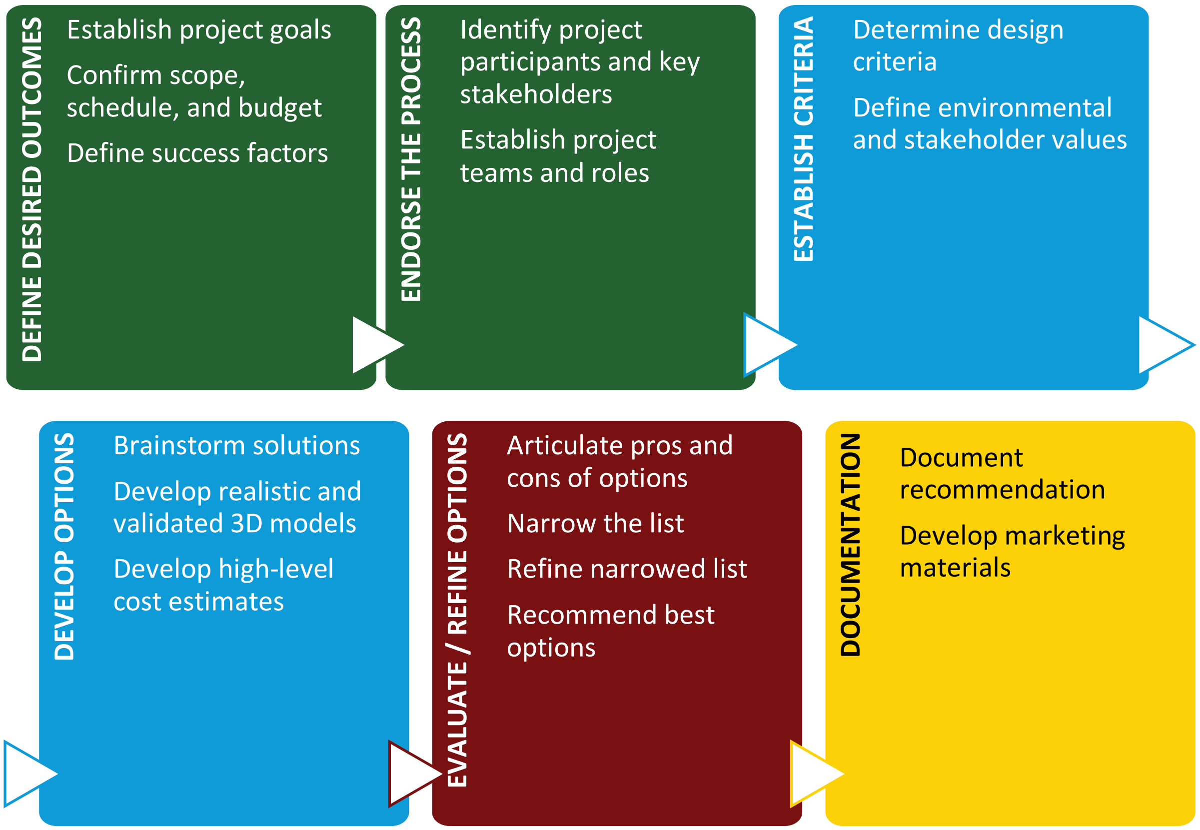
Marketing Materials. The project team developed marketing materials to raise awareness of the need for wildlife crossings and their benefits. Summit County Safe Passages anticipates using the materials in a variety of ways to garner support for the proposed crossings. These marketing materials will be delivered in a separate submittal to the project partners.

CSS Process. The I-70 Mountain Corridor CSS process is a 6-step program covering all projects in the Mountain Corridor related to the PEIS. The CSS process ensures projects are developed in collaboration with stakeholders and are consistent with a project's context and supporting core values. Although this feasibility study is not directly related to the PEIS Preferred Alternative, following the process will help ensure success during the implementation phase. The project team followed the 6-step process (see Exhibit 3), in collaboration with a Project Leadership Team (PLT) and Technical Team (TT), to:

- Define desired outcomes of the study
- Endorse the process for the study
- Establish criteria for the wildlife crossing options
- Develop conceptual designs for wildlife crossing options
- Evaluate, select, and refine those options
- Document the recommendations

Appendix A contains meeting minutes from the PLT and TT meetings.

Exhibit 3. I-70 East Vail Pass Wildlife Crossing Feasibility Study Context Sensitive Solutions Process



4. Alternatives Analysis

In the alternatives analysis, the team developed, evaluated, and recommended alternatives—or options—for the wildlife crossing locations; this corresponds with Steps 3, 4, and 5 of the CSS process outlined in Exhibit 3. The project team and stakeholders established criteria that would be used to evaluate the options. The project team developed conceptual options for the crossing locations and worked with the PLT and TT to evaluate them against the evaluation criteria and understand the pros and cons of each. The project team then refined the conceptual designs and worked with the PLT and TT to recommend the best option at each crossing location.

4.1 Evaluation Criteria

The PLT and TT agreed to use the following criteria to evaluate the wildlife crossing options:

- Wildlife and biological considerations
- Constructability
- Cost
- Maintenance
- Outreach and education opportunities

Wildlife and biological criteria included structure dimensions and characteristics required by the target species, impacts to wetlands/fens, and potential conflicts with adjacent land uses (particularly recreational activities). The vertical clearances and opening sizes of the crossing structure concepts are based on standards of practice, current research, and knowledge of other crossings in the United States and Canada.

Constructability criteria focused on traffic impacts, phasing, and other traffic-maintenance needs during construction.

The cost criteria included a relative magnitude construction cost for each structure type being considered.

Maintenance criteria assessed ongoing maintenance impacts, including snow storage around the structures, icing, bridge joints, and the introduction of new shoulder barriers.

Outreach and education opportunities considered the visibility of the potential structure, aesthetics, and fundraising/partnership opportunities.

The complete evaluation matrices are included in Appendix B.

All of the crossing options were designed to meet basic design criteria established at the beginning of the study. Roadway and structures design criteria are based on American Association of State Highway Transportation Officials (AASHTO) and CDOT standards. Additionally, because the crossings cannot preclude the construction of a third lane on I-70, the proposed overpass concepts provide a wide enough opening for the roadway to accommodate a third lane (for the underpasses, it is assumed that additional roadway width can be added in the future). A detailed description of the specific design criteria is provided in Section 5.

4.2 Wildlife Crossing Options

The project team considered three options for wildlife underpasses at each crossing location: a buried arch, a traditional bridge, and a buried bridge (Exhibit 4). The Summit County Safe Passages Plan recommended an overpass option at Area 3, where collared Canada lynx have been known to cross westbound I-70 and where the topography is better suited to an overpass than in Areas 1 and 2. Providing both below- and above-grade crossing opportunities can accommodate a broader range of species. Therefore, the project team also considered two options for a wildlife overpass at Area 3: an overpass with angled walls and an overpass with an hourglass shape (Exhibit 5).

Exhibit 4. Wildlife Underpass Options

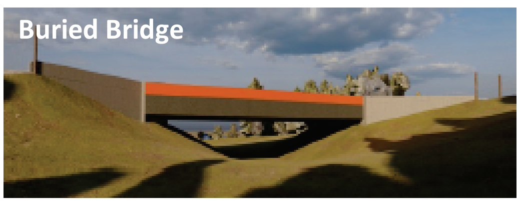


Exhibit 5. Wildlife Overpass Options

Buried arch structures can be steel or concrete. Generally, they are purchased from suppliers that design, fabricate, and deliver the structures to the project site. For this study, the team proposed a precast concrete arch.

A traditional bridge would likely comprise precast concrete girders supporting a concrete bridge deck. This type of structure provides a larger opening than an arch with little to no increase in cost. However, because bridges are not insulated by the ground, they typically ice over faster than adjacent sections of the roadway and can increase the risk of crashes. Therefore, the team also considered a buried bridge concept.

A buried bridge is essentially a traditional bridge with four feet of fill on top of the bridge deck. This should provide enough insulation to avoid the icing concerns of a traditional bridge. The opening for the buried bridge was assumed to be smaller than that of a traditional bridge as the shorter span allows the girders to carry the weight of the additional fill more effectively.

All of the underpass options were designed with adequate vertical clearance and opening size to accommodate all the target species. However, the opening sizes do vary among the options. The traditional bridge provides the largest opening, followed by the buried bridge and the buried arch. It is important to note that certain species, especially elk, are more likely to use crossings with larger openings. All three options have similar construction costs.

The overpass option with angled walls would be the same width for the entire bridge span. Although the structure type shown in Exhibit 5 is a precast arch, a buried girder bridge (similar to the buried bridge underpass option) could also be used.

The hourglass overpass option would have curved walls and would narrow to a smaller width at the center of the bridge. Because arches of this type must be a constant width, a precast arch was not considered. Girders and concrete bridge decks can be curved to create an hourglass shape.

The construction costs of the two overpass options are similar, but more than twice that of the underpass options. Additionally, challenges associated with the overpasses include snow build-up and shading of the roadway under the overpass, which leads to icing of the roadway overhead.

4.3 Wildlife Crossing Evaluation

The project team evaluated the options at each crossing location against the established criteria and discussed their evaluations with the TT.

The project team and stakeholders concluded that all the underpass structure types were acceptable for wildlife in each proposed crossing location, although elk, which require crossing structures with large openings and excellent visibility, generally do best with girder-type bridge underpasses and overpasses (which can accommodate bulls, cows, and calves). While elk have been documented using large precast buried arch underpasses, such as on State Highway 9 in Grand County, they may take longer to habituate to this structure type. For the overpass options, the project team and stakeholders also concluded that both options would work well for the animals, provided the hourglass did not narrow too much in the center of the bridge. The group also agreed that selection of the preferred structure types should consider the landscape as a whole, rather than evaluating each site individually.

