

Highway 3: Transportation Mitigation for Wildlife and Connectivity

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HIGHWAY 3: TRANSPORTATION MITIGATION FOR WILDLIFE AND CONNECTIVITY IN THE CROWN OF THE CONTINENT ECOSYSTEM

Final Report

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EXECUTIVE SUMMARY

Introduction

The Highway 3 transportation corridor, including land use and development adjacent to the highway, has been identified as a major challenge to maintaining wildlife connectivity at the northern edge of the Crown of the Continent ecosystem. Highway 3 is a two-lane, east–west highway supporting 6,000 to 9,000 vehicles per day traveling over the Continental Divide at Crowsnest Pass in the southern Canadian Rockies. The current rate of wildlife–vehicle collisions involving large mammals along Highway 3 has raised concerns among agencies and the public regarding motorist safety. Although highway segments experiencing a high number of these collisions are predominantly found to involve deer, collisions also occur with less common species such as elk, moose, bighorn sheep, grizzly bear, wolf, lynx, bobcat and cougar.

The syntheses, field assessments and recommendations described in this report reflect the best available understanding and options for direct mitigation of highway impacts to local populations of large terrestrial wildlife. Although conservation measures at regional and landscape scales are critical in maintaining wildlife population connectivity, the focus of this report is at the finest scale necessary to address Highway 3 impacts on terrestrial wildlife—that of site-specific mitigation of the highway itself.

Ecological and social contexts

The management of transportation infrastructure that ensures local-scale wildlife conservation and motorist safety requires an understanding of the ecological and social context of the project area. These contexts comprise a unified foundation from which conservation and highway mitigation actions can be incorporated into decision-making.

Synthesis of existing information and research

A synthesis of existing biological data, analyses and reports regarding key landscapes, habitat linkages and wildlife mortality for large mammals describes the current conflicts between wildlife and the Highway 3 transportation corridor. The information reviewed includes species-specific landscape suitability and vulnerability in relation to Highway 3 for the following species: 1) carnivores—grizzly bears, lynx, badgers, bobcats, wolves, wolverines, and cougars; and 2) ungulates—elk, moose, deer, bighorn sheep and mountain goats.

Assessment of wildlife–transportation conflict areas

In British Columbia, the stretch of Highway 3 from the Rocky Mountain Trench to the provincial border at Crowsnest Pass contains 81 kilometers (km) of medium to very high wildlife–vehicle collision (WVC) segments, representing 59 percent of the highway and 79 percent of total WVCs. In Alberta there were 1359 WVCs recorded from 1998–2008 along a 44-km segment between the British Columbia/Alberta provincial border and Lundbreck, Alberta. This section has 27 km of medium to very high WVC segments, representing 61 percent of the highway and 77 percent of total WVCs. Deer were the most common species involved in collisions across the study area, representing 90 percent of the WVCs.

Identifying priority areas for highway mitigation

Thirty-one sites along Highway 3 in the project area were identified as key locales where highway mitigation could benefit wildlife conservation, habitat connectivity and motorist safety. Each site was visited in the field and evaluated using five different criteria: local conservation value, level of highway caused wildlife mortality, land-use security, regional conservation significance and opportunities for highway mitigation. Each criterion was assigned a score from 1 (low) to 5 (high). The average score of the five criteria helped determine the relative importance for mitigation efforts among the 31 sites. Each mitigation emphasis site is described in the report. During each site visit, an evaluation was conducted to make recommendations for a variety of short- and long-term wildlife mitigation measures.

Monetary cost–benefits of reducing wildlife–vehicle collisions

With growing rates of WVCs over the past two decades, agencies are increasingly seeking to mitigate highways to increase motorist safety as well as to provide for the conservation of wildlife. A summary of the recent advances in evaluating the monetary cost and benefits of various mitigation measures provides information for decision-makers, managers and the public to better understand the societal benefits of investing in those measures. We performed a cost–benefit analysis using annual rates of WVCs for each of the 31 mitigation emphasis sites along Highway 3 in British Columbia and Alberta.

The number of collisions per kilometer per year involving deer, elk, moose and bighorn sheep were summarized at each mitigation emphasis site and the total cost of the ungulate–vehicle collisions was (UVCs) compiled.

Collision rates varied at the mitigation sites in British Columbia, from a low of 0.6 UVCs/kilometer/year (UVCs/km/year) at the Carbon Creek bridge site to a high of 3.1 UVCs/km/year at the Trench 3 site.

UVC rates were higher in Alberta than in British Columbia, likely due to differences in data collection efforts between the two jurisdictions.

Collision rates in Alberta ranged from a low of 1 UVC/km/year at the Rock Creek site to a high of 4.28 UVCs/km/year at the Leitch Collieries site. Nearly half of the Alberta sites had total UVC rates in excess of 3 UVCs/km/year.

The bighorn sheep–vehicle collision rate of 2.55/km/year is notably high at the Crowsnest Lakes site.

Using the UVC rates at each mitigation site, the annual costs of the UVCs were then derived based on each ungulate species' average cost per collision (i.e., human fatalities and injuries, vehicle damage): deer (\$6,617), elk (\$17,483), moose (\$30,760) and bighorn sheep (\$6,617). In British Columbia, total annual costs of UVCs ranged from a low of \$1,323 at the Alexander–Michel 2 site to \$28,329 at the Fernie–Morrissey 4 site. In Alberta, total annual costs of UVCs varied from a low of \$6,617 at the Rock Creek site, although road segments on both sides of this site were much higher, to a high of \$31,405 at the McGillivray Creek site (all figures in 2007 Canadian dollars).

A recent cost–benefit analysis for a variety of highway mitigation measures across North America found the average cost of building and maintaining a wildlife underpass with fencing and jumpouts (escape ramps for wildlife) is \$18,123 per year. Although underpasses are often considered an “expensive” infrastructure investment for wildlife, nearly one-third of the monetary costs for the sites in British Columbia were estimated in excess of \$18,123 per year and half of the sites in Alberta had estimated annual costs in excess of this threshold number. This makes many of the mitigation emphasis sites in the study area excellent candidates for underpasses or other infrastructure investments. Further, if the underreporting of WVCs were accounted for, then investment in mitigation at even more sites would be considered cost effective. Focusing highway mitigation efforts in these areas could improve motorist safety, reduce wildlife mortalities, improve habitat linkage and animal movements across Highway 3 and be cost effective.

Highway 3 mitigation emphasis site evaluations

From the field evaluation of the 31 mitigation emphasis sites, recommendations were grouped into short-term and long-term actions. A description and summary for each mitigation emphasis site along Highway 3 is in Appendix A. The relative importance of each site varies by species and local landscape attributes across the 180-km highway corridor. A variety of mitigation measures were recommended, from simple to complex. Some required only a change in operations (e.g., de-icing alternatives), while others some level of construction (e.g., wildlife underpass, fencing).

Ten of the long-term mitigation measures are described, with photos, in Appendix B. Hosmer–Sparwood-1 had the highest priority score of the entire study area. The site is particularly important in terms of regional and local conservation and the land-use security is high, as Nature Conservancy of Canada lands abut both sides of the highway. The site has good opportunities for highway mitigation. Twin culverts currently drain wetlands adjacent to the highway. Alexander–Michel-1 is within what is known to be the most critical habitat linkage in the entire Highway 3 corridor. Therefore, this site may be important in maintaining local- and regional-scale movements of wildlife, including grizzly bears, wolverines and lynx. It has moderately high opportunities for highway mitigation.

Fernie–Morrisey 1 was one of two sites with the highest scores for land-use security and is recognized for its importance for carnivore population connectivity across the lower Elk Valley. It has moderately high scores for local and regional conservation values; however, mitigation opportunities are limited. Elko–Morrisey 3 had moderately high scores for local conservation, land-use security and mitigation opportunities; however, it is a high collision area for bighorn sheep. Elko–Morrisey 1 was particularly important in terms of local conservation and highway mitigation opportunities. Similarly, it is an area of very high rates of WVCs, primarily with deer, elk, bears and bighorn sheep.

Among Alberta mitigation sites, Rock Creek is of highest priority. This site is particularly important in terms of local conservation, and has high land-use security and highway mitigation opportunities. It is also an area of very high WVC rates. There are currently plans to replace an existing culvert with a new below-grade structure, creating an excellent opportunity to improve terrestrial and hydrologic flows in the area. Crowsnest Lakes was one of two sites with the highest WVC rate, primarily involving bighorn sheep. The area is moderately important for

regional conservation, while the local conservation significance is mostly due to the local bighorn sheep population. Crowsnest East had the best opportunity for highway mitigation, while Iron Ridge had moderately high scores for local conservation and regional conservation significance.

Special consideration for American badgers

American badgers are “red-listed” in British Columbia and the subspecies in British Columbia is listed as an endangered species in Canada. Reducing road-related mortality is a key action in the Canadian recovery strategy for this subspecies of badger. The Trench 1, Trench 5, and Trench 6 sites were identified as locations to improve highway permeability and reduce mortality of badgers. Existing culverts should be made visible and passable to badgers. More culverts should be installed where data indicates they are needed.

Monitoring and research

- Monitoring and research are needed to inform agencies by providing the most current data and site-specific information to help prioritize and guide decisions regarding planning and design on Highway 3.
- Coordinate activities aimed at collecting reliable and accurate information on wildlife–vehicle collisions and wildlife movement within the Highway 3 corridor.
- Evaluate existing below-grade highway structures (i.e., culverts, creek bridge structures) for their potential for passing wildlife safely across the highway.
- Conduct at-grade surveys, including snow tracking, to provide better information on existing species-specific crossing locations.
- Review and analyze existing Highway 3 infrastructure to determine the impacts of the highway to aquatic connectivity, species movement and conservation.
- Conduct a Canadian Pacific Railway wildlife strike zone assessment to better understand the location of any problem areas along the railway and develop potential solutions.
- Keep transportation and natural resource agencies working along Highway 3 informed about the most up-to-date and effective means of mitigating highways for wildlife via workshops, training courses and other technology transfer opportunities.

INTRODUCTION

The southern Canadian Rocky Mountains connect the Crown of the Continent Ecosystem (centered about Glacier–Waterton International Peace Parks) with the Banff–Jasper–Kootenay–Yoho mountain parks complex to the north. Maintaining landscape connectivity is crucial for the wellbeing of the many native wildlife species that currently thrive in the region. One area that has been identified as a major challenge to maintaining wildlife connectivity is the Highway 3 transportation corridor and adjacent land use and development as they represent a potential fracture zone for wildlife movement at the northern edge of the Crown of the Continent ecosystem (Figure 1).

The Highway 3 transportation corridor runs west–east over the Continental Divide at Crowsnest Pass in the Canadian Rockies. Highway 3 is a two-lane highway supporting 6,000 to 9,000 vehicles per day, depending on the season and section of road. It serves local commuters from the communities of Elko, Fernie and Sparwood, British Columbia, as well as Coleman, Blairmore, Frank, Hillcrest and Bellevue, Alberta. Local transportation use is compounded by transcontinental trucking and the increased recreational needs of Calgary residents. A railway runs parallel to the road for the entire length of the corridor. Both modes of transportation are experiencing an increase in traffic volume. The implications to wildlife include direct mortality from collisions with highway vehicles and trains, fragmentation of the landscape, and avoidance behavior by wildlife due to the increased activity and presence of humans.

Understanding wildlife use and movements, associated behaviour, and habitats along this transportation corridor is essential for developing mitigation strategies to reduce transportation–wildlife conflicts and maintain connected populations. Fortunately, there have been a number of research projects in the past decade that allow us to better understand how a variety of different species use these landscapes (e.g., bighorn sheep, elk, grizzly bears). These include studies that have identified key linkages for several carnivores, including grizzly bears that cross Highway 3 and the Canadian Pacific railroad. However, the studies were not developed to focus solely on the highway and its increasing use. Therefore, scientists, agency personnel and conservationists gathered at a Highway 3 workshop in Fernie, British Columbia in January 2008 to share and discuss relevant and available knowledge on wildlife studies that may inform site-specific mitigation of Highway 3.

One recommendation from the workshop was for a sub-set of the attendees to complete a synthesis of the biological information relative to Highway 3 to inform an assessment of potential transportation mitigation sites and options. The syntheses, field assessments and recommendations described in this report reflect the best available understanding and options for direct mitigation of highway impacts to local populations of large terrestrial wildlife.

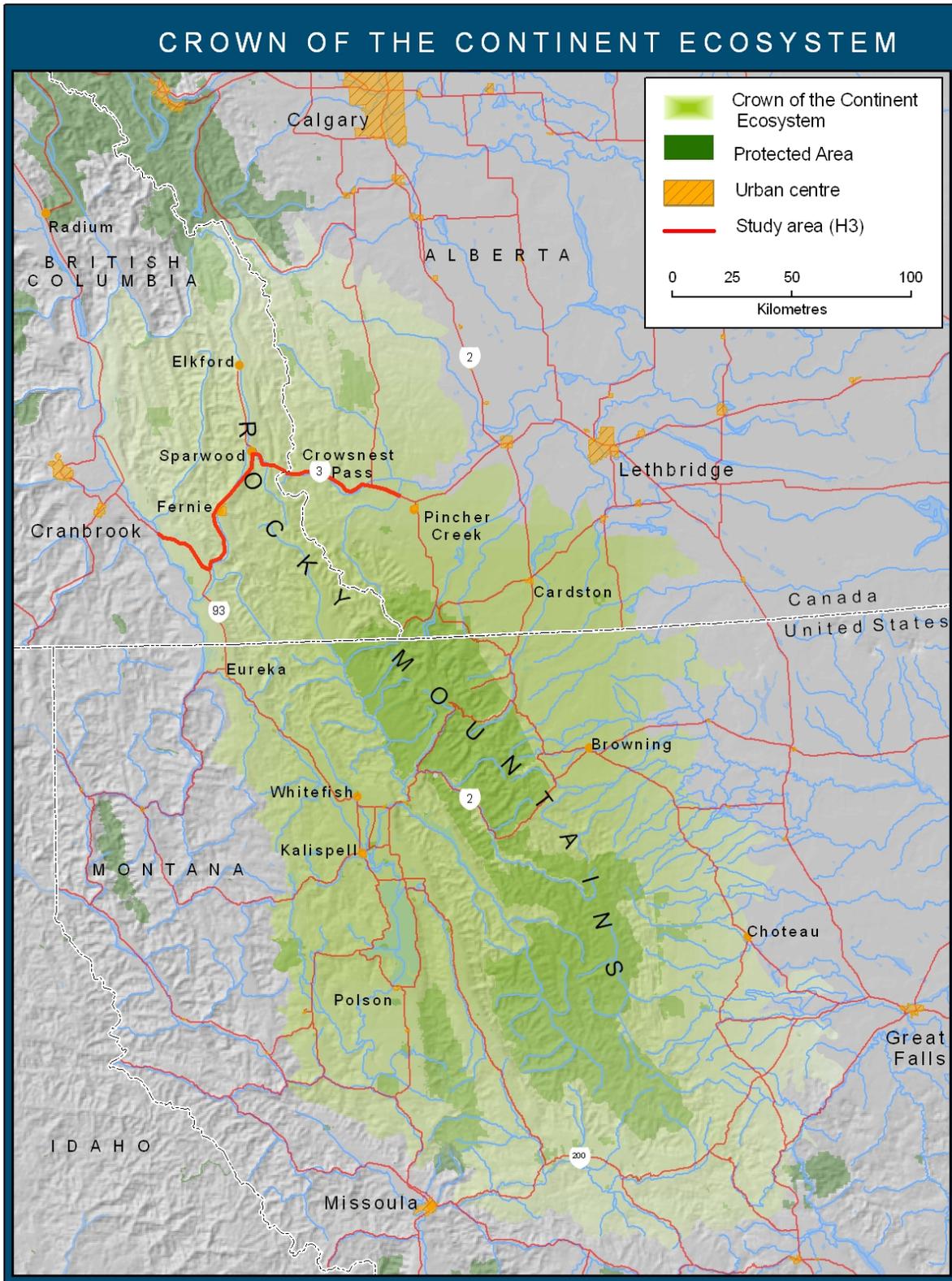


Figure 1: Highway 3 study area in the Crown of the Continent Ecosystem (courtesy Miistakis Institute).

BACKGROUND

1.1 Ecological Context

Ecological connectivity is a fundamental principle in the conservation of wildlife, ecosystems and biodiversity (Crooks and Sanjayan 2006). In a general sense, all animal and plant populations are shaped by, and persist because of, spatial connections. Habitat connections are needed for mobile animals to move through and survive within resident home ranges. At broader scales, landscape linkages allow individuals to move among core habitat areas, providing stability to regional populations and allowing range peripheries to be occupied through periodic or continual augmentation. The resulting genetic flow across large connected populations also contributes to localized adaptability to a changing environment and helps to ensure that only genes beneficial to individual fitness are expressed. Although ecological connectivity is nebulous and without definition as it pertains to species, habitats, spatial and temporal scales, thresholds and risk, the notion of connectivity is nonetheless central to effective conservation planning.

In a world dominated by human activity, the Rocky Mountain cordillera of North America, from Yellowstone to Yukon (Y2Y), is composed largely of wild lands that are relatively intact to various degrees. One key node in the Y2Y ecoregion is the transboundary Crown of the Continent Ecosystem, a critical collection of federal, state, provincial and private lands anchored by Waterton Lakes National Park in Canada and Glacier National Park in the United States. This ecosystem covers approximately 44,000 square kilometers (16,000 square miles) and is an integral part of the much larger Y2Y ecoregion. Recognizing the value to humans in maintaining fully intact and functioning natural ecosystems, and the ever-dwindling opportunities to do so, a variety of efforts are moving forward to protect, recover and enhance the integrity of local landscapes within the Crown of the Continent Ecosystem and the natural connections within and among them.

The southern Canadian Rocky Mountains encompass the northern half of the Crown of the Continent Ecosystem and comprise a zone of utmost strategic importance in the securing of connected wild land ecosystems (Tabor and Soulé 1999, Apps et al. 2007). Most of this region is managed for multiple values, including resource extraction, agriculture, human settlement, and tourism that includes both motorized and non-motorized recreation. And it is on this economic basis that several local human communities have grown and thrived. While much of the southern Canadian Rockies is relatively undeveloped and ecologically intact, such landscapes are bounded and interspersed with human settlements and activity. Despite the significance of this region in supporting some of the greatest ecosystem and large mammal diversity in North America (CORE 1994, Apps et al. 2007), few landscapes in the southern Canadian Rockies are managed primarily for ecological values.

Wide-ranging species of low density and limited distribution are central to regional conservation planning across the southern Canadian Rockies. These native wildlife, mostly carnivores but also ungulates, are appropriate species on which to focus regional conservation planning because, as a group, they are good indicators of the general health of ecosystem processes and the well-

being of native biodiversity. Carnivores also tend to sit at the top of often complex ecological food chains and are thus indicative of stable and functioning multi-species systems. Impacts to wide-ranging carnivore and ungulate species are largely manifested through roads and associated motorized human access and traffic. Roads affect wildlife populations through mortality due to collisions with vehicles (primarily on highways), legal and illegal killing, habitat loss and alienation, and the disruption of movement and seasonal-migration options (Trombulak and Frissell 2000, Forman et al. 2003). For ungulates, roads can have substantial local impacts as they limit movements between important seasonal foraging and/or reproductive habitats (e.g., Berger 2004). Changing the pattern of human access will also influence ungulate distribution, particularly in hunted populations.

For wide-ranging species, there is much concern and focus on the potential impacts of the Highway 3 transportation corridor that bisects the Crown of the Continent Ecosystem from west to east (**Figure 1**). From the Rocky Mountain Trench in the west to Alberta agricultural lands in the east, Highway 3 is associated with human settlement and development in and around the communities of Sparwood, Fernie and Elko, British Columbia, as well as the Municipality of Crowsnest Pass in Alberta. Given the existing communities, a large proportion of private land ownership and high human accessibility, much of the landscape through which Highway 3 passes is composed of, or is potentially subject to, permanent human development. Considering human demographic and socioeconomic trends, there is obvious potential for the highway corridor to fracture the north–south contiguity for populations of wide-ranging carnivores and some ungulates. As a source of high mortality and a constraint to the movements of resident and dispersing animals, the genetic and demographic implications of such a fracture zone can destabilize populations and increase the likelihood of localized extirpation. Moreover, human development and activity along the highway corridor undoubtedly results in extensive ancillary impacts, potentially reducing the effectiveness and security of core habitat areas within the larger region.

Hence, for wide-ranging species at least, Highway 3 has conservation implications that are embedded in cumulative landscape-level human impacts. Addressing cumulative impacts requires research and planning across multiple scales, with strategies tailored not only for transportation but simultaneously for public land management and the management and development of residential and industrial private lands. Associated planning tools and conservation priorities are addressed by Apps et al. (2007) and an ongoing research program. Within the Crowsnest Pass Municipality of Alberta, the potential upgrading/twinning of Highway 3 is expected to significantly impact ungulate use of existing winter range. Current and future wildlife–vehicle collisions (WVCs) in this area are also a major concern, with the potential to adversely impact wildlife populations, motorist safety and finances (Lee 2009).

There are a number of segments of Highway 3 where WVC rates are considered high and human safety is a concern. Although areas of high WVCs are predominantly associated with deer, there are numerous records of collisions with elk, moose, bighorn sheep and carnivore species, such as grizzly bear, wolf, lynx and cougar. In certain circumstances, wildlife mortality due to collisions with vehicles may have a local population-level effect, such as at Crowsnest Lakes where the

local bighorn sheep population is declining almost 10 percent annually due to mortality caused by collisions with vehicles.

It is acknowledged that conservation measures at regional and landscape scales are critical in conserving and promoting connectivity of wildlife populations across Highway 3. **However, the focus of this report is at the finest scale necessary to address Highway 3 impacts on terrestrial wildlife—that of site-specific mitigation of the highway itself.** While the information and recommendations presented here are informed by studies and data across geographic scales, our focus is in best mitigating highway impacts in terms of wildlife movement and mortality specific to current and future transportation infrastructure scenarios.

There are several issues that this report does not address related to transportation and conservation in the Highway 3 corridor:

- The needs of aquatic species.
- The effect of the adjacent and parallel railroad on wildlife.
- Potential new highway expansion alignments, particularly in Alberta.

1.2 Conservation Issues of Regional Significance and Associated Research

The Highway 3 conservation issue is essentially defined by potential impacts to wide-ranging species that persist at low densities and/or in limited distribution in the larger region. These are primarily carnivore species. Specific to large carnivores, particularly grizzly bears, the issue was initially highlighted by work done in the 1990s (Apps 1997). This late 1990s report was intended to focus attention on the potential for fracture of wide-ranging carnivore populations and its associated conservation implications, and to promote measures to secure the integrity of several multi-species population linkage landscapes that span the transportation and settlement corridor. Also, the report warned that without proactive planning, projections of future human development and activity along the highway corridor may result in the irreversible loss of habitat available for wildlife movement and/or unsustainable mortality risk, contributing to population isolation for some species.

Since the Apps (1997) report, several other researchers have independently corroborated the importance of Highway 3 as an issue in carnivore conservation. In a broad scale assessment across the Y2Y ecoregion, Carroll et al. (2001) identified Highway 3 as an emerging gap for several large carnivores. In his assessment of habitat connectivity for large mammals in the transboundary Flathead drainage, Weaver (2001) also reiterated the threat of population fracture from Highway 3 and associated land development. Theoretical predictions of population impacts were partially substantiated by Proctor (2003) in a study demonstrating that the Highway 3 transportation and settlement corridor has had a measurable impact in restricting gene flow among grizzly bears.

In 2001, several researchers embarked on a multi-species and multi-scale collaborative study specific to carnivores and Highway 3. This work was initiated in response to a need for more

refined decision-support and planning tools to focus and direct conservation action at the scale of the larger region as well as landscapes within and around the highway corridor. The first two of three phases of this study culminated in a report addressing core areas and connectivity for carnivores, with a focus on Highway 3 (Apps et al. 2007). In Phase 1, the researchers selected a suite of six carnivore species that represent the broad variation in ecosystem conditions across the regional landscape. For each species, they developed and applied regional models of population distribution and vulnerability across the southern Canadian Rockies. In Phase 2, the study applied hair-snagging and DNA analysis to sample the actual distribution of grizzly bears and lynx within a zone 15–40 km wide along the highway corridor through the Rocky Mountains.

These data were used to test and refine regional models, and to inform a finer-scale assessment of landscape occupancy, relative abundance, and movements in landscapes directly adjacent to the highway. At the finest scale, Phase 3 is the most detailed and long-term study component. This third phase involves intensive and representative sampling of grizzly bear movements by way of tracking collars and a multi-scale assessment of spatial and temporal factors influencing space-use and movements. Data and associated analyses are being used to predict seasonally important core habitats within home ranges, movement options among them, and dispersal opportunities. These predictions are especially relevant in multi-scale conservation planning to offset impacts associated with Highway 3. This specific study will culminate in a multi-scale assessment of the influence of both cumulative human and habitat influences on the movements and persistence of resident grizzly bears.

The ways by which major highways influence wide-ranging carnivores and their populations varies among the species depending on their behavior and life-history. For all species, movements are influenced by highways but ultimately determined by underlying habitat quality and distribution in and around the associated landscape. To the degree to which highways bisect or coincide with landscapes of preferred habitats, transportation infrastructure can be an obvious mortality source either by way of direct vehicle collision or through facilitation of human access and permanent presence. Both movement restriction and mortality increase the potential for population fracture and isolation. The resulting loss of gene flow and the potential for inbreeding depression is a concern, but one that can be alleviated by even small measures of successful movement and breeding. Of much greater concern are the demographic effects of isolation including the loss of potential immigration, augmentation, and recolonization opportunities. Species that occur at low densities and/or in limited distribution may be vulnerable to such effects especially near range peripheries. Grizzly bears are particularly sensitive because they exhibit relatively low dispersal potential, especially among females. Dispersal by young bears is a gradual process that can take years, with adults residing close to their natal ranges and females usually overlapping their mother (McLellan and Hovey 2001). As a result, connectivity across highways requires consideration for specific movement options as well as landscape management for habitat effectiveness and security.

1.3 Social Context

The communities that lie between Elko, British Columbia, and Lundbreck, Alberta, took root at the turn of the twentieth century, with an economy based primarily on the plentiful coal resources of

the region. The resource extraction industries attracted a large immigrant population to supply the manual and skilled labour for the mines. The transportation routes grew to meet the needs of these communities, including getting their raw resources to distant markets. The transportation infrastructure is not only for local use since Crowsnest Pass is one of a few geographically viable routes across the Rocky Mountains for both rail and highway making it a crucial transportation link between the prairies and the west coast. In addition, this route serves to transmit Alberta petroleum to the west coast of the United States via a major pipeline.

Based on local resources, the coal mining communities were largely economically separate from their agricultural neighbours to the east and formed their own unique culture and social identity. This was the social pattern, complicated by occasional fluctuations in the commodity markets, for most of the twentieth century.

The last two decades have seen a series of changes to this pattern. At both the east and west ends of the study area, the natural resource economies have been increasingly supplanted by tourism and recreation. In the Alberta portion of the study area, coal mining activities have gradually subsided and those still employed in the industry now commute down Highway 3 to the mines in British Columbia. This loss of the traditional economic base has resulted in a decline in population of over 21 percent. While occasional fluctuations were part of the history of the community, the population dropped from 7302 in 1981 (Municipality of Crowsnest Pass 2001) to 5749 in 2006 (Statistics Canada 2006). The 2006 Canadian census records a population in the Crowsnest Municipality with a significantly higher median age (48) than the Alberta average (36) and lower levels of mobility and educational attainment than the provincial averages (Statistics Canada 2006), often indicators of a community in transition.

At the same time, the scenic beauty and outdoor recreation potential of communities such as Blairmore and Coleman have attracted both tourists and amenity migrants—affluent members of society who can choose to live in aesthetically valuable places. The relative proximity of Calgary and Lethbridge has brought citizens from those urban centres to buy recreational and second properties in the pass. The Economic Development Office of the Municipality of Crowsnest Pass has estimated that 20 to 25 percent of utility bills are mailed to owners outside the municipality. As property ownership shifts to those who do not have year-round local residencies, increases to commuting distances and traffic volume occur, primarily on weekends and holidays.

Sparwood, British Columbia, has not experienced this shift to the same extent as Alberta communities, likely because coal mining continues in the upper Elk Valley. To its south, Fernie, however, has grown into a major recreational and tourism destination in both summer and winter. This is now the major economic driver for the town. The majority of visitors to the Elk Valley travel via Highway 3 from Alberta. The economic renewal that tourism and recreation appear to be bringing to the region is adding to the need for safe, sound Highway 3 design and operations.

Decision-making authority for Highway 3 in the study area is split between the provincial jurisdictions of the British Columbia Ministry of Transportation and Alberta Transportation. Alberta Transportation is currently conducting a long-term planning study with respect to the upgrading and potential realignment of Highway 3. British Columbia is not engaged at this time in transportation planning for Highway 3 or any major reconstruction projects in the study area.

The relationship between public land management, private land use and the future of Highway 3 is multifaceted. The transportation infrastructure has a major influence on local communities and their patterns of development. Conversely, land use decisions have the potential to impact Highway 3's traffic patterns and traffic volumes. In addition, for highway mitigation to be effective in safeguarding wildlife and their movement, it must be accompanied by conservation measures on adjacent private land as well as compatible uses and management on public land. Thus, public and private land use decisions, the responsibility of public agencies and the municipalities along Highway 3 are integral to sound transportation design and implementation. In Alberta, the need to coordinate infrastructure and different levels of land use regimes has been recognized and is one of the tasks of the Alberta Land-Use Framework, a process which is currently underway.