Ultimately, the group recommended advancing a diversity of structure types across the study area forward for more detailed design, including above-grade and below-grade options. At each location, a single structure type was advanced, with no two areas having the same structure type. (Although the three areas are not identical, critical issues and costs associated with a structure type at one location would likely be similar to those at the other locations. Design data developed at one site could be used to inform decisions at another site.)

With this in mind, the group recommended advancing the design of a buried bridge at Area 1, a buried arch at Area 2, and an hourglass-shaped overpass at Area 3. A traditional bridge was not selected for more advanced design because of the concerns about icing discussed in Section 4.2. A buried bridge was selected for Area 1 specifically to accommodate elk passage. Area 1 is across from an existing bridge under the eastbound lanes, creating a nearly direct connection across I-70. By providing an overpass at Area 3 and one of the larger underpasses at Area 1, elk passage is accommodated across the widest geographic area.

Area 3 was recommended by previous studies for an overpass, as described in Section 2, and although an overpass option is significantly more expensive and has some engineering challenges to overcome, it has unique advantages and was supported by the PLT and TT. The hourglass-shaped design offers a unique aesthetic appeal, innovative engineering, and an opportunity to conduct research on this new wildlife crossing shape to inform future projects—this would be the first hourglass-shaped wildlife overpass in the US. And while the overpass is narrower at the center point, it is the same width as a traditional overpass in the approaches and has a more gentle and even grade across the length of the structure, providing better visibility for wildlife attempting to cross over the structure.

The TT also discussed wildlife fencing, which is required to keep animals off the highway and guide them to the crossings. The fencing will be designed to function with the planned remodel and reconstruction of the rest area complex at the top of Vail Pass and the West Vail Pass Auxiliary Lanes Project and will not interfere with the existing Vail Pass Recreation Trail.

Appendix B contains illustrations, dimensions, and evaluation matrices for each of the initial wildlife crossing options considered, and Appendix A contains a summary of the evaluation discussion in the TT Meeting #2 minutes.

4.4 Recommendations

The project team further evaluated the initial recommendations for each wildlife crossing location and discussed the refined concepts with the TT in August 2020. The refined concepts considered snow plowing and snow storage space, CDOT bridge inspection and maintenance practices, construction phasing, and the effects of shading at the overpass (following construction of the structure).

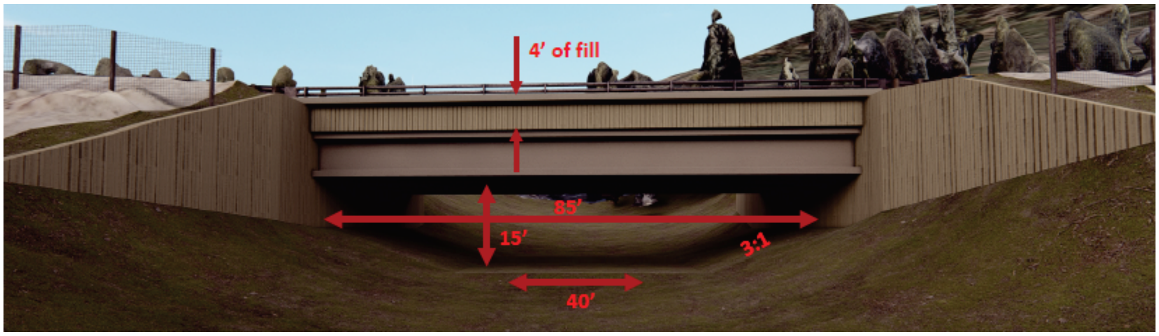
The project team and TT agreed to the proposed width for the narrowest section of the hourglass-shaped overpass and further discussed the implications of building an overpass in Area 3. It was noted that, although more expensive, the overpass would provide better connectivity for elk and have high visibility, thus providing greater opportunity for public support and fundraising. The group discussed the possibility of building the project in phases as funding and possibly new information become available.

To accommodate a diversity of structure types, best accommodate elk passage at the two ends of the study area, adhere to previous overpass recommendations, and support research objectives, the project team and TT concluded that the following options would be carried forward as the final recommendations:

- Area 1: buried bridge (Exhibit 6)
- Area 2: buried arch (Exhibit 7)
- Area 3: hourglass-shaped overpass (Exhibit 8)

The remaining sections of this report describe the design and construction considerations, traffic and environmental impacts, and next steps for implementation for the three recommended wildlife crossings.

Exhibit 6. Area 1 Recommended Wildlife Crossing – Buried Bridge



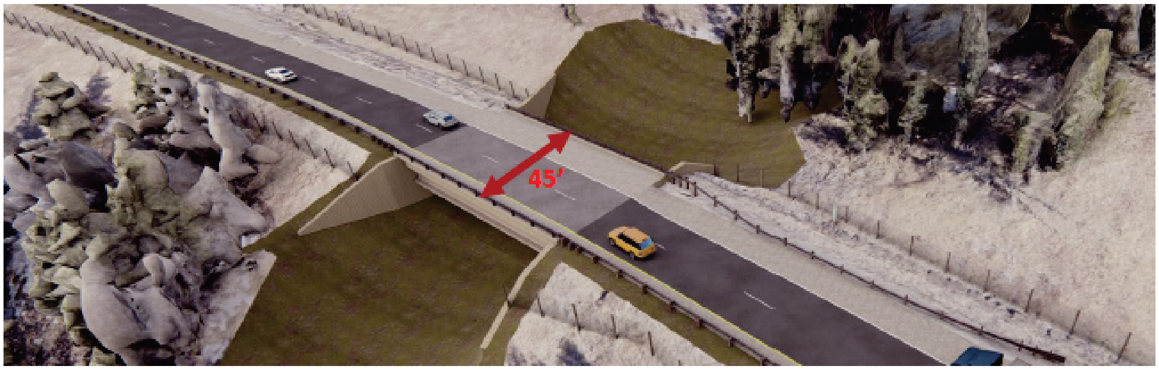


Exhibit 7. Area 2 Recommended Wildlife Crossing – Buried Arch

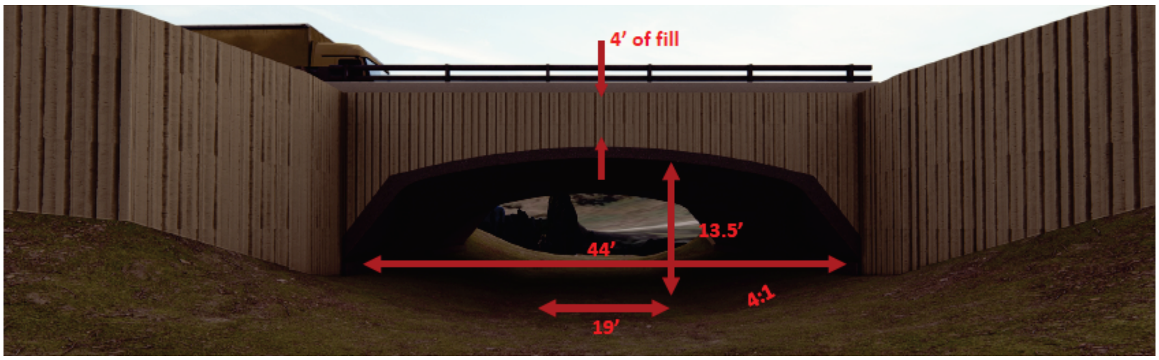
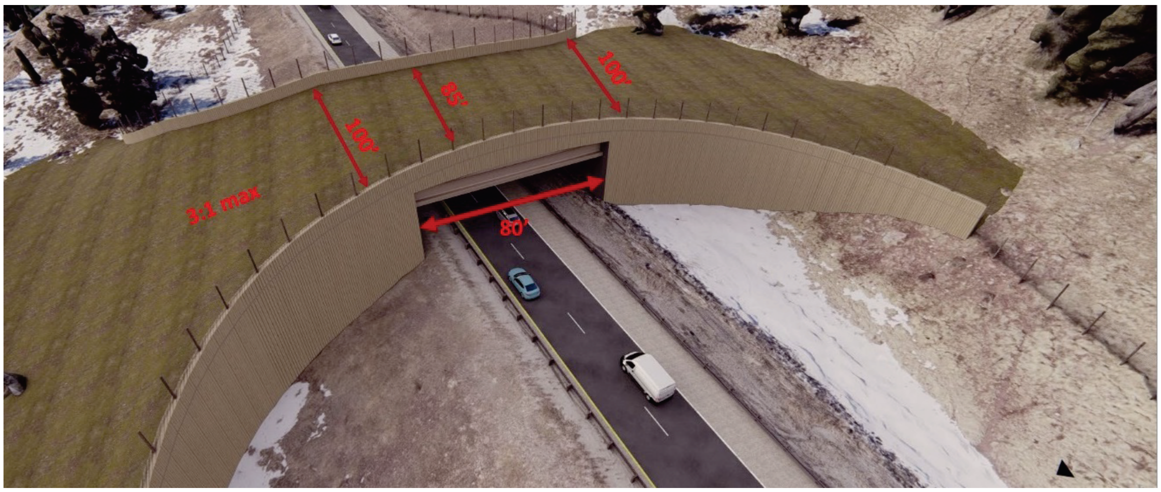


Exhibit 8. Area 3 Recommended Wildlife Crossing – Hourglass-Shaped Overpass



5. Conceptual Design and Construction Considerations

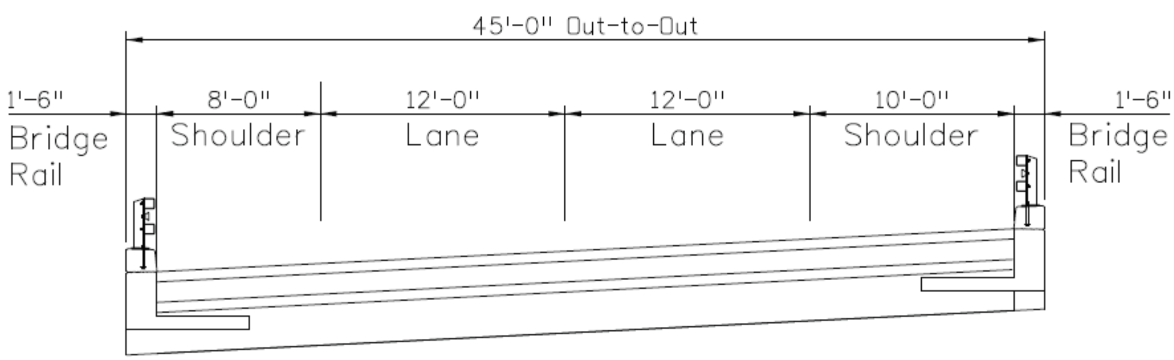
5.1 Design Criteria

Engineering Criteria

Baseline geometric design criteria were developed for underpass and overpass structures. Roadway configurations are shown in Exhibits 9 and 10 and overall geometric criteria is summarized in Exhibit 11.