This report aims to provide credible analyses and recommendations so officials at all levels of government involved with transportation and land use planning are aware of the relevant wildlife science and options available in the Highway 3 study area. For the report's recommendations to be successful, wildlife mitigation measures for the highway should be coordinated with conservation planning on adjacent public and private lands.

SPECIES-SPECIFIC LANDSCAPE SUITABILITY AND VULNERABILITY TO HWY 3

2.1 Carnivores

Along the route by which Highway 3 passes through the southern Canadian Rockies, impacts and mitigation options for individual carnivore species vary according to inherent habitat potential in landscapes around the highway and the distribution of known core habitats. This knowledge is best informed by Phase 1 and Phase 2 outputs of Apps et al. (2007).

For grizzly bears, landscape suitability is rather high in the mountains and higher foothills throughout much of the region, both south and north of Highway 3. Core habitats are specifically associated with the following areas: (1) the lower Flathead basin and adjacent Castle drainage, (2) east side of the Wigwam basin, (3) the upper reaches of the Flathead basin and adjacent Carbondale area, (4) Michel Creek and adjacent Ptolemy Creek area, (5) Alexander drainage and upper Oldman River basin, (6) upper Elk River basin and adjacent upper Highwood River drainage, (7) west side of the upper Elk River, and (8) Lizard Range. Movements of resident grizzly bears (C. Apps, unpubl. data) largely corroborate the major landscape linkages spanning Highway 3 that were identified by Apps et al. (2007).

One important zone is near the junction of Alexander and Summit Creeks, 3–5 km by highway west of the Continental Divide. Moving west, another key landscape spans the lower Elk Valley between Sparwood and Hosmer. A third linkage is located between Fernie and Morrissey. These data also suggest a movement zone of potential importance within the Rocky Mountain Trench linking seasonal foraging areas in the Sand Creek drainage to those around lower Kikomun Creek.

East of the Continental Divide in Alberta, there is less potential for cross-highway grizzly bear movement (Apps et al. 2007), compared to west of the Continental Divide. However, there is evidence that suggests potential for movement directly east of Crowsnest Lakes in the vicinity of Crowsnest Creek. The authors do not discount the potential for movement by grizzly bears across Highway 3 farther to the east.

For lynx, suitable habitat is unevenly distributed along major ridge complexes and upper valleys. This disjunct pattern indicates that the stability of the regional lynx population likely is dependent on the productivity, security, and connectivity among several key areas. Important landscapes include: (1) upper elevation basins east of Fernie and south of Sparwood, including the upper Flathead River drainage, (2) upper Elk Valley and the confluence of the upper branches of the White River in British Columbia, and (3) forested and subdued terrain just east of the Continental Divide extending from upper Racehorse Creek northward to upper Highwood River. Habitats adjacent to primary highways in the major valleys are generally suboptimal for lynx, but often used for travel between key areas.

Badgers generally occur at low elevations and in ecosystems that are relatively dry and open. The highest landscape suitability for badgers is associated with semi-arid, open grasslands of the Rocky Mountain Trench along Highway 93 in British Columbia and the Rocky Mountain foothills north and south of Lundbreck in Alberta. Highway right-of-ways are often attractive habitats for

badgers. Their proximity to highways increases the risk of mortality from vehicles; however, drainage culverts can be used to safely cross highways if positioned correctly or adapted for badger movement.

Bobcats in the region occur near a natural range limit. Their habitats are associated with low elevation forests within ecosystems characteristic of relatively dry and mild winter climatic conditions. Regional bobcat distribution is somewhat peninsular, with resident animals occurring mostly along the shoulders of the Rocky Mountain Trench parallel to Highway 93 in British Columbia as well as forested plains and foothills in Alberta.

The potential distribution of wolves through the region is generally associated with major valley networks—specifically the grasslands and foothills flanking the east side of the Canadian Rockies in Alberta and the larger montane valleys in British Columbia such as the Elk, Flathead, Kootenay, and Columbia River valleys. However, actual wolf distribution is largely influenced by current and historic human actions to reduce the resident wolf population. At present, wolf persistence in the region likely depends on the somewhat higher productivity and security of landscapes such as the Flathead River basin and the upper Elk Valley, and also the upper Carbondale–Castle River. Major valleys parallel to the Continental Divide from Glacier National Park up to Banff National Park and associated passes along the Continental Divide are conduits for wolf movements.

Wolverines are expected to occur at relatively low densities across the southern Canadian Rockies. Landscape suitability for wolverines is rather high in the mountains and higher foothills throughout much of the region. Many of the areas of high suitability for grizzly bear are also apparently conducive to core wolverine habitat. Like lynx, habitats in transportation corridors are typically suboptimal, but wolverines occasionally need to travel through these areas to access key resources.

Cougars generally are more widespread and ubiquitous across the southern Canadian Rockies than the aforementioned species. For this reason, they are not considered an ideal focal species in managing for connectivity (although acquiring reliable movement data for cougars is easier than for most other species). Along the Highway 3 corridor, individual cougars undoubtedly move and use habitats as determined by available prey that primarily include bighorn sheep, white-tailed and mule deer, and elk. In one local study, cougar movements were largely influenced by ungulate densities benefiting from habitat enhancements and reclamation associated with the Elkview coal mine (Spreadbury 1989). In Rocky Mountain ecosystems, cougars generally benefit from complex terrain in association with adequate vegetative cover (Jalkotzy et al. 1999). Accordingly, habitat model predictions in the Municipality of Crowsnest Pass suggest that cross-highway cougar movements are more likely between Blairmore and Frank, west of Coleman in association with Iron Ridge, and possibly between Crowsnest Lake and Island Lake (Chetkiewicz 2008).

Not surprisingly, Apps et al. (2007) indicate that wide-ranging carnivores are most vulnerable across the region where suitable landscapes occur in close proximity to settlements, highways, and primary roads that facilitate high-intensity recreation and motorized access. These include Highway 3, Highway 43 (Elkford Highway) and Highway 93 in British Columbia. In Alberta it

includes Highway 3, Highway 22 (Chain Lakes Highway), Road 940 (Forestry Trunk Road) and Road 774 (Castle River Road).

In their report, Apps et al. (2007) review current knowledge regarding the impacts to carnivores of highways, railways, and their associated traffic. However, the authors stress that the greatest impact of highways on carnivores is the cumulative human activity and spin-off development that they facilitate over time. It is the linear pattern of these impacts along the highway route that are the ultimate reason why Highway 3 may fracture some carnivore populations. To inform carnivore conservation planning at multiple landscape scales, the authors describe 15 core areas across the southern Canadian Rockies, which they rate in terms of conservation significance and relative security. Interdependent on these core areas, the authors map and describe 11 landscape linkages and key movement options across and adjacent to Highway 3. They also rate these connectivity options in terms of conservation significance and vulnerability. Readers should refer directly to the above report for a detailed treatment of core areas and connectivity for carnivore populations in relation to Highway 3.

2.2 Ungulates

Impacts and mitigation options for different ungulate species may be addressed with various strategies depending on topography and highway path across both ranges and movement routes of ungulates. Valley bottoms are typically important wintering areas for ungulates that provide access to forage and cover to ensure survival during the critical and population-limiting winter season. These low-lying areas are also associated with the route of Highway 3 and associated human settlement. In both Alberta and British Columbia, key ungulate winter range is primarily found in broad valleys and associated slopes of south or southwest aspect where soils, climate and topography can provide both winter forage and cover to satisfy thermal and security needs. Elk, moose and deer winter ranges can overlap depending on specific plant communities. Elk and bighorn sheep are grazers with a preference for grasses, whereas deer and moose are browsers and prefer shrub communities. Ungulate winter range is mapped for both provinces (Alberta Sustainable Resource Development 2005, British Columbia Environment, Lands and Parks 2005) and overlap to varying degrees along and around Highway 3 (**Figure 2**). We believe that impacts of highway upgrades on wildlife connectivity, vehicle collisions on wildlife mortality, and improved motorist safety can be partially mitigated through structural engineering that includes proper placement of overpasses and underpasses with respect to landscape context, habitat and terrain.

Landscape suitability for elk is generally high along and around the entire span of Highway 3 through the southern Canadian Rocky Mountains, and includes high quality and critical winter range. During winter, hundreds of elk rely on associated grassland and mixed forest habitats bisected by the highway. The herds in British Columbia and Alberta are partially migratory with some residing in the valleys and adjacent slopes during summer and others migrating to summer ranges often at higher elevations. Core winter ranges are found in association with (1) Natal Ridge, (2) lower Michel and Alexander creeks east of Sparwood, (3) adjacent to the highway between Sparwood and Fernie, and (4) within the Rocky Mountain Trench west of Elko (Jalkotzy 1994, Gibson and Sheets 1997, Lee 2009). Within Alberta, our current understanding of elk winter

range and movements suggests considerable potential for disruption from additional highway development from Sentinel to Iron Ridge (known locally as the West Block) and in the eastern portion of the Crowsnest Pass municipality, in the vicinity of Burmis and Rock Creek.

Mule deer and white-tailed deer winter ranges are generally associated with windblown valleys and rolling montane forests commonly found along the Highway 3. Winter habitats provide accessible browse forage and important reproductive and thermal requirements. Along the highway, the largest populations of both species occur near Sparwood, Morrissey, and Elko in British Columbia and Lundbreck/Burmis and Coleman in Alberta.

Moose occupy primarily riparian habitats along Highway 3, making use of available willow and dogwood browse. Locally, moose occur at low densities relative to other ungulates, but seasonal ranges with important forage and reproductive habitats are found adjacent to the highway across the Rockies. Based on local knowledge and road mortalities, key areas for moose along the highway are associated with Alexander Creek, Hosmer, and between Fernie and Morrissey in British Columbia and near the Crowsnest River Bridge east of Crowsnest Lakes in Alberta.

Bighorn sheep prefer open or semi-open habitats in close proximity to escape terrain consisting of steeply sloped rocky cliffs and outcrops. Along the highway bighorn sheep are found at the following four sites that are low-elevation connections between primary ranges on shoulders of adjacent mountains: (1) a seasonal crossing on the highway just east of Blairmore between Bluff and Turtle Mountain; (2) roadside habitat adjacent to the highway near Crowsnest Lakes used during spring green, fall rutting periods, and winter; (3) at a short section along the highway along lower Alexander Creek; and (4) southwest of the highway tunnel between Morrissey and Elko where important spring, fall rut, and wintering habitats are found. Movement options for bighorn sheep near the Crowsnest Lakes and Elko sites we consider to be of regional significance. The presence of bighorn sheep along Highway 3 is frequently due to their attraction to salt that they lick off the roads.

Mountain goats, like bighorn sheep, prefer precipitous terrain and occasionally subalpine forests. They sporadically cross Highway 3 near the Crowsnest Lakes.

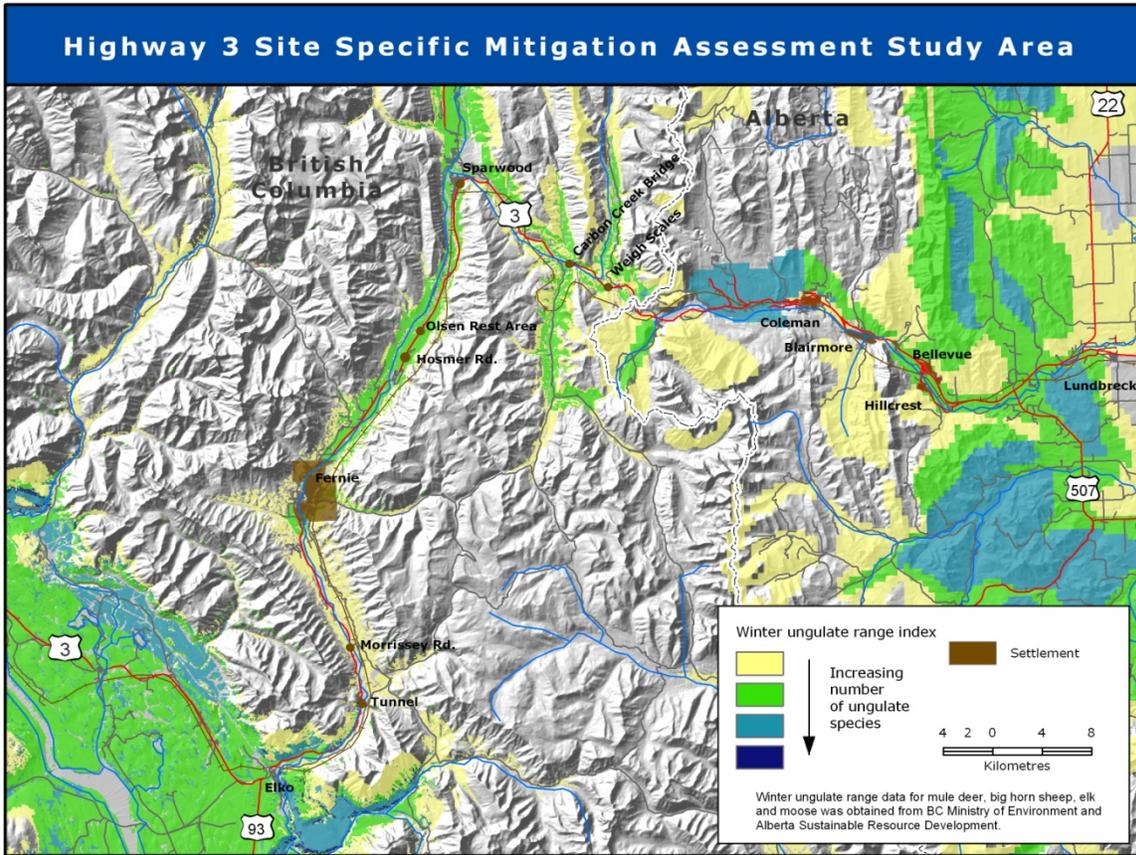


Figure 2: Distribution of ungulate species in association with the Highway 3 transportation corridor in the southern Canadian Rocky Mountains.

WILDLIFE–TRANSPORTATION CONFLICT AREAS ASSESSMENT

3.1 Introduction to Wildlife–Transportation Conflict Areas

Roads constitute the most ubiquitous and extensive human footprint on the global landscape. The traffic associated with the extensive and growing network of roads results in a large number of wildlife–vehicle collisions (WVCs). WVCs are the leading source of human-caused mortality to land vertebrates and are the source of significant population effects for some species (Forman et al. 2003). WVCs pose both wildlife conservation and human safety issues and have recently received widespread attention from ecologists, transportation planners and local communities (Trombulak and Frissell 2000). The effects reach beyond individual wildlife populations and pose broader conservation, economic and social consequences, including a considerable human safety risk (Husijer et al. 2007). In Canada, collisions between large mammals and vehicles occur at a rate of four to eight per hour resulting in approximately 17 human deaths and over 2,000 injuries a year. In 2003, Alberta recorded a loss of 11,632 large mammals, an 80 percent increase in WVCs from 1992 (L.P. Tardif and Associates 2003). In 2008, approximately 10 percent of all reported vehicle collisions involved animals (primarily wildlife) resulting in 498 human casualties and nine deaths (Alberta Transportation 2009). British Columbia reported over 9,000 animal-related vehicle collisions in 2004 costing the insurance system over \$23 million (Wildlife Collision Prevention Program 2009). Reducing WVCs has become an issue of increasing importance for human safety and wildlife conservation.

Addressing wildlife transportation issues requires access to timely, accurate information on the spatial and temporal movement patterns of motorists and wildlife. Research emphasizes that the success of mitigation measures to ensure wildlife movement while reducing collisions is highly dependent on having an accurate understanding of wildlife distribution and movements (Clevenger and Waltho 2005, Huijser et al. 2007).

To address concerns where species pose a risk to motorists, the identification of WVC “hotspots” (locations with high WVC occurrence) is an important first step. There are many factors that result in certain segments along the roadway having a higher number of WVCs (e.g., topographical features, habitat patches, traffic volume, line of sight (Litvaitis and Tash 2008). Identification of WVC hotspots typically involves identifying clusters of WVCs. Therefore, the accuracy of locations of WVCs is an important consideration in any analysis to identify collision hotspots (Gunson et al. 2009). Unfortunately, transportation planners often rely on WVC data that is spatially inaccurate and statistically problematic.

The current rate of WVCs is a concern along Highway 3 through the Crowsnest Pass region. Issues of wildlife movement and motorist safety may further be complicated by a proposed upgrade of Highway 3 from two to four lanes in Alberta. Identifying the location of high WVC hotspots along Highway 3 provides important information for managers responsible for reducing WVCs and facilitating wildlife movement, especially when planning for highway expansion. We report here on the analysis of WVC hotspots using existing wildlife mortality data.

3.2 Methods

3.2.1 Mortality Data

Mortality data were acquired independently for Alberta and British Columbia. The datasets for Alberta and British Columbia were processed independently because data are collected using different processes resulting in inconsistencies in rates of recording and accuracy of location.

In Alberta, data were acquired from three sources:

- Highway Maintenance Contractors (Volker Stevin) (1997–2008)
- Road Watch in the Pass (2005–2008)
- Alberta Sustainable Resource Development (SRD), Fish and Wildlife (1997–2007).

Highway maintenance contractors from Volker Stevin are responsible for removing carcasses found along the highway on weekdays. They record on hard copy sheets the date, time, species, number of individuals and distance to nearest local landmark for each carcass collected.

Road Watch in the Pass is a community-based monitoring project that enables citizens in the region to enter their wildlife observations, including mortality data, into an on-line mapping tool. Participants enter their observations, through a project website, directly onto a high-resolution map that includes local landmarks, roads and river features. A pop-up form then allows the participant to enter information on species, number of individuals, date, and time of day.

Alberta SRD, Fish and Wildlife Division maintain an Enforcement Database (ENFOR) that tracks responses by Fish and Wildlife officers to wildlife concerns in the Crowsnest Pass Region. The database includes WVC reports where Fish and Wildlife officers respond to calls reporting injured wildlife along the highway and/or species of special interest involved in WVCs such as any carnivore species or bighorn sheep. Data were extracted by Fish and Wildlife personnel and used in this report.

Each dataset was converted into spatial layers by Geographic Information System (GIS) software using tools in ArcMap® (Environmental Systems Research Institute 2009) and the HawthTools extension (Beyer 2009). The three datasets were assessed for duplicate records. Duplicate records were deleted based on the following conservative assumptions: same species on the same day within 1000 meters of each other. In cases with duplicates, the most spatially accurate record was selected. The order of preference for datasets was: highway maintenance contractors (the same individuals for the last ten years), ENFOR and Road Watch data. The point files from the three datasets along Highway 3 were merged together to form one file of WVC data.

In British Columbia, point data were provided by British Columbia Ministry of Transportation. Locations were provided to the nearest kilometer marker along Highway 3. A file of mortality points was created along Highway 3 using the GIS software and extensions. To the best of our knowledge this is the only WVC dataset available for the region.

3.2.2 Data Error

All datasets used in this analysis identified WVCs in relation to the nearest road reference or landmark, therefore the spatial accuracy of WVCs is unknown and of lower quality than data collected using GPS units. To address this issue, WVC data obtained without a GPS were referenced to the nearest kilometer segment along Highway 3.

In addition, data on WVC occurrence is generally underestimated because data are collected when driving roads. Underestimating mortality is common as injured animals may move away from the road or vegetation may obscure carcasses. In addition species may be removed by passing vehicles or scavenging animals. It is difficult to quantify the percentage of large mammals that go unrecorded, but our observations are likely on the conservative side. A comparison for the Alberta datasets between mortality observations collected by Volker Stevin's staff and Road Watch participants showed an increase by 22 percent in the number of observations through the union of the two data sources. British Columbia Ministry of Transportation estimates that reported wildlife mortality represents only 25 to 35 percent of actual number of animals killed (Wildlife Collision Prevention Program 2009).

3.2.3 Identifying Wildlife–Vehicle Collision Zones

For each region, datasets were examined in a GIS to identify WVC hotspots for large mammals occurring along 1.0 km segments on Highway 3. Mortality data points were assigned to the nearest highway segment. To address the potential for spatial error and possibility of observations occurring on the segment boundary, a smoothing function was implemented where the mortality observations per road segment were equated to the sum of the road segment and its two neighboring segments.

The number of WVCs per segment was then categorized into 20, 40, 60 and 80 percentiles equating to "very low" (>0–20%), "low" (20–40%), "medium" (40–60%), "high" (60–80%), and "very high" (80–100%) as modeled after Huisjer et al. (2008). Segments with no observations were excluded from the analysis. Zones meeting medium, high and very high standards were identified as WVC hotspots.

3.3 Results

On the 136 km British Columbia section of Highway 3, 1906 wildlife mortality observations were recorded from 1998–2007 between Rocky Mountain Trench (Highway 3/93 junction to Fort Steele) and the British Columbia/Alberta provincial border. Local experts were asked to review the WVC maps for each large mammal species as provided by the British Columbia Ministry of Transportation. Based on local expert knowledge the WVC hotspots were deemed spatially accurate but the wildlife mortality dataset appeared to underestimate the true rate of mortality occurring along Highway 3 (Lee 2009).

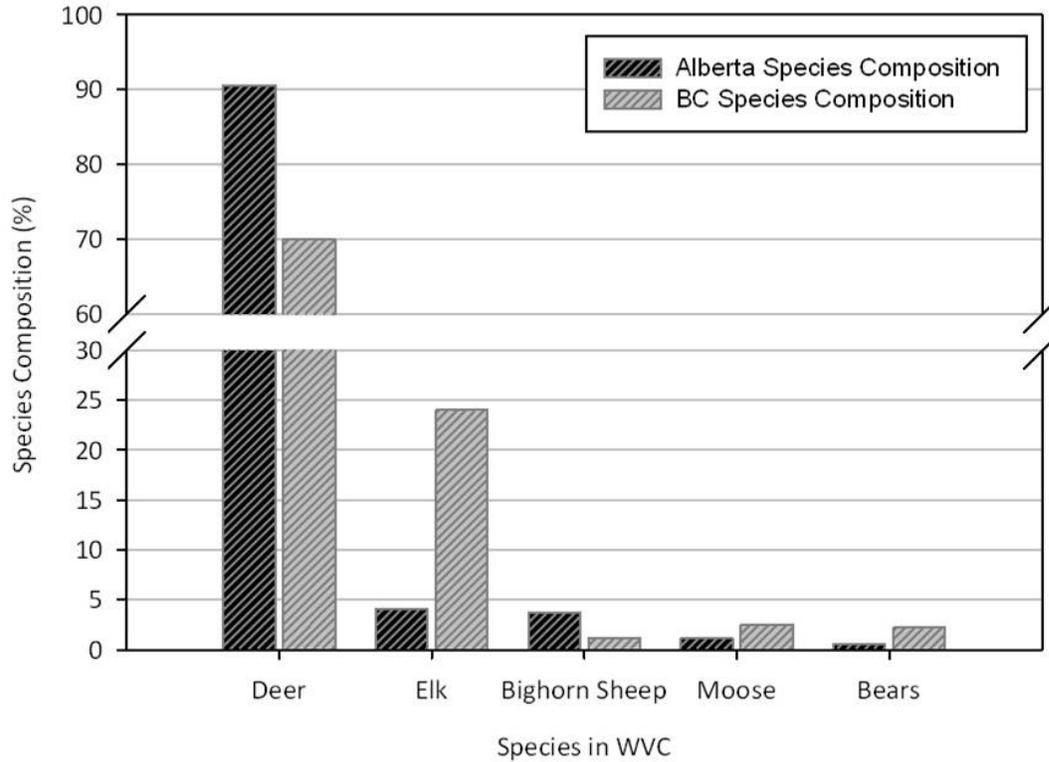


Figure 3: Large mammal composition of wildlife–vehicle collisions in the Highway 3 study area.

The stretch of Highway 3 from Rocky Mountain Trench to the provincial border at Crowsnest Pass contains 81 km of medium to very high WVC segments, representing 59 percent of the highway and 79 percent of total WVCs (**Figure 4**). Very high WVC segments occur along most of the Rocky Mountain Trench and the first few kilometers east of Elko (**Figure 5**). High WVC segments occur at the town of Sparwood, Sparwood dump site (Hosmer–Sparwood 3), Olsen Rest Area (Hosmer–Sparwood 2), north of the town of Fernie (Fernie–Hosmer 1), Fernie Ski Hill Access, at the Town of Elko (Fernie–Morrissey 4) and several locations within the Rocky Mountain Trench (Trench 4 and 5) (**Figure 5** and **Figure 6**).

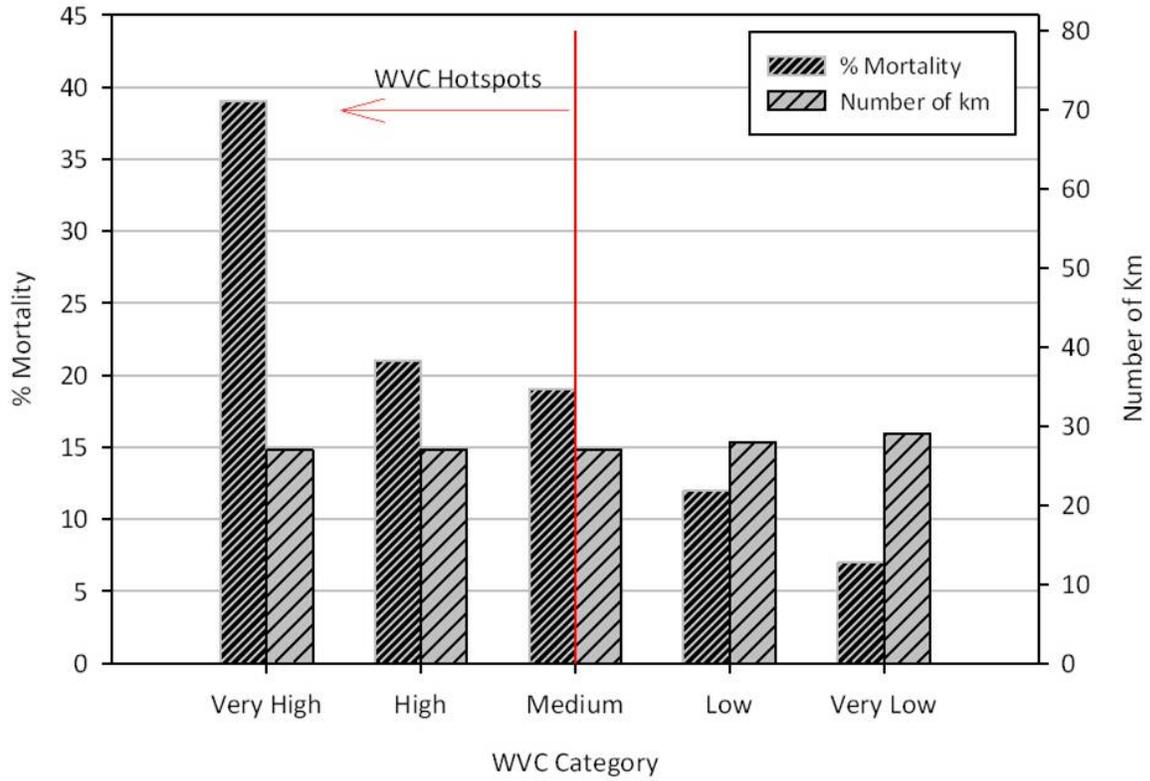


Figure 4: Percentage of wildlife–vehicle collisions (WVCs) and kilometers of highway by WVC category along Highway 3 in the British Columbia portion of the study area.

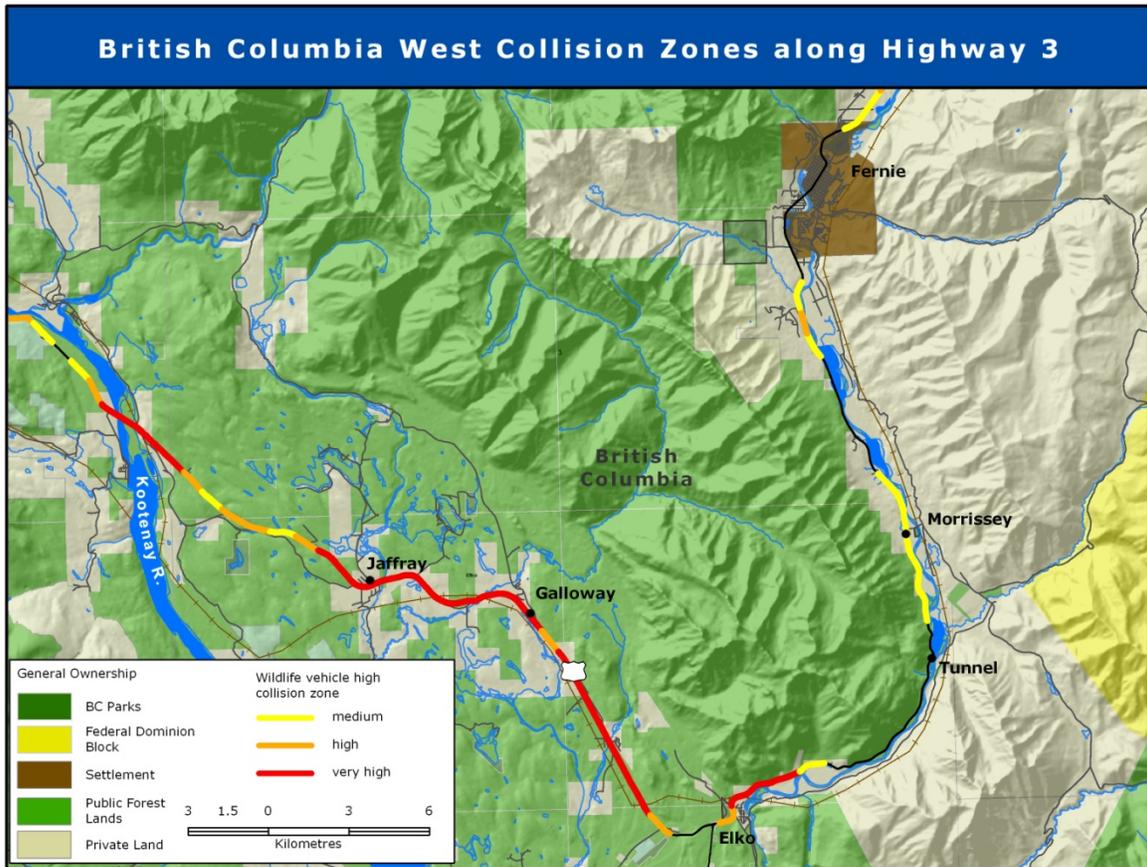


Figure 5: Wildlife–vehicle collision segments (categorized as very high, high and medium) along Highway 3 from the Columbia River to Fernie, BC.