For underpasses (where wildlife passes under the highway), it was assumed that the structures had to accommodate two lanes on I-70. However, structure opening size was determined based on a presumed additional future lane; if the extra lane was added after these structures were built, they could be widened/extended to accommodate it. The overall dimension of the underpass structures from outside edge of barrier to outside edge of barrier was set at 45 feet. The roadway template consists of two 12-foot lanes with a 4-foot inside shoulder and 10-foot outside shoulder. At the bridge, the inside shoulder is widened to 8 feet to provide space for required guardrail offsets and additional snow storage. The barriers are both 1.5 feet wide.

Exhibit 9. Roadway Configuration Over Underpasses

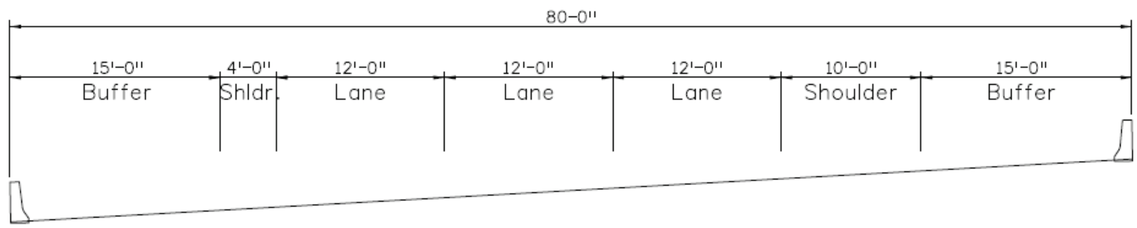


The team evaluated the potential effects of CDOT's snow plowing operations on the new underpasses, which will push snow off the bridge and could create pileups on the ground below, partially blocking the entrance to the passages. The team considered providing an even wider shoulder to prevent this. However, based on typical snowfall and standard plowing operations, it was determined that as much as 30 feet of additional structure on each side of the roadway would be needed to provide adequate snow storage. This additional 60 feet would be detrimental to wildlife usage. In addition, larger animals are not expected to use the structures in the winter and the medium and small-bodied species would have adequate clearance even with the expected snow pileup. Therefore, the team determined that a width of 45 feet was appropriate for the structures.

Similarly, extending the structures beyond the edge of the clear zone to eliminate the need for guardrail was discussed. However, this would also require an additional 30 feet of structure on both sides of the highway. Again, the team determined that the shorter passage was desired, and a 45-foot width was appropriate.

The overpass structure (where animals cross over the highway) was designed to accommodate three lanes on I-70 (if the structure was designed to accommodate only two lanes, it would have to be completely replaced if and when a third lane was added). The preliminary design provides an 80-foot opening for I-70 from front face of wall to front face of wall. This accommodates a roadway template with three 12-foot lanes, a 4-foot inside shoulder, and a 10-foot outside shoulder with a buffer to account for shy distance and snow storage. In the fully built-out condition (three lanes), the distance from edge of shoulder to inside face of barrier on both sides of the road is 13.5 feet.

Exhibit 10. Three-Lane Roadway Configuration Under Overpass



Conceptual bridge design was based on the AASHTO LRFD Bridge Design Specifications (8th edition) (AASHTO, 2017) and the CDOT Bridge Design Manual (CDOT, 2020). The weight of the soil on the buried bridge was assumed to be 540 pounds per square foot (psf) (4 feet of 135 pcf soil) and standard HL-93 live loads were assumed. For the overpass, the weight of the soil was assumed to be 540 psf (4 feet of 135 pcf soil) and snow load of 175 psf was based on the 2016 Colorado Design Snow Loads by the Structural Engineers Association of Colorado (SEAC) Snow Load Committee (SEAC, 2016). Live load for the overpass was assumed to be either an H10 Truck or 60 psf (herd loading). All the structures are determined to be in Seismic Zone 1 and will therefore be required to meet the AASHTO LRFD Bridge Design Specifications Section 3.10.9.2. No further seismic analysis will be required.

Exhibit 11. Geometric Design Criteria

Design Parameter	AASHTO PGDHS (2018)		CDOT Design Guide (2018)		Criteria
	CRITERIA	REFERENCE	CRITERIA	REFERENCE	
Classification	Rural Freeway	Section 1.3.3	Rural Freeway	1.1	Rural Freeway
Terrain	Mountainous		Mountainous		Mountainous
Design Vehicle					WB-67
Average Daily Traffic (2019)	21,000	CDOT OTIS			
Average Daily Traffic (2039)	26,292	CDOT OTIS			
Design Speed	65 MPH		65 MPH	I-70 Mountain Corridor Design Speed Study	65 MPH
Posted Speed	65 MPH	CDOT OTIS			65 MPH
UNDERPASS					
Number of Thru Lanes	2		2		2
Lane Width	12'	pg. 8-3	12’	Table 4-1	12'
Typical Shoulder Width [2]	4' Inside, 10' Outside	pg. 8-3	10'	Table 4-1	4' Inside, 10' Outside
Shoulder Width @ Bridge	6' Inside, 10' Outside	M-606-1	10'	Table 4-1	8' Inside, 10' Outside [3]
Total Roadway Width					42'
Clear Zone Width [1]	30'	RSDG Table 3-1			30'
Vertical Clearance	16'	Section 8.3.1	16.5'	Table 3-3	16.5'
Z-Slope			12' @ 6:1	Table 4-2 and Fig 4-1	12' @ 6:1
OVERPASS					
Number of Thru Lanes	3		3		3
Lane Width	12	pg. 8-3	12	Table 4-1	12'
Shoulder Width [2]	4' Inside, 8' Outside	pg. 3 of DSIS	10' inside, 10' outside	Table 4-1	4' Inside, 10' Outside
Total Roadway Width					50'
Clear Zone Width [1]	30	RSDG Table 3-1			30'
Shy Distance	9'	RSDG Table 5-7			9'
Vertical Clearance	16'	Section 8.3.1	16.5'	Table 3-3	16.5'
Z-Slope			12' @ 6:1	Table 4-2 and Fig 4-1	12' @ 6:1

[2] Per AASHTO Policy on Design Standards Interstate System, January 2005

[3] Used 8’ to better accommodate plowing and snow storage

Wildlife Considerations

Wildlife considerations were driven by the crossing requirements of the target species—in this case, Canada lynx, mule deer, and elk. While other species, such as moose, black bear, bobcat, and coyote, are also expected to use the crossing structures, these are all more generalist species, and a crossing structure designed for the target species will also accommodate these other species. While mule deer and Canada lynx are tolerant of smaller structure openings, elk require large openings with excellent visibility through or across a structure. Underpass openings must be high enough to accommodate large animals like elk and moose, and wide enough to encourage the animals to enter—structures that require the animals to cross a long distance need to be wider at the opening to achieve the necessary openness. Structure width on overpasses is subject to the same rule: the longer the distance the animals must cross, the wider the entrance must be. Specific structure dimensions at each crossing location were derived from similar crossing structures in North America with proven effectiveness for these target species.

Additional wildlife considerations informing crossing structure design included visibility through or over the structures, the steepness of the approach slope on the overpass, vegetation cover in the approaches to the structure, and light and noise attenuation.

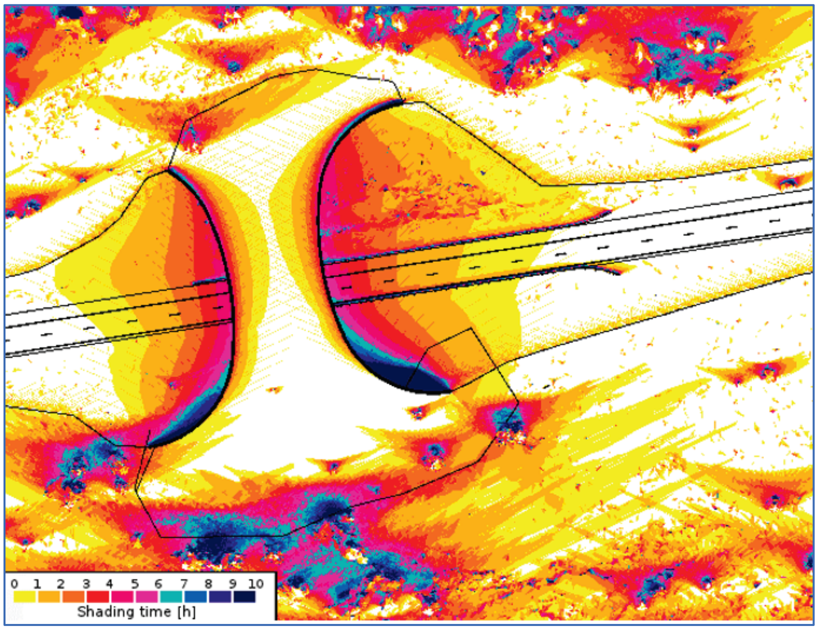
Special Considerations for the Overpass

Special design considerations for the overpass included lighting, shading, and blowing snow.