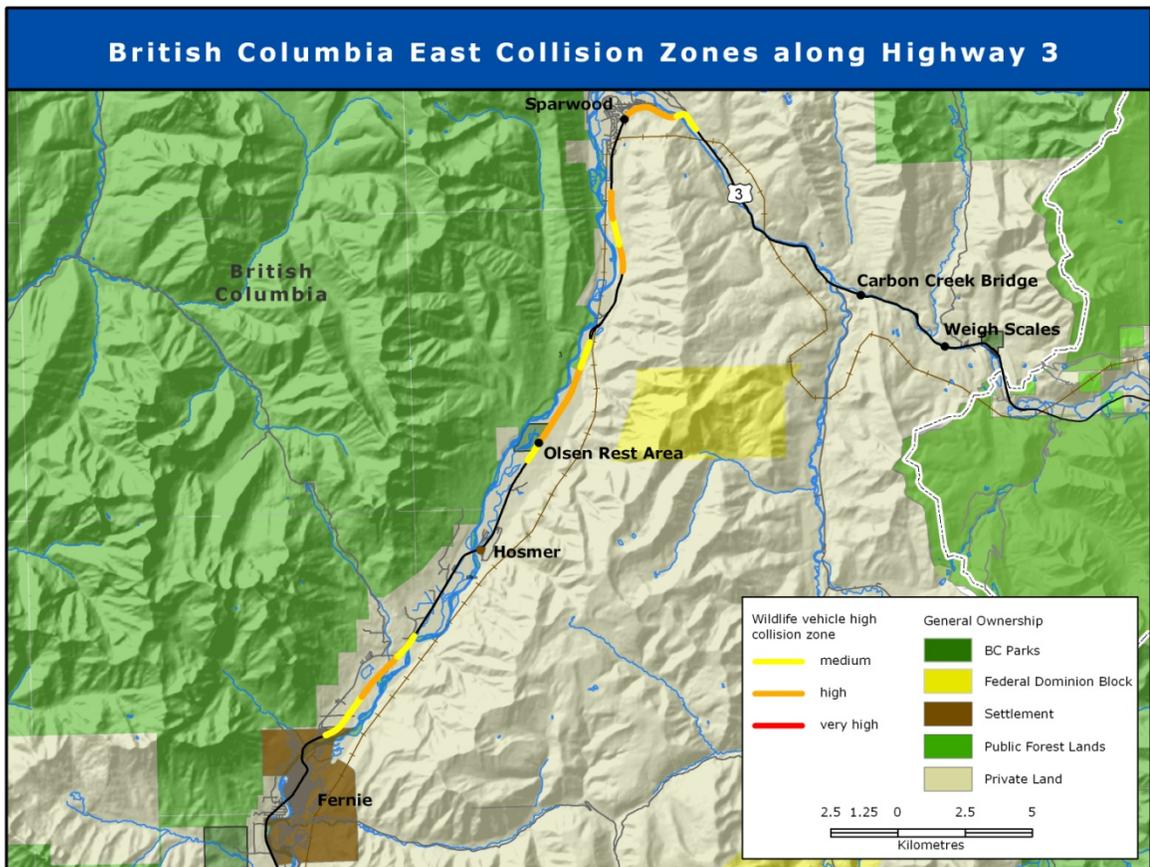


Figure 6: Wildlife–vehicle collision segments (categorized as very high, high and medium) along Highway 3 from Fernie, BC to the Alberta provincial border.

On Highway 3 in Alberta there were 1359 WVCs recorded from 1998–2008 along the 44 km section between the British Columbia/Alberta provincial border and Lundbreck. Deer were the most common species involved, representing 90 percent of the WVCs. The section from the provincial border to Lundbreck has 27 km of medium to very high WVC segments, representing 61 percent of the highway’s length and 77 percent of total WVCs (Figure 7). Very high WVC segments occur along Highway 3 from Highway 22 to the intersection with Highway 507 (mid-point is Crowsnest East) and a stretch of Highway 3 around Leitch Collieries (Figure 8).

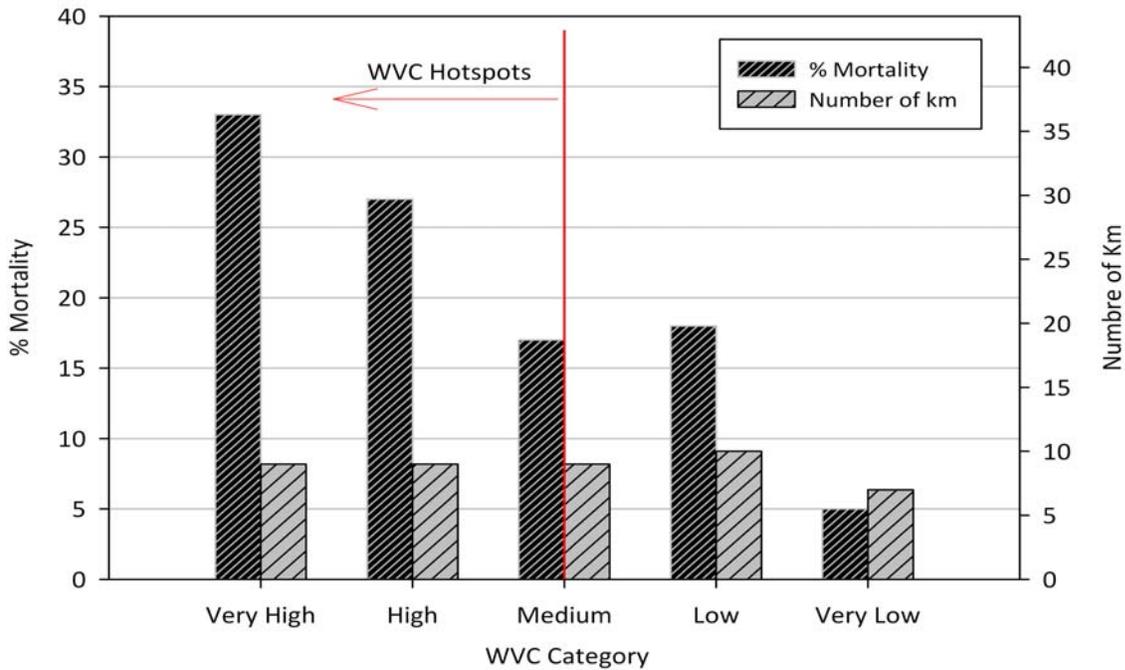


Figure 7: Percentage of WVC mortality in and kilometer of highway per WVC category for Highway 3 in the Alberta portion of study area.

For ungulate species, WVCs are primarily a concern because they pose a motorist safety issue; however, from a conservation perspective, the impact of WVCs on local populations has little impact. The exception may be for bighorn sheep, a blue listed species in British Columbia. Bighorn sheep are highly susceptible to WVCs where their home ranges cross Highway 3, as they are attracted to the highway to lick salt. Four well defined areas along Highway 3 were identified where bighorn sheep are frequently found on the roadway: Elko-Morrissey 3 and Carbon Creek Bridge mitigation sites in British Columbia (**Figure 5** and **Figure 6**) and the East Blairmore Bridge and Crowsnest Lakes mitigation sites in Alberta (**Figure 8**). Of the four sites, the Crowsnest Lakes population may be impacted the most given approximately 10 percent of the population is killed on the highway annually.

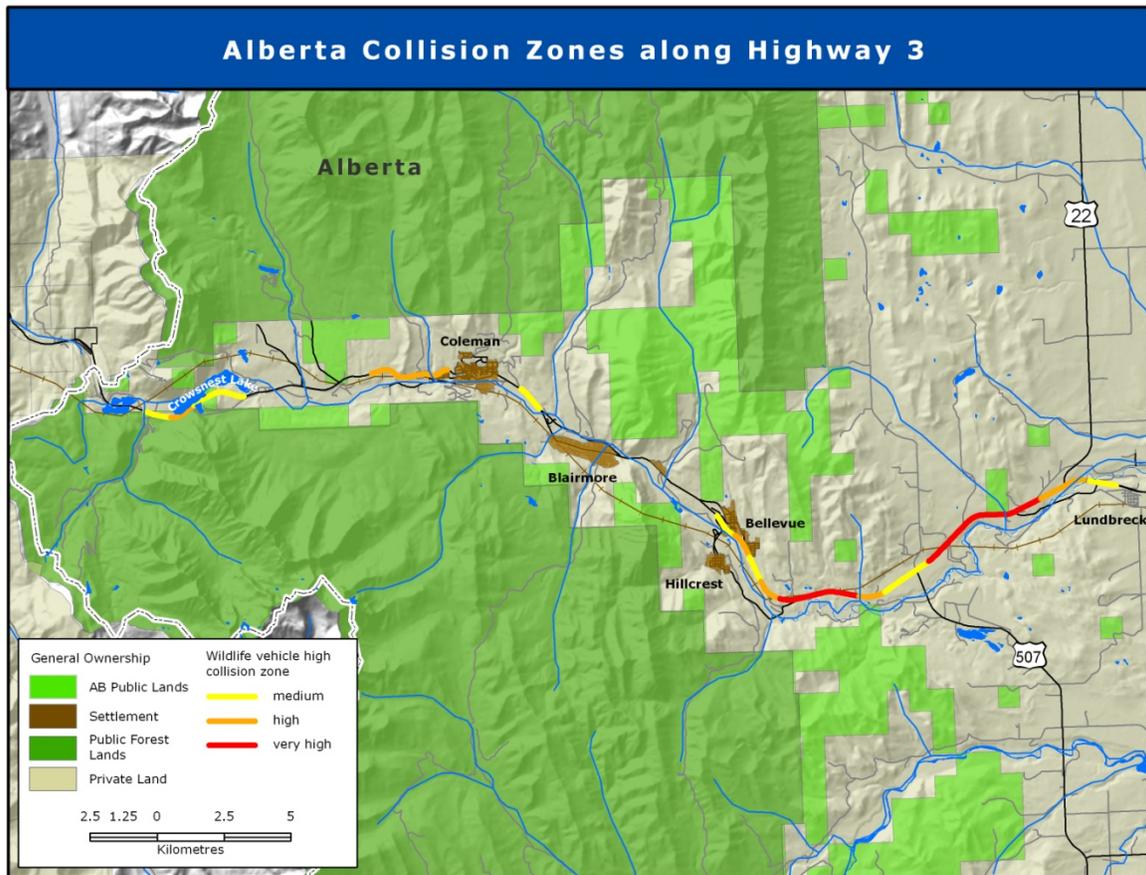


Figure 8: Highway segments of interest due to WVCs (categorized as very high, high and medium) as well as potential mitigation sites along Highway 3 from the Alberta provincial border to Lundbreck, AB.

VALUATION OF WILDLIFE CORRIDOR AND WILDLIFE-TRANSPORTATION CONFLICT ZONES

4.1 Identifying Priority Areas for Highway Mitigation

Below, we describe specific sites along Highway 3 that have been identified as in need of mitigation of current impacts on wildlife mortality and movement. The importance of specific locations varies by species, landscape and conservation concern. These “mitigation emphasis sites” are at the relatively fine scale necessary for highway planning and mitigation. The mitigation emphasis sites we discuss are identified through a synthesis of information provided by detailed wildlife movement data, habitat models, highway data, researcher opinion, available anecdotal reports, and opportunities and constraints with respect to adjacent land ownership and use (Figure 9).

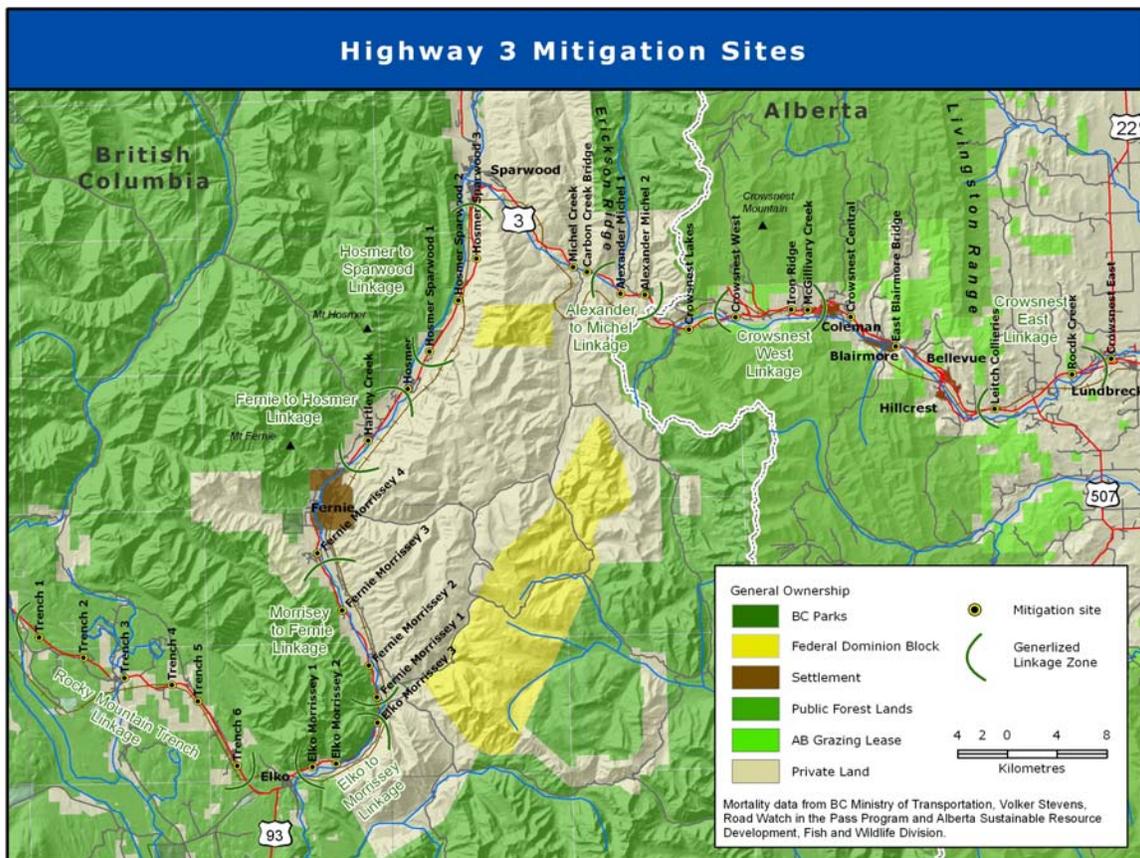


Figure 9: Highway 3 Mitigation Sites

The selected mitigation emphasis sites were visited in the field and evaluated for mitigation potential. Furthermore, to assist in ranking sites for mitigation priority, we assigned each site a subjective score from 1 (low) to 5 (high) on the basis of the following criteria:

- *Local Conservation Value* – the value of the highway mitigation to local wildlife conservation regardless of regional significance
- *Highway Mortality* – relative rate of wildlife–vehicle collisions as a proxy for motorist safety risk
- *Land-Use Security* – the degree to which lands adjacent to the site are secured *de facto* for conservation
- *Opportunities for Highway Mitigation* – the degree to which mitigation options are available and can be implemented with reasonable cost
- *Regional Conservation Significance* – the potential significance of highway mitigation to address wildlife conservation concerns of regional significance

Table 1 and Table 2 display the scores for each criteria and the average for all five criteria for each mitigation emphasis site, by province. These matrices may assist transportation planners in prioritizing sites for wildlife mitigation based on the five criteria. In British Columbia, Elko–Morrisey 1 and 3, Fernie–Morrisey 1, Hosmer–Sparwood 1 and Alexander–Michel 1 have the highest average scores in the matrix. In Alberta, Crowsnest West, Leitch Collieries and Rock Creek have the highest average scores in the matrix. Table depicts the location of the mitigation emphasis sites along Highway 3 in both British Columbia and Alberta.

Table 1: Highway 3 wildlife mitigation emphasis sites prioritization matrix in British Columbia.

Site Name	Species	Local Conservation Value	Highway Mortality	Land Use Security	Transportation Mitigation Options	Regional Conservation Significance	Average
Trench 1	Multi	3	4	4	4	2	3.4
Trench 2	Multi	3	4	4	3	2	3.2
Trench 3	Multi	1	5	1	1	1	1.8
Trench 4	Multi	2	5	2	1	2	2.4
Trench 5	Multi	3	5	3	2	4	3.4
Trench 6	Multi	3	5	4	3	3	3.6
Elko-Morrisey 1	Multi	4	5	3	4	3	3.8
Elko-Morrisey 2	Multi	4	3	3	3	3	3.2
Elko-Morrisey 3	BHS	4	4	4	4	3	3.8
Fernie-Morrisey 1	Multi	4	3	5	3	4	3.8
Fernie-Morrisey 2	Multi	3	3	3	3	4	3.2
Fernie-Morrisey 3	Multi	3	3	2	2	4	2.8
Fernie-Morrisey 4	Multi	5	4	2	2	5	3.6
Hartley Creek	Multi	4	4	1	4	4	3.4
Hosmer	Multi	2	2	3	5	3	3
Hosmer-Sparwood 1	Multi	5	3	5	4	5	4.4
Hosmer-Sparwood 2	Multi	3	3	4	4	4	3.6
Hosmer-Sparwood 3	Multi	2	4	3	3	2	2.8
Michel Creek	Multi	5	2	2	3	2	2.8
Carbon Creek Bridge	BHS	3	4	3	2	2	2.8
Alexander-Michel 1	Multi	5	2	3	4	5	3.8
Alexander-Michel 2	Multi	4	2	3	3	5	3.4

Table 2: Highway 3 wildlife mitigation emphasis sites prioritization matrix in Alberta.

Site Name	Species	Local Conservation Value	Highway Mortality	Land Use Security	Transportation Mitigation Options	Regional Conservation Significance	Average
Crowsnest Lakes	BHS	4	5	3	2	3	3.4
Crowsnest West	Multi	5	2	3	4	4	3.6
Iron Ridge	Multi	4	4	2	2	4	3.2
McGillivray Creek	Multi	3	3	2	3	3	2.8
Crowsnest Central	Multi	2	2	2	1	2	1.8
East Blairmore Bridge	BHS	3	2	3	3	2	2.6
Leitch Collieries	Multi	4	4	3	4	4	3.8
Rock Creek	Multi	5	5	4	4	3	4.2
Crowsnest East	Multi	3	4	3	5	2	3.4

4.1.1 Rocky Mountain Trench Linkage Zone

This section of Highway 3 occurs within the Rocky Mountain Trench and is of importance for ungulates, especially during winter, as well as carnivores that include bobcat, badger, and cougar. As noted below, grizzly bears are also known to make occasional localized movements into the Trench during fall. While land ownership in the greater landscape is largely provincial public, lands directly abutting several mitigation emphasis sites are under private ownership.

Trench 1 – Land ownership is entirely public north of the highway. South of the highway, it is also mostly public but some private land exists along a secondary road within a kilometer of this site.

Trench 2– This site is surrounded by public land that is relatively contiguous both north and south of the highway.

Trench 3– Situated on Sand Creek, this site is on what would likely be a wildlife movement conduit under more natural circumstances. However, the immediate area is currently built up in association with the community of Jaffray and is surrounded by private land.

Trench 4– Lands directly to the north are under private ownership. The public land that occurs to the south is itself largely surrounded by private land.

Trench 5– Fall movement by grizzly bears has also been documented through this area. Land ownership is private south of the highway and public to the north.

Trench 6– Grizzly bear movements across the highway have been documented in this specific area. Bears are typically moving between the Sand and McDermit drainages and lower Kikomun Creek where they have opportunities for feeding on kokanee salmon in the fall. Land on both sides of the highway is under private ownership, other than the strip between the highway and the forestry road to the east.

4.1.2 Elko to Morrissey Linkage Zone

This section of the Crowsnest Highway from Elko through the only tunnel on the highway to Morrissey separates the Elk River and associated bottom flats to the South and the south end of the Lizard Range to the north. This area is important for ungulate species including deer, elk and bighorn sheep; all of these species frequently cross the highway to move from valley bottom to the mountains, particularly near Elko.

Elko–Morrissey 1– Total wildlife–vehicle collisions along this section are very high, mostly with deer, elk, bears and bighorn sheep. There is the potential for subdivision of the private lands north of the highway. There is a strip of private land directly south of the highway, but public land lies south of the Elk River.

Elko–Morrissey 2– Public lands are north of the highway, with a strip of private lands directly south of the highway, further south of this strip are public lands and a private land trust south of the Elk River.

Elko–Morrissey 3– This area represents a very high collision zone for bighorn sheep, where they are often observed licking salt that gets trapped in the highway’s rumble strips. The tunnel access pit is used as a carcass pit for wildlife involved in wildlife–vehicle collisions. The ownership surrounding this site is primarily public lands to the west of the highway and private conservation lands held by a land trust east of the highway and the Elk River.

4.1.3 Morrissey to Fernie Linkage Zone

The importance of this landscape for carnivore population connectivity has been well documented (Apps 1997, Apps et al. 2007). Across the lower Elk Valley the linkage zone connects the valleys of Morrissey Creek with the east slopes of the Lizard Range. While there is some human development within the valley bottoms, extensive movement by resident GPS-collared female grizzly bears has been documented as well as anecdotal evidence of lynx movement. This

linkage zone is rated as having high conservation significance, with reasonable movement permeability and moderate vulnerability (Apps 1997, Apps et al. 2007). For highway mitigation, there are four potential sites for consideration.

Fernie–Morrissey 1 – This site corresponds with known cross-highway movements of grizzly bears, consistent with habitat and topographic features. Ownership is public west of the highway and private conservation lands to the east. Associated human influence is low and habitat security appears to be high on both sides of the highway.

Fernie–Morrissey 2 – This second site of the linkage zone is just north of the Hwy 3 and Morrissey Road junction. While grizzly bears have moved through this zone, this site has less potential than the previous one due to private land ownership and residency on either side of the highway. This site represents a high wildlife–vehicle collision zone including mortality records for deer, elk, and bear. There is two-meter high fence (to exclude elk) along the northwest edge of the highway.

Fernie–Morrissey 3 – There has been extensive grizzly bear movement in this vicinity, particularly by females. This site is within a natural movement conduit associated with Lizard Creek and closely links private conservation lands east of the Elk River with public lands to the west. A small piece of private land is, however, integral to this connection.

Fernie–Morrissey 4 – Despite relatively high human activity associated with the ski area and private land, this site is within an obvious multi-species movement route associated with Lizard Creek. The site is also proximal to core grizzly bear habitats and many highway crossings have been documented. There is adequate security cover on either side of the highway. This site represents a very high wildlife–vehicle collision zone including mortality observations for deer, elk, moose and bears. To the west, land ownership is private. To the east, ownership is unknown between the highway and the Elk River. Beyond the river, lands to Cokato Road are under multiple private owners and have little security cover. Beyond that, land is under private corporate ownership with no restrictive covenants. Zoning associated with the site is rural/residential with a minimum size of two- to four-hectare parcels. According to the Fernie Area Land Use Strategy, these lands will be maintained as agricultural and will not be annexed into Fernie. Lands west of the highway are subject to development in the expansion of the Fernie Alpine Resort and are currently zoned for such.

4.1.4 Fernie to Hosmer Linkage Zone

This section of highway is not considered part of a linkage zone due to the high concentration of human settlement, use and activity. Nonetheless, we know that grizzly bears have occasionally moved across the Elk Valley here, undoubtedly influenced by home range distribution and associated habitats.

Hartley Creek – Despite high human presence near the highway, grizzly bears (and presumably other species) funnel into this area to and from Hartley Pass. It is also close for bears whose home ranges are centered in Lizard Basin and that occasionally move around Fernie to the east via the Coal Creek drainage. Several known movements and one mortality are focused within a fairly well-defined location here. This natural route funnels to a point where Hartley Creek passes under the highway and enters the Elk River. This mitigation emphasis site is within a very high

wildlife–vehicle collision zone, primarily elk and deer. The specific highway crossing site is, however, between private land, with adjacent land in the Dicken Road area zoned for two- and eight-hectare parcels. Private corporate land (no covenant) abuts the Elk River to the east, beyond which are private corporate moratorium lands.

Hosmer– This site is located where the Elk River passes under the highway just outside of Hosmer. Lands are under private ownership on both sides of the highway, except for those within the river’s course.

4.1.5 Hosmer to Sparwood Linkage Zone

Hosmer–Sparwood 1– The area surrounding this site has good security cover and low human presence. Any of a number of locations would work well for mitigation. However, the fine-scale terrain conditions here are more conducive to multi-species movement, and the site is central to the secure private conservation lands that abut both sides of the highway (timber rights are retained to the east). Elk Valley Provincial Park is also adjacent to this site to the north.

Hosmer–Sparwood 2– Although there are few empirical data of wildlife movement within this linkage zone, landscape and site attributes do suggest high value for at least cross-valley connectivity. In relation to Hosmer–Sparwood 1, this second site is farther east and closer to Ladner Creek, which some wide-ranging species use to move into and out of the Elk Valley. This site is situated in a very high wildlife–vehicle collision zone, mostly with deer, elk and bear. A carcass pit for wildlife involved in collisions with vehicles is located near the Olsen railway crossing; local wildlife experts suggest this is an attractant for carnivore species drawing them closer to Highway 3 and the Canadian Pacific railway. East of the highway is private conservation trust land on which there are corporate timber rights. Lands to the west are also mostly under free-hold ownership by a land trust.

Hosmer–Sparwood 3– This site is slightly less optimal than Hosmer–Sparwood 1 and 2 from a landscape-linkage perspective, but site-specific conditions warrant consideration as a mitigation option. This site is situated in a very high wildlife–vehicle collision zone, primarily with deer, elk and bears. Lands to the west are under public ownership. Lands east of the highway are owned by a corporation and a different company owns the private land just to the north (no existing conservation covenant).

4.1.6 Michel and Carbon Creeks

Michel Creek– Few empirical data exist confirming multi-species movement; nonetheless, this site where Michel Creek passes under Highway 3 near the mouth of the Erickson Valley is an obvious candidate for mitigation. Elk wintering and calving habitats are near both sides of the highway and large carnivore movements can be expected. Private corporate lands are on both sides of the highway.

Carbon Creek Bridge– Selected because it is a site where bighorn sheep interact with Highway 3 and mortality from wildlife–vehicle collisions may be having an impact on this relatively small herd.

4.1.7 Alexander to Michel Linkage Zone

This is a very important linkage zone and there is good evidence that it is functionally intact for multiple carnivore species. A private company has restricted motorized access north of the highway on the east side of Michel Creek. Private corporate lands south of the highway are gated.

Alexander–Michel 1 – This site at the base of Alexander Creek maximizes landscape and site-specific potential and likely is most optimal for highway mitigation. Security cover is available for wildlife on both sides of the highway and human influence is relatively minimal. North of the highway, animals have the option to continue along the creek or stay higher along a ridge that has moderate forest cover. Among carnivores, grizzly bears and wolves are known to have moved across the highway here. A gun range is just to the west of Alexander Creek but should not detract much from the potential of this site. A private company is the primary landowner north and south of the highway, with land north of the highway and west of Alexander Creek owned by a different corporation.

Alexander–Michel 2 – This site is of lower priority than the previous, but conditions may allow some mitigation options immediately to the west of the parking lot for the provincial park and spacing from the previous site is appropriate. Private corporate lands are on both sides of the highway. There has been a proposal for quarry development to the south but the status of this plan is unknown.

4.1.8 Crowsnest Lakes

Crowsnest Lakes – This site was selected to address a very high bighorn sheep mortality area from Island Lake to Emerald Lake. There is concern that the impact of bighorn sheep mortality from collisions with vehicles may be adversely affecting the local population. Public lands are on both sides of the highway.

4.1.9 Crowsnest West Linkage Zone

Known as the West Block locally, this region represents an important movement area for carnivores (both grizzly bear and wolf have been documented crossing Highway 3 in this area). It also represents key ungulate winter range for elk. There are considerable private land conservation efforts underway within this region. Private land is interspersed with public parcels (grazing leases) before giving way to public forest reserve lands.

Crowsnest West – This site, the most obvious for mitigation within the local landscape, is where the Crowsnest River passes under the highway. There is evidence of carnivore movements at this site, as it is within the home range of the Crowsnest wolf pack and they have been documented crossing the highway. This site is associated with moderate human presence and relatively low security cover. The area north of the highway is privately owned, while south of the highway it is a mix of private, public and municipal reserve lands.