According to the CDOT Lighting Design Guidelines (CDOT 2019), overpasses do not require nighttime lighting if the adjacent roadway is not lit. Daytime lighting could be required for underpasses over 80 feet in length (measured along the roadway) if the owner determines that the structure should be considered a tunnel. Because of the hourglass shape of this option, the distance traveled through the opening is just over 80 feet and will likely not require lighting.

Specific design criteria for the overpass related to shading were not developed at this stage of the design. Shading refers to the overpass blocking the sun, which reduces the speed of snow and ice melt. A shading investigation was conducted as part of this study to determine the typical number of hours of shading at various locations of the roadway adjacent to the structure. Exhibit 12 shows the hours of shading for February 15, 2020. It is important to note that areas that are completely shaded throughout the day are outside of the traveled way or directly under the structure. Additional study is required to determine if the shading creates a safety issue requiring mitigation.

Exhibit 12. Hours of Shading at Area 3 Proposed Overpass



To minimize the overpass width and associated cost, the project team opted to transition from wildlife exclusion fencing along the right-of-way (ROW) to a noise wall over the top of the structure. In North America, soil berms have traditionally been used along either side of an overpass to block wildlife from the light and noise impacts of the traffic passing below. However, soil berms create a large footprint on an overpass, necessitating a wider structure, and add deadload to the structure. Noise walls provide the same function as soil berms with no added footprint.

Additional study is also required to evaluate how snow on top of the overpass will behave in the wind. The wildlife overpass will not be plowed, and it is expected that the wind will blow from west to east, which could cause a cornice to form at the edge of the bridge and drop snow onto I-70. At this level of design, the team developed a hybrid noise and permeable wall solution consisting of a 4-foot-high solid wall (for noise and light attenuation) topped by a 4-foot-high permeable fence (to dissipate blowing snow and reduce the likelihood of cornice formation). Additional study is required to determine if this type of barrier will be an effective solution.

5.2 Geotechnical Considerations

A geotechnical investigation was conducted between April 29 and May 1, 2020. A single boring was taken at each crossing location, and laboratory testing was completed to determine the characteristics of the subgrade. In general, subsurface conditions consisted of 10 to 27 feet of stratified layers of silty, clayey sand over gravel or bedrock. At Area 3, bedrock was encountered 10 feet below subgrade. Bedrock was not encountered at Areas 1 or 2. Standard bridge foundations such as steel h-piles and drilled shafts are acceptable foundation elements for these subgrade conditions. At Areas 1 and 2, where bedrock was not encountered, there are dense bearing gravels that will provide end bearing resistance. For the buried arch, it is possible that shallow foundations could be utilized, but more detailed design is required to confirm the feasibility of this foundation type. Deep foundations were assumed at this stage of conceptual design to provide a more conservative cost estimate.

The initial geotechnical investigation indicates that settlement could occur, especially at the overpass. Future geotechnical studies should quantify the risk and level of settlement expected and provide mitigation measures. The use of two-phase wall construction should be considered as a solution.

The team's site investigation found no geologic hazards that would preclude construction of the proposed wildlife crossings. Although debris flow deposits were noted, the flow is historical and unlikely to occur again. If the drainage basin were to be affected by fire, a debris flow incident is more likely. In that event, the open channel wildlife crossings that we propose will function better than the existing culverts (which would likely clog).

A copy of the preliminary geotechnical report is provided in Appendix C.

5.3 Conceptual Structural Design for Recommended Wildlife Crossings

The team completed conceptual structural design for each bridge structure to define required structural depth and obtain a realistic concept-level cost estimate for the structures. Typical sections of the proposed structures are provided in Appendix D.

Area 1: Milepost 193.5 – Buried Bridge

Preliminary design of the buried bridge assumes the bridge will be a standard girder bridge with a concrete deck and a span length of 82.5 feet. At this level of design, precast concrete I-girders were assumed, but this could be adjusted in future design phases.

The structure was assumed to have integral abutments supported on steel h-piles. Integral abutments are a key element of the design because they allow for an important tradeoff between standard engineering maintenance requirements and wildlife accommodation. CDOT typically requires a 3-foot-wide soil bench at the face of abutments for bridge inspectors to stand on while inspecting the bearings. This bench deters wildlife because it provides an area (or a perceived area) for predators to perch. During the stakeholder outreach process, CDOT agreed that the bench could be eliminated if integral abutments, with leveling pads rather than bearings, were implemented as part of the design.

Another critical design element is the bridge barrier. Because there is significant fill on top of the bridge to reduce the potential for icing (as discussed in Section 4.2), the standard deck-to-bridge barrier connection cannot be utilized. For this level design, it was assumed that moment slabs will be used to support the barrier. In final design, other options such as a robust wall connected to the deck and supporting the bridge barrier should be investigated.

The configuration of the wingwalls shown for the underpasses at Areas 1 and 2 is feasible from a design and constructability standpoint. Other configurations, such as walls running parallel to I-70, are also feasible. During final design, the exact layout of the wingwalls should be adjusted to the provide the greatest value to the project.

Area 2: Milepost 193.0 – Buried Arch

Preliminary design of the buried arch assumes a 44-foot-long, 13.5-foot-tall precast concrete arch, which would be designed, supplied, and delivered to the site by the fabricator. The proposed foundation is a cast-in-place concrete cap supported by drilled shafts. Shallow foundations should be investigated at final design due to the proximity of a dense gravel layer to the abutment location. For this level design, it was assumed that a moment slab will be constructed on top of the headwall to provide the required bridge barrier on both sides of the roadway. In final design, other options, such as robust headwall connected to the deck and supporting the bridge barrier, should be investigated.

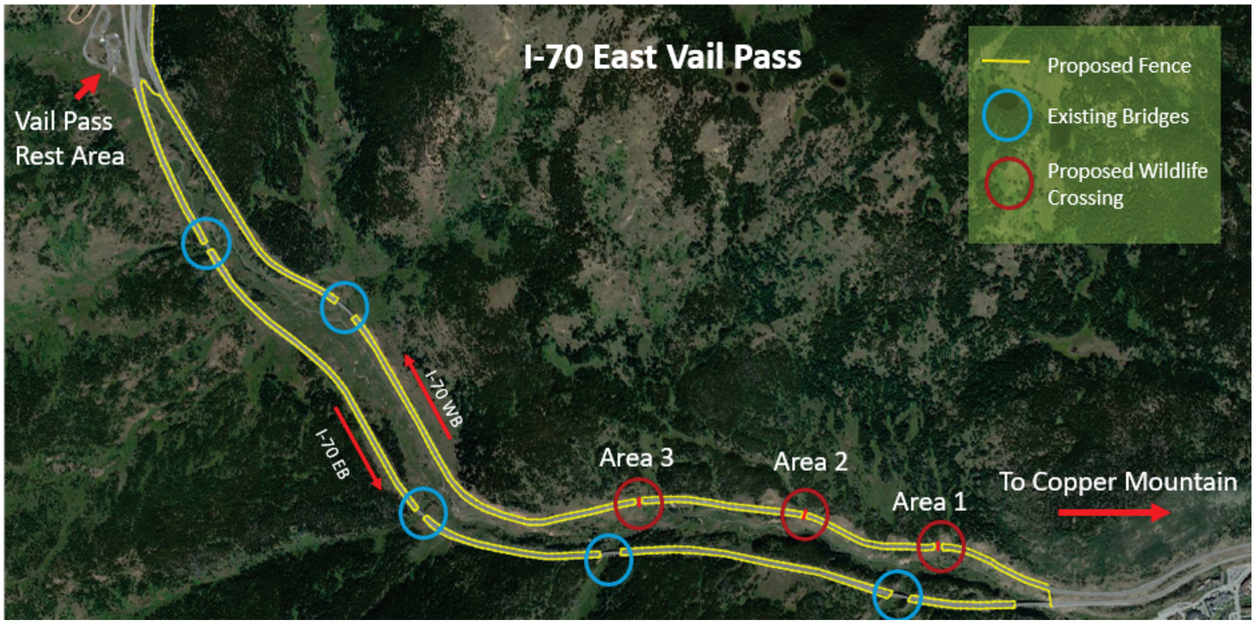
Area 3: Milepost 192.3 – Hourglass-Shaped Overpass

The hourglass-shaped overpass bridge was conceptually designed as a precast concrete tub girder bridge with integral abutments supported on h-piles. The abutments are placed on top of fill supported by retaining walls that wrap around the front face of the abutment. The span of the bridge is 90 feet. The exterior girders are curved to accommodate the hourglass shape and the interior girders are straight. Because of the design of this structure, standard methods and equations used to determine load distribution to each girder will likely not be applicable and a finite element model will be required for design. The wall type for the curved retaining walls has not yet been determined, and the team recommends that truly curved and chorded wall solutions should both be considered.

5.4 Wildlife Exclusion Fencing

Wildlife exclusion fencing is an important component of the mitigation system on Vail Pass: wildlife crossing structures combined with fencing allow animals to safely access resources on either side of the roadway and reduce wildlife-vehicle collisions by 80 to 90 percent (Clevenger and Barrueto, 2014; Huijser et al., 2009; Kintsch et al. 2020). On East Vail Pass, the wide, open median area—which provides additional habitat including forest cover, grassy meadows, and the riparian corridor along West Tenmile Creek—means that the eastbound and westbound lanes of I-70 must be fenced individually, with the fencing coming together at the Vail Pass Rest Area at the west end of the study area and at the West Tenmile Creek bridge near Copper Mountain at the east end of the study area (Exhibit 13).

Exhibit 13. Fencing



Additional considerations for the wildlife exclusion fencing include planning for continuity with the West Vail Pass Auxiliary Lanes Project, the planned remodel and reconstruction of the rest area complex at the top of Vail Pass, the Vail Pass Recreation Trail, and other recreational access. The PLT and TT discussed providing recreation access through the fencing along I-70; however, because parking on I-70 is prohibited (although not generally enforced), the group determined that access through the fencing should not be encouraged. Future outreach and education initiatives were discussed to inform recreational users of the prohibition and prevent damage to the fencing.

5.5 Conceptual Site and Hydraulic Design for Recommended Wildlife Crossings

Preliminary hydrologic and hydraulic analysis was performed at each site to evaluate drainage design features that could have a significant impact on the overall cost of the project and to uncover any critical flaws related to drainage at each site. Based on CDOT guidance for rural interstate cross-drains and bridge scour, 50-year, 100-year, and 500-year events were evaluated at each location. For purposes of developing preliminary cost estimates, it is assumed that areas that require scour protection will be armored with riprap. As discussed in Section 6, during later phases of design, other methods of revetment that are more conducive to fostering plant growth should be considered in areas with riparian vegetation.

Area 1: Milepost 193.5 – Buried Bridge

There is an existing CDOT culvert at this location, assumed to be 36 inches, which will be replaced by the proposed buried bridge. The drainage basin for this crossing is approximately 53 acres, and preliminary analysis indicates that peak discharge will be approximately 70 cubic feet per second (cfs), 110 cfs, and 190 cfs for the 50-year, 100-year, and 500-year return periods, respectively. The proposed underpass would increase the slope of the main drainage and thus the potential for scour. Scour protection will be required within the base of the main channel, but abutment scour is not anticipated. To ensure the area is traversable for wildlife, any areas with riprap should be filled in with aggregate base course covered with 2 feet of topsoil.

Existing roadside ditches would be regraded to follow the alignment of the retaining walls. At this level of design, it was assumed that scour protection is required for the ditches. During the next stages of design, the use of inlets to reduce the flow in the ditches should be considered.

Area 2: Milepost 193.0 – Buried Arch

In this area, there is an existing 36-inch culvert approximately 150 feet to the east of the proposed project location. The drainage basin for this crossing and the existing culvert is approximately 450 acres, and conservative preliminary analysis indicates that the peak discharge will be approximately 230 cfs, 350 cfs, and 610 cfs for the 50-year, 100-year, and 500-year return periods. For the purpose of this study, it was assumed that half of the flow would go to the buried arch and half would go the existing culvert to the east. The proposed underpass would increase the slope of the main drainage and thus the potential for scour. Scour protection will be required within the base of the main channel, but scour is not anticipated at the arch footings. To ensure the area is traversable, any areas with riprap should be filled in with aggregate base course and covered with 2 feet of topsoil. It is important to note that the slope at the downstream end of the drainage is steep; additional scour protection, especially near the recreation trail, should be investigated at later stages in the design.

Existing roadside ditches would be regraded to follow the alignment of the retaining walls. At this level of design, it was assumed that scour protection is required to armor the ditches. During the next stages of design, the use of inlets to reduce the flow in the ditches should be considered.

Area 3: Mile 192.3 – Hourglass-Shaped Overpass

At this location, the proposed overpass would impact the roadway ditches and an existing culvert located east of the proposed structure. The existing culvert, assumed to be 36 inches, conflicts with the proposed overpass retaining walls and would have to be replaced with a culvert of similar size. On the north side of the roadway, the water that is currently carried by the roadside ditch would be captured and carried to the 36-inch replacement culvert on the east side of the underpass. On the south side of the roadway, armored ditches will be required to direct flow around the proposed retaining walls.

On the north side of the overpass itself, flows would likely require a portion of the surface runoff to be captured and let out through the proposed retaining wall. In the next stages of design, the grading required to direct surface flow into an inlet at this location must be carefully coordinated so that the graded area is still traversable by the target species using the overpass.

5.6 Construction Phasing and Maintenance of Traffic

In accordance with CDOT's lane closure policies for I-70 in this location, no long-term closures or lane reductions will be allowed during construction of this project. At Areas 1 and 2, temporary detours would be required to maintain two lanes of traffic during construction. Exhibits 14 and 15 show the limits of impact for the proposed temporary detours, including grading and paving.

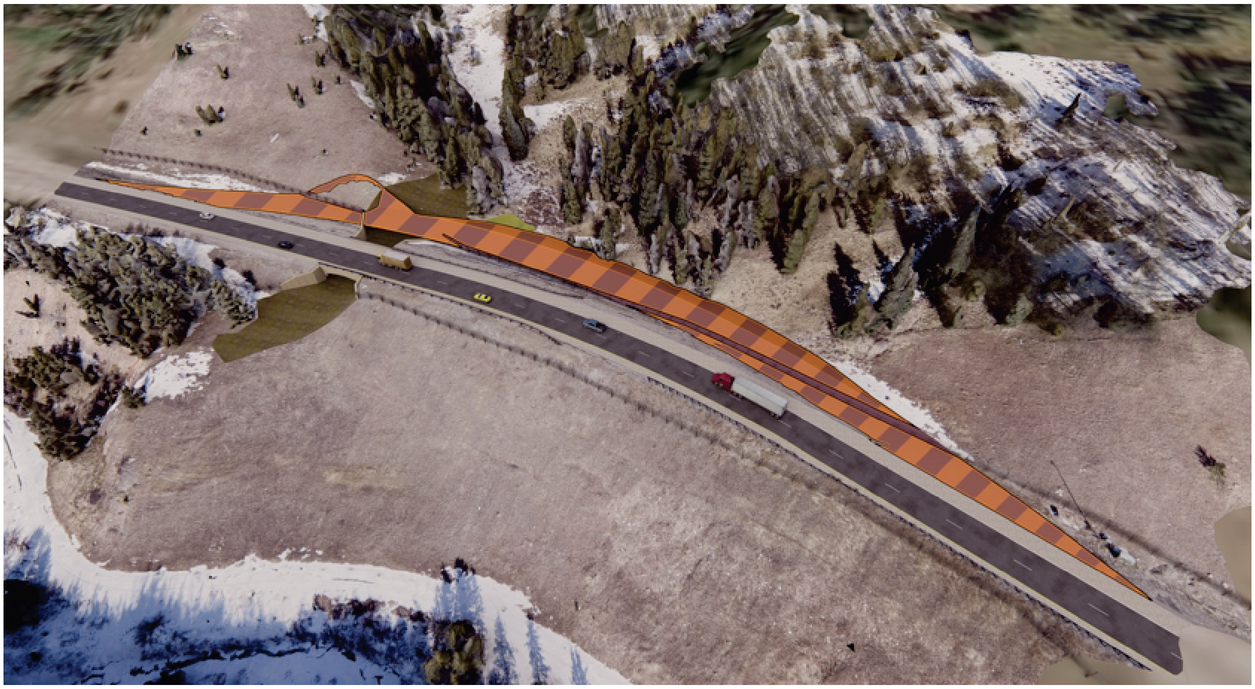
At Area 1, the detour is proposed to the south of I-70. This would require additional embankment but would completely avoid the potential fen wetlands discussed in Section 6. The buried bridge would be constructed in phases. Temporary shoring would be required for abutment excavation and girder placement. However, the majority of the excavation under the bridge could be completed after the bridge is opened to traffic.

At Area 2, there are potential temporary impacts to wetlands from the proposed detour; these could likely be reduced by minor adjustments in alignment and grading or the use of temporary shoring. There is enough room between the temporary detour and the proposed structure that the arch could be constructed in a single phase.

At Area 3, where the overpass would be constructed, temporary detours would not be required. The majority of the construction would be completed outside of the traveled way. Night closures would be required to set girders and perform any other overhead, safety-critical work.

Exhibit 14. Area 1 Temporary Detour

Exhibit 15. Area 2 Temporary Detour



6. Environmental Review

This study included a preliminary environmental review to identify resource issues or concerns that could affect the design or construction of the wildlife crossings and to identify environmental requirements for the next phase of project design and National Environmental Policy Act (NEPA) clearance. Resource considerations at the wildlife crossing locations comprise wetlands, wildlife, threatened and endangered species, historic resources, recreation resources, resources protected under Section 4(f) of the US Department of Transportation (USDOT) Act, and visual resources.

Wetlands. The project team conducted a preliminary wetlands investigation at the proposed wildlife crossing locations on October 10, 2019, and August 26, 2020. Potential wetlands and riparian boundaries were defined during these trips. Mapping of the wetlands found during these investigations are provided in Appendix E.