Iron Ridge – This site is where the highway bisects what is locally known as Iron Ridge. The area represents a high wildlife–vehicle collision zone, mainly with deer and elk. Lands to the west represent important ungulate winter range, particularly for elk. Carnivore movement has been

noted here including a recent grizzly bear mortality. This area has high potential for conservation as land to the north of the highway is owned by Alberta Transportation, a land trust or the public. There is also a piece of land in municipal reserve on the south side that is important for providing land security to this mitigation site. To the south there is a small piece of private land before linking to public lands (forestry reserve). However, to create connectivity between the various ownerships on both sides of the highway, there are a few key private parcels that would need to be secured for conservation purposes.

4.1.10 Crowsnest Central Linkage Zone

This linkage zone occurs between the two Albertan communities of Blairmore and Coleman. It is the most compromised of all the linkage zones in the study area due to human development.

McGillivray Creek – This site is in a valley situated between the town of Coleman and the East Coleman access road. It contains a high wildlife–vehicle collision zone predominantly due to deer.

Crowsnest Central – Although this site is not within a linkage zone of regional significance, it may be associated with natural movements of local resident ungulates. Land trusts have conservation lands to the south of the highway on the wetland parcels. There are no conservation lands to the north and developments such as Iron Stone are recent additions to the landscape.

East Blairmore Bridge – This site was selected to address bighorn sheep movement across the Crowsnest Highway. Wildlife–vehicle collisions are rare for this site and the sheep have been observed to cross under the existing Crowsnest River bridge. In addition, conservation officers actively attempt to keep the sheep off the highway due to their close proximity to town. Future concerns include increased human use of a footpath running under the bridge.

4.1.11 Crowsnest East Linkage Zone

There are large blocks of private land where the predominant land use is cattle grazing in this linkage zone. There is anecdotal evidence of carnivores including grizzly bear, using this landscape directly north and south of the highway in addition to a crossing that was recorded at the Leitch Collieries. In addition, high levels of wildlife-vehicle collisions occur throughout the area, especially to the east and west of Rock Creek.

Leitch Collieries – This site is within an important wildlife linkage zone and is in a high wildlife–vehicle collision zone, predominantly deer. It lies on the boundary between the Municipality of Crowsnest Pass and the Municipality of Pincher Creek and is directly east of the Leitch Collieries parking lot. Grizzly bear have been known to cross the highway in this area and have been observed consuming berries at the historic site. Private conservation lands exist on both sides of the highway, but there are additional private parcels on both sides of the highway that are important to secure for conservation purposes for this site.

Rock Creek – This site is located where Rock Creek passes under the Crowsnest Highway through a small culvert. This site may provide movement opportunities for carnivores and other species. There are very high wildlife–vehicle collision zones to the east and west of the guard rails, predominantly driven by deer that are forced up out of the valley to cross the highway and

due to attractive foraging habitat north and south of the highway. Public land parcels occur just to the north and south of the highway as do sections of private land of which some are already under conservation easement.

Crowsnest East– This site is situated where the Crowsnest River flows under Highway 3 near Lundbreck. There has been little documentation of carnivore movement in this area. Wildlife mortality from collisions with vehicles increases to the west toward the Highway 3–Highway 22 junction. Land on both sides is under private ownership and conservation potential has not been explored.

HIGHWAY 3 WILDLIFE MITIGATION OPTIONS

5.0 Introduction

In rural and suburban areas of North America, accidents with wildlife are quickly becoming a major safety concern for motorists. In Alberta, collisions with large ungulates (deer, elk, moose) comprise 50 percent of all accidents on rural roadways with an average of five human fatalities per year (Peter Mah, personal communication; Alberta Transportation 2003). In 2006, these accidents cost Albertans more than \$250 million (Clevenger et al. 2008).

Road mitigation measures are designed to facilitate the safe movement of wildlife across roads and increase motorist safety. Warning signs and reflectors have become standard measures used by transportation agencies for decades; however, research shows that they along with many other tools that agencies routinely use are not effective in preventing accidents and wildlife mortality (Huijser et al. 2007).

Wildlife crossing structures are being designed and incorporated into road construction and expansion projects to help restore or maintain animal movements across roads. Engineered wildlife crossings are designed to meet the dual needs of allowing animals to cross roads with reduced hazard to motorists and wildlife. Typically crossing structures are combined with high fencing and jump-outs (escape ramps), and together are proven measures to reduce road-related mortality of wildlife and connect populations (Clevenger et al. 2001, Dodd et al. 2007).

Construction of wildlife crossings has been increasing in North America in the last decade. Alberta Transportation has built crossings for large mammals along the Trans-Canada Highway in Canmore, Dead Man's Flats, and near Calgary, while the British Columbia Ministry of Transportation has built a wildlife overpass on the Coquihalla Highway and a number of other crossings province-wide designed for wildlife ranging from amphibians to moose and elk.

5.2 Benefits of Reducing Wildlife–Vehicle Collisions

There are many benefits provided by mitigation measures aimed at reducing WVCs, such as fewer motorist accidents that may include human injuries, deaths, and property damage. Benefits to wildlife include protecting individual wildlife from death or injury, keeping populations intact, allowing individuals free movement to access important habitats and resources, thus enhancing long-term survival and population viability. A review of 13 different mitigation measures used by transportation agencies to reduce WVCs (Huijser et al. 2009)—such as warning signs, vegetation removal, fencing, and wildlife crossing structures—indicated estimated effectiveness can vary from as low as a 26 percent reduction in WVCs (seasonal wildlife warning signs) to a 100 percent reduction in WVCs (elevated roadway). Each mitigation measure has a different cost to implement and maintain and thus the selection of the appropriate mitigation measure should take into account the different safety and conservation goals as well as its effectiveness in reducing WVCs.

5.3 Monetary Costs and Benefits of Highway Mitigation Recommendations

As the rates of WVCs have increased over the past two decades (Huijser et al. 2008b), transportation and natural resource agencies are increasingly seeking to mitigate highways to increase motorist safety as well as provide for the conservation of wildlife. To support their efforts, recent advances in evaluating the monetary costs and benefits of mitigation measures are helping decision makers, managers and the public better understand the trade-offs of investing in a variety of mitigation measures to reduce WVCs. Unfortunately, estimations of the economic costs and benefits of maintaining local- and landscape-level connectivity for wildlife have not been developed at this time.

5.4 Summary of Ungulate–Vehicle Collision Rates at Each Mitigation Site

Alberta and British Columbia collect WVC data separately and use different methodologies as noted in the Methods section (section 4.2). In British Columbia, point data were provided by British Columbia Ministry of Transportation. In Alberta, data were acquired from three sources: (1) Highway Maintenance Contractors (Volker Stevin; 1997–2008), (2) Road Watch in the Pass (2005–2008) and (3) ENFOR data from Alberta SRD (1997–2007). Locations were provided to the nearest kilometer marker along Highway 3 in each province.

Total ungulate–vehicle collision rates varied at the mitigation emphasis sites in British Columbia between a low of 0.6 WVCs/kilometer/year (WVCs/km/year) at the Carbon Creek bridge segment to a high of 3.1 WVCs/km/year at the Trench 3 site. These relatively low numbers are most likely a result of underreporting based on British Columbia’s information collection system. As a result, it has been estimated that for every observed WVC in British Columbia there are three unreported collisions (Hesse 2006). Hesse’s research finding is further supported by a local expert knowledge assessment of wildlife mortality and movement zones on the British Columbia portion of the Highway 3 study area, where wildlife–vehicle collision zones were deemed accurate but the number of wildlife records was considered low (Lee 2009). Therefore, **Table 3** totals could be multiplied by a factor of four to reach a more realistic estimate of ungulate–vehicle collision rates at these mitigation emphasis sites in the study area.

Table 3: Average annual number of ungulate–vehicle collisions for the Highway 3 road segment at each mitigation emphasis site in British Columbia.

Highway 3 - British Columbia: Mitigation Emphasis Site	Average Collision Rates: Species/Kilometer/Year				Total Annual Average Ungulate Collision Rate
	Deer	Elk	Moose	Bighorn	
Trench 1	0.8	0.4	0	0	1.2
Trench 2	1.4	0.1	0	0	1.5
Trench 3	2.9	0.1	0.1	0	3.1
Trench 4	2	0.7	0	0	2.7
Trench 5	1.1	0.8	0	0	1.9
Trench 6	2.2	0.2	0	0	2.4
Elko-Morrissey 1	0.9	0.1	0.1	0.1	1.2
Elko-Morrissey 2	1.2	0	0	0	1.2
Elko-Morrissey 3	0.6	0.1	0	0.05	0.75
Fernie-Morrissey 1	1.2	0.1	0.1	0.1	1.5
Fernie-Morrissey 2	1.05	0.2	0.1	0	1.35
Fernie-Morrissey 3	0.5	0.1	0.3	0	0.9
Fernie-Morrissey 4	0.9	0.4	0.5	0	1.8
Hartley Creek	0.9	1.1	0	0	2
Hosmer	0.4	0.1	0	0	0.5
Hosmer-Sparwood 1	0.8	0.2	0.1	0	1.1
Hosmer-Sparwood 2	0.4	1.1	0	0	1.5
Hosmer- Sparwood 3	0.8	0.6	0	0	1.4
Michel Creek	0.6	0.1	0	0	0.7
Carbon Creek Bridge	0.1	0	0	0.5	0.6
Alexander-Michel 1	0.8	0.9	0.2	0	1.9
Alexander-Michel 2	0.2	0	0	0	0.2

Total ungulate–vehicle collision rates were higher in Alberta than in British Columbia, most likely the result of the more concentrated effort to record WVCs in Alberta. Total ungulate–vehicle collision rates varied at mitigation sites in Alberta between a low of 1 WVC/km/year at the Rock Creek site to a high of 4.28 WVCs/km/year at the Leitch Collieries site (**Table 4**). The Rock Creek site has a large culvert and the highway is slightly elevated in this area, which may account for the relatively low collision rate; however, on the adjacent kilometer of highway on either side of this mitigation site, deer–vehicle collision (DVC) rates are very high, 8.45 DVCs/km/year to the east and 4.73 DVCs/km/year to the west of the Rock Creek site. Nearly half of the Alberta sites (n=4) had total ungulate–vehicle collision rates in excess of 3 WVCs/km/year. The bighorn sheep–vehicle collision rate of 2.55/km/year is notably high at the Crowsnest Lakes mitigation emphasis site (**Table 4**).

Table 4: Average annual number of ungulate–vehicle collisions for the Highway 3 road segment at each mitigation site in Alberta.

Highway 3 - Alberta: Mitigation Emphasis Site	Average Collision Rates: Species/Kilometer/Year				Total Annual Average Ungulate Collision Rate
	Deer	Elk	Moose	Bighorn	
Crowsnest Lakes	0.36	0.36	0	2.55	3.27
Crowsnest West	0.82	0.9	0	0	1.72
Iron Ridge	1.36	0.45	0	0	1.81
McGillivray Creek	4.09	0.09	0.09	0	4.27
Crowsnest Central	1.73	0.09	0	0	1.82
East Blairmore Bridge	2	0	0	0.18	2.18
Leitch Collieries	4.28	0	0	0	4.28
Rock Creek	1	0	0	0	1
Crowsnest East	3.27	0	0	0	3.27

5.5 Direct Monetary Costs of Ungulate–Vehicle Collisions

Huijser et al. (2009) summarized the costs of the most prevalent group of ungulates—deer, elk, moose—that are the source of over 90 percent of WVCs in North America (Table 5). All three species are present in the Highway 3 corridor and have been recorded in the mortality databases for Highway 3 in both Alberta and British Columbia. Although Huijser et al. (2007) developed monetary costs in U.S. dollars, for the purposes of this report it is reported in Canadian dollars at a par exchange rate.

Table 5: Summary of the monetary costs of the average wildlife–vehicle collision in North America for three common ungulates.

Description	Deer	Elk	Moose
	Dollars (2007)	Dollars (2007)	Dollars (2007)
Vehicle repair costs per collision	\$2,622	\$4,550	\$5,600
Human injuries per collision	\$2,702	\$5,403	\$10,807
Human fatalities per collision	\$1,002	\$6,683	\$13,366
Towing, accident attendance, and investigation	\$125	\$375	\$500
Hunting value animal per collision	\$116	\$397	\$387
Carcass removal and disposal per collision	\$50	\$75	\$100
Total	\$6,617	\$17,483	\$30,760

Highway records indicate that bighorn sheep are the cause of frequent WVCs in certain sections of Highway 3 within the study area. For this report's cost-benefit analyses, a conservative average bighorn sheep-vehicle collision monetary cost value of \$6617 (2007 \$) is used (the equivalent to deer). This is a conservative estimate since the average bighorn sheep weighs more than the average deer and thus is more likely to cause higher vehicle repair costs per collision, as well as higher average human injuries or fatalities per collision. In addition, the average hunting value for a bighorn sheep is typically higher compared to deer.

5.5.1 Cost-effectiveness Thresholds

For mitigation to be cost-effective there needs to be a break-even point or a dollar value threshold. Huijser et al. (2009) thoroughly detailed these values for deer, elk and moose in North America. The number of deer-, elk-, and moose-vehicle collisions per kilometer per year were compared to the actual cost of different mitigation measures and the realized effectiveness of each technique. For example, if a road section averages 4.4 deer-vehicle collisions per kilometer per year, a combination of wildlife fencing, under- and overpasses, and jump-outs would be economically feasible, because the threshold value of 4.3 is exceeded (see **Table 6**). The threshold value for less costly mitigation of fencing, jump-outs and wildlife underpasses, however, is 3.2 deer-vehicle collisions per kilometer per year. Because we know the cost of different mitigation measures per year (**Table 6**) and their effectiveness at reducing WVCs (Huijser et al. 2007), we can calculate the break-even point for sections of Highway 3 with high WVC rates.

Table 6: Threshold values for different mitigation measures used to reduce deer-vehicle collisions by more than 80 percent (adapted from Huijser et al. 2009). Shaded area is referred to in "cost-effectiveness thresholds" section.

Threshold values	Discount rate ¹	Fence	Fence, underpass, jump-outs	Fence, under- and overpass, jump-outs	ADS ²	Fence, gap, ADS, jump-outs	Elevated roadway	Road tunnel
\$ Cost (2007)/yr	3%	\$6,304	\$18,123	\$24,230	\$37,014	\$28,150	\$3,109,422	\$4,981,333
Deer/km/yr	3%	1.1	3.2	4.3	6.4	4.9	470	752.8

¹ For explanation of discount rate, see Huijser et al. 2009.

² ADS: Animal detection system

5.6 Monetary Costs for Ungulate-Vehicle Collisions at Mitigation Emphasis Sites

Table 7 and Table 8 summarize the costs at each mitigation emphasis site based on average annual collision rates for each ungulate species from Table 3 and Table 4 that are combined with the costs for each species from Table 5 in combination with the average monetary cost of \$6617 used for bighorn sheep, where appropriate. In British Columbia, total annual monetary costs of ungulate-vehicle collisions varied between \$1,323 at the Alexander-Michel 2 site and \$28,329 at the Fernie-Morrissey 4 site (**Table 7**). Nearly one-third (7 of 22) of the mitigation emphasis sites in the British Columbia section of Highway 3 were in excess of \$18,123 in annual monetary costs, making them excellent cost-effective candidates for infrastructure mitigation using underpasses, fencing and jump-outs. If underreporting of wildlife-vehicle collisions were accounted for, multiplying monetary costs by a factor of four would make ungulate-vehicle collision costs for

most mitigation emphasis sites in Alberta and British Columbia much more expensive and therefore the cost-effectiveness of implementing highway mitigation would be more attractive at additional mitigation emphasis sites.