At Area 1 (Exhibit 16), there are multiple wetland areas. Our team determined that one of the wetland areas is likely a fen, due to the depth of organic soil, vegetation composition, and the known presence of fens on Vail Pass, although the organic soil composition was not confirmed. Fens can take thousands of years to form and are a high priority for conservation and restoration. The team imported the mapped wetlands into the engineering and modeling software and designed the proposed crossings to avoid the potential fen and adjacent wetlands. The area of the proposed crossing contains a narrow intermittent channel with a 1-foot wetland fringe along a portion of the channel. Outside of the wetland area is a dense riparian corridor dominated by Salix and Betula. The channel daylights approximately 30 feet below the road grade on the south side of I-70. There is a small Carex-dominated wetland within this area surrounded by a riparian corridor. The distance between the proposed wetland impact areas and the potential fen located in Area 1 are unlikely to be considered adjacent by the USACE as there is a considerable amount of upland separating the two. Additionally, because the potential fen is upland of the wetland area north of I-70, impacts to the wetland should not impact the groundwater supply to the fen.

At Area 2 (Exhibit 17), the majority of the site is dry. There is a channel with a riparian corridor and a narrow potential wetland along the channel. This area can be avoided during construction.

A small depression wetland dominated by Carex was observed on the north side of Area 3 (Exhibit 18). A narrow intermittent channel runs through this depression and daylights on the south side of the road. The intermittent channel on the south side of the road is deeply incised and surrounded by a narrow riparian corridor dominated by Salix. At this location, the possibility of shifting the wildlife crossing to the west to avoid the wetlands was investigated. While this option is feasible for engineering and construction, it does create a larger impact area, due to steepening slopes toward the west. Fill would extend farther down the slope, toward the channel and bike path. It is likely that this would result in greater impacts to wetlands and riparian areas. During final design, the exact location of the overpass could be adjusted to minimize these impacts.

Exhibit 16. Potential Wetland Impacts at Area 1

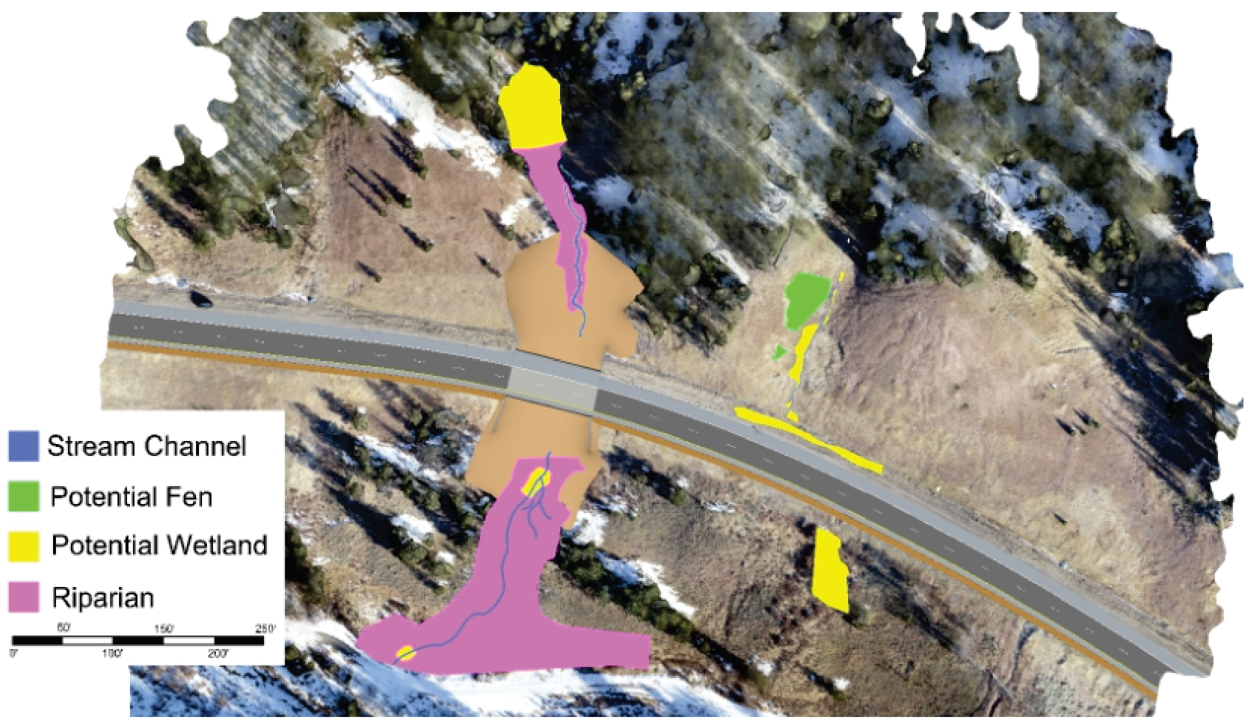


Exhibit 17. Potential Wetland Impacts at Area 2

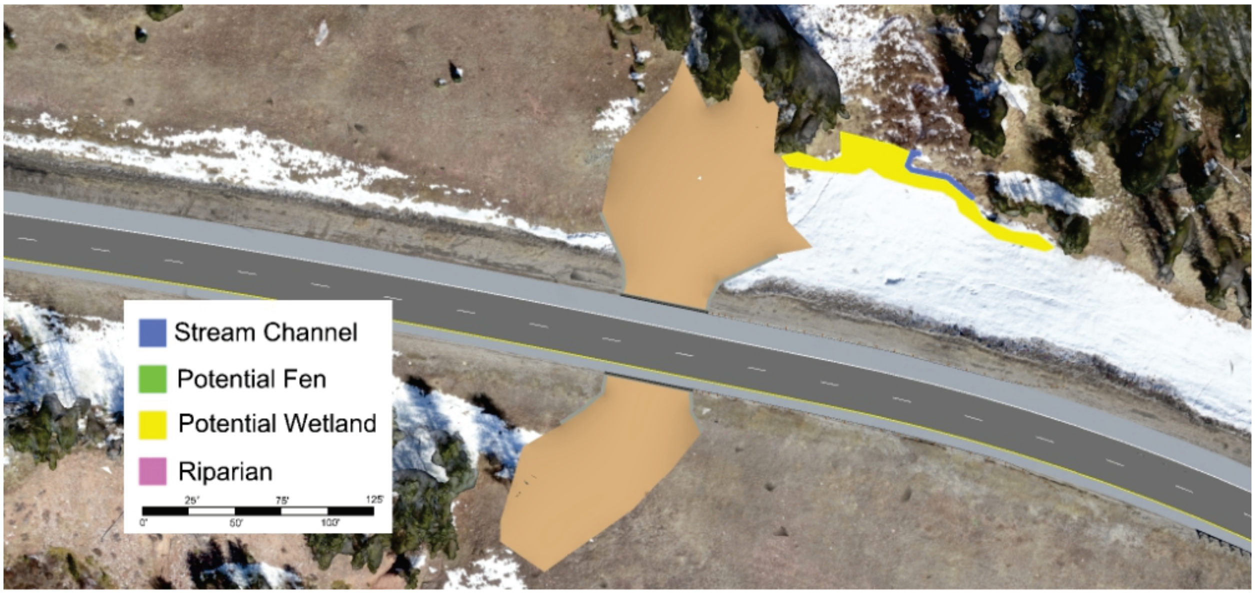
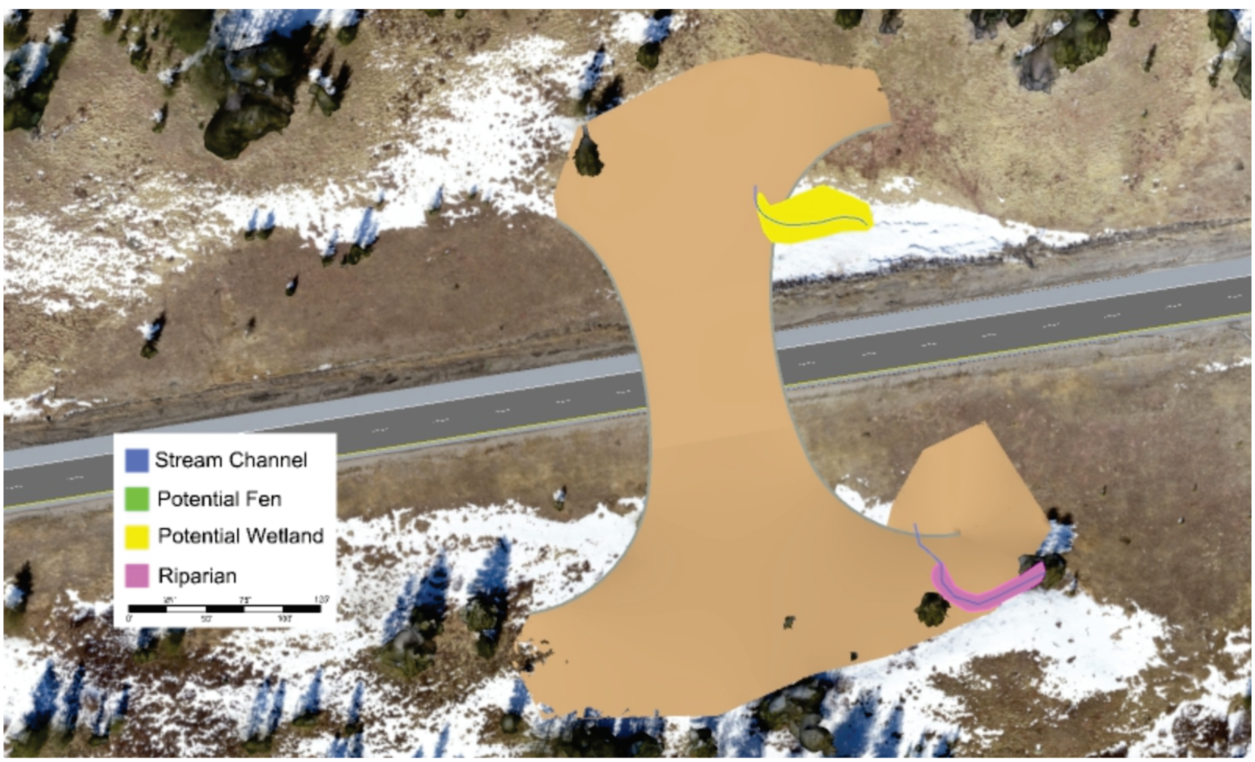


Exhibit 18. Potential Wetland Impacts at Area 3



While impacts to riparian areas, wetlands, and stream channels are likely to occur through the construction of the crossings, the crossings will open portions of stream channels that are currently carried by pipe culverts. This will provide the opportunity for additional wetlands and riparian areas to establish within the newly opened channels. The engineering design will incorporate the USFS Management Measure 5, which states that a proponent "conduct actions so that stream pattern, geometry, and habitats maintain or improve long term stream health" (USFS 2006). This will be done in part by determining if riprap buried in topsoil is necessary to protect the new channels from erosion or if alternate methods that are more conducive to plant growth can be used. Alternative methods could include turf mats or concrete open cell block.

The project will also incorporate USFS Management Measure 6, to "maintain long-term ground cover, soil structure, water budgets, and flow patterns of wetlands to sustain their ecological function" (USFS 2006). This will be done in part by restoring disturbed areas with native plants known to occur within the habitat, region, and elevation of the crossings.

In addition to those listed above, there are several more potential riparian, wetland, and stream mitigation areas adjacent to the proposed impact areas. For example, the ground adjacent to the wetland at Area 3 appears to have been impacted through years of snow removal and vehicle traffic in the area; recontouring the area could reestablish the hydrology needed to sustain the wetland vegetation and hydric soil.

During later stages of design, the lead agency will need to conduct a full wetland delineation survey to confirm the location and boundary of wetlands, including any fens, within the project area. Permanent and temporary impacts to wetlands will need to be documented through a wetland finding and permitted under Section 404 of the Clean Water Act (CWA). Additional details on appropriate project mitigation and restoration should be determined once the project design is clear and impacts to wetlands and streams are known.

Threatened and endangered species. One federally listed wildlife species, the Canada lynx, is known to occur in the study area. The east side of Vail Pass is home to one of the few known breeding populations of Canada lynx in this part of Colorado, with a small breeding population on the south side of I-70. No critical habitat is known to occur within the study area.

During the future design and NEPA phase, the lead agency will need to conduct a field survey to document the potential for other state- or federally listed protected species and USFS-designated sensitive species to occur within the study area. The project will need to comply with Section 7 of the Endangered Species Act (ESA), which requires findings of effect for listed species or critical habitat, and consultation with the USFWS if the project may affect listed species or critical habitat.

Wildlife and vegetation. Habitat in the Vail Pass wildlife linkage area is primarily spruce/fir and mixed conifer, with some aspen and riparian habitat. The habitat is high quality and contiguous. Moose, elk, mule deer, black bear, bobcat, fox, marten, badger, and other wildlife are common in this landscape. The Vail Pass linkage area connects high elevation elk and mule deer summer range with separate deer herds on the north and south sides of I-70. Lynx have been documented crossing I-70 at grade as well as using the bridges under the eastbound lanes. The Summit County Safe Passages Plan (USFS, 2017) provides more detail on wildlife movement patterns in the Vail Pass linkage area.

Wildlife and vegetation would need to be evaluated in accordance with the CDOT NEPA Manual (CDOT, 2020) during the future design and NEPA phase of the project.

Historic resources. I-70 over Vail Pass, from MP 180 to MP 195.2, is a nationally and exceptionally significant historic feature of the Federal Interstate Highway System. The Vail Pass engineering design is historically significant as an early representation of CSS and because of the design's incorporation of environmental sensitivity and mitigation.

The wildlife crossings would likely cause an adverse effect to the I-70 Vail Pass historic resource, as defined by Section 106 of the National Historic Preservation Act (NHPA). During the design process, efforts should be made to incorporate the aesthetics of the original I-70 Vail Pass design into the design of the new wildlife crossings.

CDOT completed a historic context statement for I-70 Vail Pass in 2019 as a mitigation measure for future impacts to Vail Pass. CDOT is also developing a supplement to the I-70 Mountain Corridor Section 106 Programmatic Agreement that outlines mitigation commitments associated with CDOT's ongoing West Vail Pass project. These commitments include efforts to honor the aesthetic of the original design and the creation of an Aesthetics Issues Task Force to develop project-specific aesthetic guidance that builds on existing agency and PEIS guidance and incorporates the Vail Pass historic context. When the project-specific aesthetic guidance for West Vail Pass is complete, it may be a helpful reference for the aesthetic design of the wildlife crossings proposed on East Vail Pass.

NHPA Section 106 review will be required when project design and NEPA activities are initiated for the proposed wildlife crossings. Most of the interstate highway system is exempt from historic review under Section 106, but nationally and exceptionally significant features—including I-70 Vail Pass—are exceptions and must undergo the Section 106 review process when projects have the potential to affect them. Section 106 review and consultation is typically a lengthy process and should be incorporated into the future design and environmental clearance schedule.

The project will also need to follow the principles and stipulations of the I-70 Mountain Corridor Section 106 Programmatic Agreement (CDOT, 2008), which include consultation requirements and implementation of corridor-wide mitigation measures and project-specific mitigation strategies.

Recreational resources. The Vail Pass Recreation Trail meanders through the wide median between the eastbound and westbound I-70 lanes on East Vail Pass. Because the paved trail is not proximate to any of the wildlife crossing locations, none of the proposed crossings or wildlife fencing would permanently impact the trail or cause construction impacts to it. If any construction activities temporarily impact the trail, the project would have to provide a detour route. No Section 6(f) properties, which are properties purchased or improved with grants from the Land and Water Conservation Fund Act, are present on East Vail Pass.

Currently, some recreational users do park illegally along the side of I-70 in order to access the National Forest land. We recommend that early outreach is conducted with recreational user groups in order to communicate the rules and safety issues involved in parking along I-70 and to plan for safer access both before and after the wildlife fencing is installed.

Section 4(f) resources. Section 4(f) of the USDOT Act of 1966 protects significant publicly owned parks, recreation areas, wildlife or waterfowl refuges, and historic resources listed or eligible for listing on the National Register of Historic Places. During the design and NEPA phase, if the Section 106 consultation determines the wildlife crossings would cause an adverse effect to historic Vail Pass, an individual Section 4(f) evaluation will need to be completed and approved by FHWA in order for the project to proceed. The evaluation will need to demonstrate that there is no feasible and prudent avoidance alternative to the use of the historic resource and that the proposed action includes all possible planning to minimize harm to the historic resource.

If the wildlife crossings affect the Vail Pass Recreation Trail, the project will need to determine whether the impact would cause a Section 4(f) use. Any impact to the trail would most likely result from construction activities and would likely not be considered a Section 4(f) use.

Visual resources. The I-70 Mountain Corridor CSS process developed guidelines to provide an aesthetic vision for the entire corridor and four different design segments within it. The design of the proposed wildlife crossings should follow the *I-70 Mountain Corridor Aesthetic Guidance* (CDOT, 2015) for the Crest of the Rockies design segment. The guidelines cover transportation and land relationships, bridge structures, retaining walls, guardrails and other edge delineation, color selection, earthworks, grading, and cuts, hydrologic features, landscape planting and revegetation, and wildlife corridors and fencing.

The project will also need to follow the *2019 CDOT Visual Impact Assessment Guidelines* (CDOT, 2019) and complete CDOT's visual impact assessment (VIA) scoping questionnaire to determine the appropriate level of VIA analysis (none, memorandum, or standard). If a VIA is required, the analysis should consider the visual context discussed in the PEIS, which identified visually distinct landscape units along the I-70 Mountain Corridor. East Vail Pass and the proposed wildlife crossings are located within the Copper Mountain landscape unit.

7. Cost Estimates

Cost estimates for each of the sites were developed based on an itemization of major structural and roadway quantities with a contingency applied to account for additional items, design adjustments, and change in conditions. The CDOT Bridge Design Manual suggests using an overall contingency of 50 percent during the early planning stages of design; as the design progresses to FIR level (approximately 30 percent complete) the suggested contingency is reduced to 15 percent. Based on the level of design achieved for this study, a general contingency of 30 percent is appropriate. Additional costs based on percentage account for mobilization, erosion control, and traffic control. Shoring and temporary detours for maintenance of construction were included as itemized costs. Design and contract administration are estimated to be 20 percent of the total construction cost. Estimated costs are provided in the table below. Detailed accounting of itemized costs is provided in Appendix F.

Exhibit 19. Estimated Cost

Estimated Cost			
Structure	**Construction Cost**	**Design and Contract Administration (20%)**	**Total Cost**
Area 1: Buried Bridge	$ 2,530,000	$ 506,000	$ 3,036,000
Area 2: Buried Arch	$ 3,470,000	$ 694,000	$ 4,164,000
Area #: Hourglass-Shaped Overpass	$ 7,560,000	$ 1,512,000	$ 9,072,000
Fence	$ 4,000,000	$ 800,000	$ 4,800,000
TOTAL:	**$ 17,560,000**	**$ 3,512,000**	**$ 21,072,000**

8. Implementation

8.1 Funding

Project proponents are working to identify funding for design and construction of the three wildlife crossings. The marketing materials developed through this feasibility study comprise a brief video, a brochure, a PowerPoint presentation, and boards and posters. These materials focus on the feasibility study recommendations and the importance of wildlife crossings in protecting the diversity of wildlife in the area; they also provide information on how to get involved, how to support the project, and how to help move the project forward through fundraising. These materials are available to all members of the PLT and TT for use with their stakeholders.

8.2 Design, Environmental Clearance, and Construction

Once funding has been identified, the wildlife crossings can move forward into design and construction. The lead agency for the next phase of the project is unknown, but because the crossings are located on a federal interstate highway, the project will have a federal nexus and will most likely need to comply with CDOT procedures. If funds are obtained from Central Federal Lands Highway Division (CFLHD), their procedures will be followed. In either case, protocols that meet federal regulations such as NEPA, CWA, and ESA will be required. The processes described below assume that CDOT procedures will be followed. Similar work elements will be required regardless of the lead agency. The processes also assume that this project would be completed under the traditional Design-Bid-Build mechanism rather than Design-Build or Construction Manager/General Contractor (CMGC).

Exhibit 20 illustrates CDOT's project development process. The project will also follow the I-70 Mountain Corridor CSS process and follow the protocols in the ALIVE MOU, as the crossings are mitigation commitments identified in the ALIVE MOU (CDOT, 2008). The NEPA class of action is expected to be a programmatic categorical exclusion, as it fulfills the criteria for several different actions considered to be programmatic categorical exclusion actions under 23 CFR § 771.117(c) and 23 CFR § 771.117(d): the project is a highway safety project that will take place within the existing operational ROW and will likely meet the funding criteria for federally funded projects in 23 CFR § 771.117(c).

For the purposes of this study, the engineering design was progressed to about the ten percent level. Preliminary engineering analysis, geometric layout, and grading was completed. Accurate three-dimensional computer models of the engineering concepts were developed. Construction design drawings were not advanced to any level. The expected next steps for the project include scoping (the overall approach to the next phases of design must be established with the lead agency), thirty-percent design and final design.

- Scoping
  - Confirm the project limits and NEPA class of action (It is likely that a Categorical Exclusion, rather than an Environmental Assessment (EA) or Environmental Impact Statement (EIS), will be required)
  - Discuss design and implementation considerations including I-70 Mountain Corridor Engineering Design Criteria (CDOT, n.d.) and I-70 Mountain Corridor Aesthetics Guidance (CDOT, 2015)
  - Convene the project PLT in accordance with the 6-Step CSS process
  - Determine the level of involvement of stakeholders through the CSS process and estimate the required number of meetings and other outreach
  - Evaluate project risks and determine the appropriate level of effort for all permitting elements; determination of level of effort for additional geotechnical investigation, survey, and studies to determine effects related to blowing snow, icing, and shading will be critical
  - Establish procedures and protocols for developing ROW agreements between CDOT and the USFS
  - Set a baseline schedule for design, advertisement, and construction
- Thirty-percent design: Field Inspection Review (FIR)

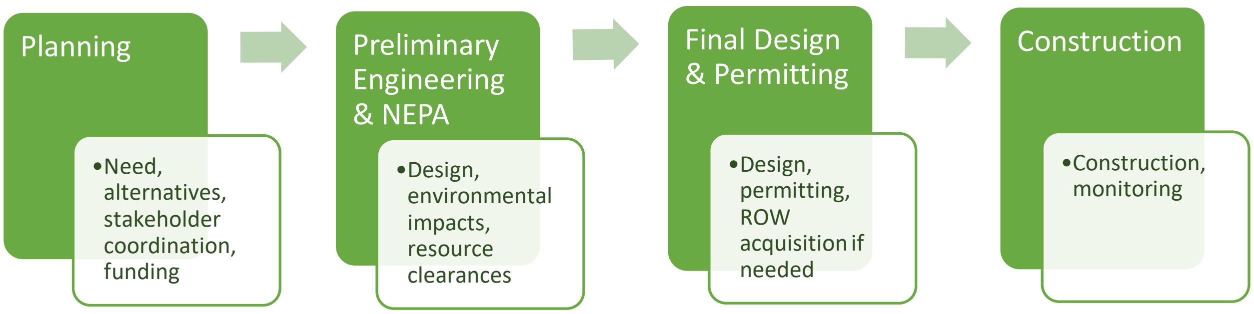
- Develop detailed structural design criteria to including applied loads, aesthetic criteria, and durability requirements.
- Obtain field survey by a registered PLS (if required)
- Complete additional geotechnical investigation and associated report (AASHTO requires at least one boring at each bridge abutment)
- Produce Structural Selection Reports; this includes developing a detailed, stand-alone report that provides more detailed information regarding cost estimates for steel and concrete options, cost estimates for variety of substructure options, consideration for construction methods, discussion of hydraulic impacts, geometry and layout, and other items used to determine the most appropriate bridge type
- Produce Wall Selection Reports; this includes developing a detailed stand-alone report that provides comparative cost estimates for a wide variety of wall types to select the most appropriate materials and construction methods
- Produce Hydrology and Hydraulics Report; this includes developing a detailed stand-alone report that describes the methodology and results of the hydrologic and hydraulic analysis
- Resolve structural design concepts for unique design features for buried structures
- Confirm lighting requirements for the overpass
- Determine impacts of shading and blowing snow related to the overpass; conduct a wind study
- Develop thirty-percent construction drawings for the grading plan
- Develop thirty-percent design and construction drawings for landscaping
- Confirm overall geometry (wall layouts may be adjusted) and clearly define limits of impact (extent of cut and fill slopes) on the construction drawings
- Validate temporary detour design meets CDOT requirements and develop preliminary plan and profiles and associated thirty-percent construction drawings
- Develop General Layouts (thirty-percent construction drawings for the bridges and walls)
- Develop Bridge Hydraulic Information sheets (thirty-percent construction drawings for bridge hydraulics)
- Develop a list of pay items and special provisions (written requirements defining materials, construction, and measurement and payment for any items not covered in the CDOT Standard Specifications for Road and Bridge Construction)
- Refine and update quantity calculations for the pay items and develop a refined FIR-level cost estimate (reduce contingency to 15 percent)
- Complete the first half of the NEPA categorical exclusion clearance documenting impacts and mitigation commitments
- Meet with the TT to gather input on the design, construction planning, and environmental impacts; because the 6-Step CSS process was completed for the planning

phase of the project as part of this feasibility study, the TT will provide input that falls in "Step 5 Refine Options" of the 6-Step CSS process.

- Final design: Field Office Review (FOR) and PS&E
  - Complete final design and develop final construction drawings meeting CDOT standards; includes development of final structural calculations for the bridges and walls and a second set of independent calculations (the majority of the bridge design calculations are completed during this phase of the project)
  - Confirm measurement and payment for all items on the construction drawings are well defined
  - Complete a constructability review
  - Update quantities and finalize construction estimates (reduce contingency to 0 percent)
  - Complete final project special provisions
  - Finalize all reports (Structure Selection Report, Wall Selection Report, Geotechnical Report, and Hydrology and Hydraulics Report are not finalized until this stage)
  - Complete bridge ratings for underpass structures; this consists of an additional structural analysis and reporting that defines the capability of the bridge to carry legal loads
  - Compile and submit design calculation packages
  - Complete field package for all structures; this includes two independent sets of quantity calculations for all structural pay items.
  - Develop ROW plans (if needed)
  - Finalize ROW agreements between CDOT and USFS
  - Obtain environmental permits to complete the second half of the NEPA categorical exclusion clearance and final environmental certification
  - Meet with the TT to review the final design and construction plans
- Construction
  - Advertise and award the project for construction and require the contractor to adhere to design and environmental commitments, including the I-70 Mountain Corridor design criteria and aesthetics guidance
  - Monitor construction in accordance with CDOT requirements, including mitigation monitoring to ensure environmental compliance with permit requirements

It is important to note that this list focuses on the engineering and environmental work to be completed as part of the design and permitting process. Additional steps are required for establishing contracts between agencies, selecting consultants, establishing contracts with consultants, and invoicing and payment. These processes will be highly dependent on the lead agency and the funding that is used for the project. It is also important to note that monitoring construction in accordance with CDOT requirements is a significant effort and requires special attention to documentation procedures.

Exhibit 20. CDOT Project Development Process



8.3 Key Elements for Future Success

This study has identified a number of items that should be carefully considered in future phases of the design. They include the following:

- Blowing snow, cornice development, and noise and light attenuation on the overpass. In particular, creative approaches to the design of the noise wall on top of the overpass may be needed. The preliminary design includes a combination noise wall and permeable snow fence.
- Shading issues created by the overpass. The design team will need to determine if the overpass ultimately decreases safety on I-70 through shading, and if so, identify the best approaches to mitigating and limiting the safety concerns.
- Unique structural details. Various design elements for buried structures should be evaluated early in the process to allow time to incorporate good ideas and make structural adjustments without backtracking. One example is structural details for bridge barriers that retain fill. Moment slabs have been proposed, but other creative solutions should be investigated.
- Settlement of retaining walls. Future geotechnical studies should quantify the risk and level of settlement expected and provide mitigation procedures, such as two-phase wall systems.
- Refinement of design. The designs presented here were developed to establish feasibility and develop initial cost estimates. Through the formal CDOT Structural Selection Process, these concepts will be refined, and cost-saving ideas developed. Specific considerations include shallow foundations for the buried arch, reducing the opening size for I-70 on the overpass, refining the exact wingwall layout and grading, finalizing the radius of curvature for the overpass, and using curved versus chorded wall systems for the overpass.
- CSS design criteria and aesthetic guidelines. The final design should be consistent with CSS design criteria; any exceptions must be agreed to through the CSS process. Interpretation of the exact requirements related to the aesthetic guidelines will be required to finalize proposed girder types.

- Impacts to wetlands. The conceptual wildlife crossing designs discussed here do not impact any of the potential fen wetlands. However, future design will need to confirm the location and type of wetlands in the project area and be particularly sensitive to any identified fens.

9. References

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