In Alberta, total annual monetary costs of ungulate–vehicle collisions varied between \$6617 at the Rock Creek site (does not include very high WVC rates occurring immediately to the east and west of this mitigation site) and \$31,405 at the McGillivray Creek site (**Table 8**). Over one-half (5 of 9) of the mitigation emphasis sites in Alberta had annual monetary costs in excess of \$18,123 per year.

Table 7: Costs of wildlife–vehicle collisions at each Highway 3 mitigation emphasis site in British Columbia (sites in grey are potentially cost-effective for the use of underpasses, fencing and jump-outs to mitigate ungulate–vehicle collisions).

Highway 3 - British Columbia: Mitigation Emphasis Site	Average Estimated Costs of Collisions (in 2007 \$)				Total Average Annual Costs (in 2007 \$)
	Deer	Elk	Moose	Bighorn	
Trench 1	\$5,294	\$6,993	\$0	\$0	\$12,287
Trench 2	\$9,264	\$1,748	\$0	\$0	\$11,012
Trench 3	\$19,189	\$1,748	\$3,076	\$0	\$24,013
Trench 4	\$13,234	\$12,238	\$0	\$0	\$25,472
Trench 5	\$7,279	\$13,986	\$0	\$0	\$21,265
Trench 6	\$14,557	\$3,497	\$0	\$0	\$18,054
Elko-Morrissey 1	\$5,955	\$1,748	\$3,076	\$662	\$11,441
Elko-Morrissey 2	\$7,940	\$0	\$0	\$0	\$7,940
Elko-Morrissey 3	\$3,970	\$1,748	\$0	\$331	\$6,049
Fernie-Morrissey 1	\$7,940	\$1,748	\$3,076	\$662	\$13,426
Fernie-Morrissey 2	\$6,948	\$3,497	\$3,076	\$0	\$13,520
Fernie-Morrissey 3	\$3,309	\$1,748	\$9,228	\$0	\$14,285
Fernie-Morrissey 4	\$5,955	\$6,993	\$15,380	\$0	\$28,329
Hartley Creek	\$5,955	\$19,231	\$0	\$0	\$25,187
Hosmer	\$2,647	\$1,748	\$0	\$0	\$4,395
Hosmer-Sparwood 1	\$5,294	\$3,497	\$3,076	\$0	\$11,866
Hosmer-Sparwood 2	\$2,647	\$19,231	\$0	\$0	\$21,878
Hosmer-Sparwood 3	\$5,294	\$10,490	\$0	\$0	\$15,783
Michel Creek	\$3,970	\$1,748	\$0	\$0	\$5,719
Carbon Creek Bridge	\$662	\$0	\$0	\$3,309	\$3,970
Alexander-Michel 1	\$5,294	\$15,735	\$6,152	\$0	\$27,180
Alexander-Michel 2	\$1,323	\$0	\$0	\$0	\$1,323

Table 8: Costs of wildlife–vehicle collisions at each Highway 3 mitigation emphasis site in Alberta (sites in grey are potentially cost-effective for the use of underpasses, fencing and jump-outs to mitigate ungulate–vehicle collisions).

Highway 3 - Alberta: Mitigation Emphasis Site	Average Estimated Costs of Collisions (in 2007 \$)				Total Average Annual Costs (in 2007 \$)
	Deer	Elk	Moose	Bighorn	
Crowsnest Lakes	\$2,382	\$6,294	\$0	\$16,873	\$25,549
Crowsnest West	\$5,426	\$15,735	\$0	\$0	\$21,161
Iron Ridge	\$8,999	\$7,867	\$0	\$0	\$16,866
McGillivray Creek	\$27,064	\$1,573	\$2,768	\$0	\$31,405
Crowsnest Central	\$11,447	\$1,573	\$0	\$0	\$13,020
East Blairmore Bridge	\$13,234	\$0	\$0	\$1,191	\$14,425
Leitch Collieries	\$28,288	\$0	\$0	\$0	\$28,288
Rock Creek	\$6,617	\$0	\$0	\$0	\$6,617
Crowsnest East	\$21,638	\$0	\$0	\$0	\$21,638

5.7 Mitigation Measures

As described in section 5, mitigation emphasis sites are specific locations within the Highway 3 study area where opportunities for reducing wildlife–vehicle collisions and improving connectivity for all wildlife are highest, including fragmentation-sensitive species. Focusing highway mitigation efforts in these areas should improve motorist safety, reduce wildlife mortalities and improve habitat linkages and animal movement through transitional habitat along these highway segments.

From the field evaluation of the 31 mitigation emphasis sites, recommendations were grouped into actions that can be carried out in the short-term and long-term. *Short-term* mitigation consists of relatively simple, low-cost actions to reduce wildlife–vehicle collisions and improve the local and regional conservation values of the area. This type of mitigation may be combined with other highway construction or upgrade projects in the area (e.g., bridge reconstruction, culvert replacement, passing lanes). Recommendations for *long-term* mitigation would typically occur during major reconstruction and lane expansion of Highway 3 in the study area.

We developed recommendations for mitigation opportunities at each mitigation emphasis site along Highway 3. The relative importance of each site varies by species and local landscape attributes across the 180-kilometer highway corridor. Each site and conservation ranking (see Table 2 and Table 3) was informed by field data on wildlife movement, wildlife mortality, expert opinion, and opportunities and limitations with respect to adjacent land use (see “Identifying Priority Areas...,” Section 5.1). A variety of mitigation measures are recommended, from simple to complex, some requiring a change in operations (e.g., de-icing alternatives), while others necessitating structural work (e.g., wildlife underpass construction).

In a recent report to the U.S. Congress commissioned by the Federal Highway Administration, Huijser et al. (2007) summarized 36 different animal–vehicle collision mitigation measures currently in use throughout the world. The mitigation measures were grouped into four types:

- Measures that attempt to influence driver behaviour (18).

- Measures that attempt to influence animal behaviour (10).
- Measures that seek to reduce wildlife population size (4).
- Measures that seek to physically separate animals from the roadway (4).

As part of the 2007 report, a Technical Working Group was convened that included seven national experts in the area of animal–vehicle collisions. One of their tasks was to rank the current animal–vehicle collision mitigation measures into three categories:

- Measures that should be implemented (where appropriate).
- Measures that appear promising but require further investigation.
- Measures or practices that are proven ineffective.

The recommendations for improving motorist safety and wildlife connectivity for Highway 3 include a total of 11 different proven or promising mitigation measures.

Table 9 includes a list of the measures, their effectiveness in reducing WVCs (if data are available), the target of the measure (type) and the ranking category as presented in the Huijser et al. (2007) report.

Table 9: Wildlife mitigation measures, their focus and effectiveness.

Mitigation measure	Effectiveness	Type ¹	Category ²
Intercept feeding (salt licks)	N/A ³	Animal	Promising
De-icing alternatives	N/A	Animal	Promising
Variable message sign	N/A	Driver	Promising
Animal detection system	87%	Driver	Promising
Fencing	86%	Separate	Proven
Badger tunnel	86%	Animal	Proven
Underpass with water flow	86%	Animal	Proven
Underpass – wildlife	86%	Animal	Proven
Underpass – multi-use	86%	Animal	Proven

Overpass – wildlife	86%	Animal	Proven
Overpass – multi-use	86%	Animal	Proven

¹ *Driver*: Measures that attempt to influence driver behaviour; *Animal*: Measures that attempt to influence animal behaviour; *Size*: Measures that seek to reduce wildlife population size; *Separate*: Measures that physically separate animals from the roadway. From Huijser et al. 2007.

² *Proven*: Measures that should be implemented (where appropriate); *Promising*: Measures that appear promising, but require further investigation. From Huijser et al. 2007.

³ Not Available: data or studies on effectiveness.

RECOMMENDATIONS

A large amount of information has been amassed specific to each mitigation emphasis site. Information sheets (Appendix A) were prepared for each site and describe all site-specific information with regard to mitigation importance, target species, wildlife objectives, and mitigation measures recommendations. The Information Sheets are a quick and easy reference that summarizes mitigation opportunities at each site. There are many mitigation emphasis sites throughout the Highway 3 corridor and multiple recommendations for each site. Instead of reviewing each site, we highlight the most relevant sites with regard to a) regional conservation and connectivity, b) wildlife–vehicle collision reduction and c) immediate mitigation action that Alberta Transportation and British Columbia Ministry of Transportation can undertake (Figure 10). We first review the British Columbia section of Highway 3, followed by the Alberta section. Last, because of the status of badgers in the Highway 3 corridor and their unique mitigation requirements we highlight where transportation agencies should be aware of opportunities to protect this species.

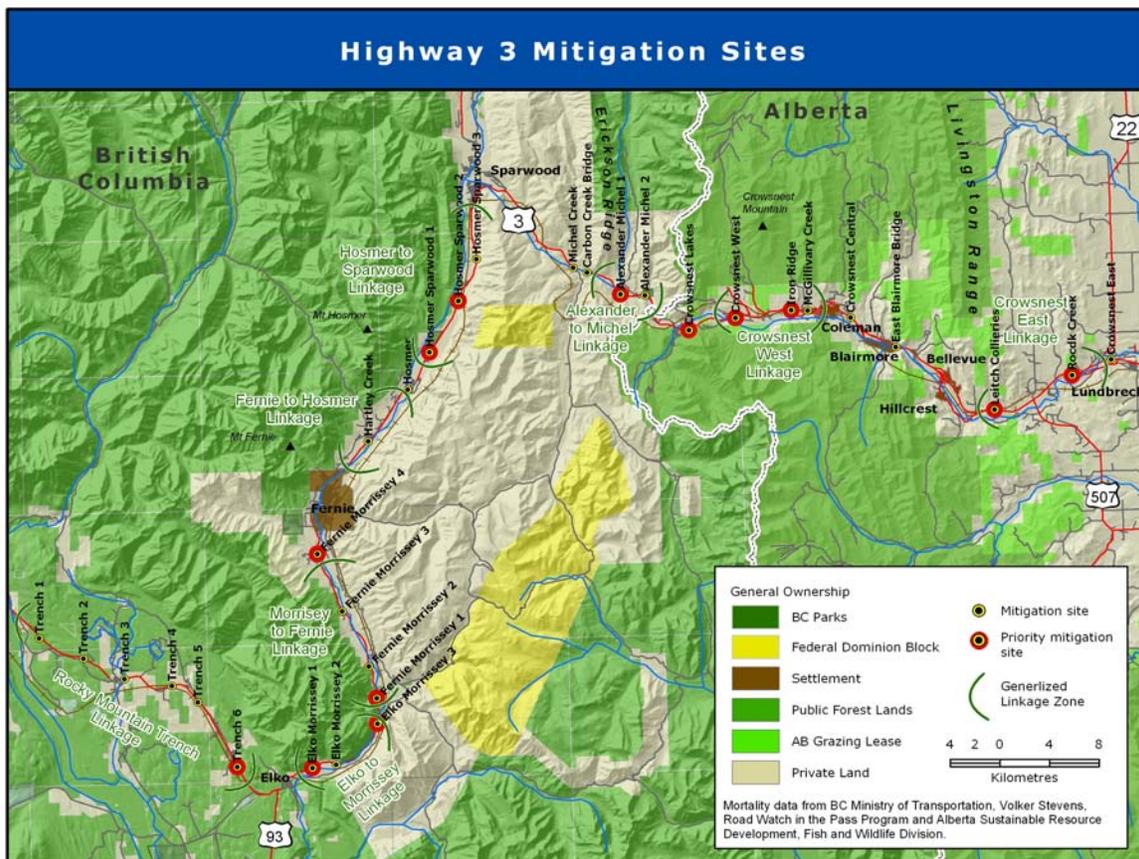


Figure 10: Priority (most relevant) mitigation sites (highlighted in red).

6.1 British Columbia

The average score for the matrix valuation of the nine sites in British Columbia was 3.27 (see Table 1). Slightly less than half of the 22 sites (n=12) had scores equal to or above the average score. Eight of the 22 sites had scores greater than 3.4.

- Hosmer–Sparwood 1 (4.4)
- Alexander–Michel 1 (3.8)
- Fernie–Morrisey 1 (3.8)
- Elko–Morrisey 1 (3.8)
- Elko–Morrisey 3 (3.8)
- Trench 6 (3.6)
- Fernie–Morrisey 4 (3.6)
- Hosmer–Sparwood 2 (3.6)

We discuss each of these sites and their mitigation recommendations in light of their respective attributes associated with local and regional conservation values and the safety of motorists traveling Highway 3. Specific mitigation techniques are italicized and general descriptions of each mitigation emphasis site are found in Appendix B.

6.1.1 Hosmer–Sparwood 1

This site has the highest matrix score for the British Columbia sites and the entire study area (4.4). It is particularly important in terms of regional and local conservation (both = 5) and the land-use security is high (=5), as Nature Conservancy of Canada lands abut both sides of the highway. The site has good opportunities for highway mitigation (=4). Twin culverts currently drain wetlands adjacent to the highway.

In the short-term it will be most important to conserve and manage the existing network of lands for wildlife habitat and movements through the area and across Highway 3. WVCs are not high in this area, therefore fencing is not recommended.

In the long-term, a *wildlife overpass* and *fencing* are recommended should the highway be upgraded or expanded to four lanes. A wildlife overpass structure is the most suitable design given the high water table in the area. The recommended minimum dimension for a wildlife overpass is 25–30 m wide (see *wildlife overpass*, Appendix B, Sheet J).

Wing fencing (minimum 200 m) should be used to guide wildlife to the overpass. An *animal detection system* (Appendix B, Sheet A) can be placed at fence ends to warn motorists when animals cross the highway. *Boulders between fence* and roadway and *jump-outs* may be required depending on the site-specific situation.

6.1.2 Alexander–Michel 1

This is the most critical habitat linkage in the entire Highway 3 corridor. It is the most important site from a conservation and management standpoint, to preserve for local and regional scale movements of wildlife, particularly fragmentation-sensitive species such as grizzly bears, wolverines and lynx. Alexander–Michel 1 is recognized as a site with high regional and local conservation value (=5). It has moderately high opportunities for highway mitigation (=4).

In the short-term mitigation alternatives should focus on improving the land-use security in the area and managing adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.

Potential opportunities in the long-term consist of bridge reconstruction or highway twinning (bridge construction) project. All bridge construction or reconstruction must be designed with wildlife movement (and hydrologic flow) in mind. Bridges should be designed with a wide span, allowing dry travel sections (7–10 m wide) above high-water mark and more than 4 m vertical clearance. Wing *fencing* (100–200 m depending on terrain) should be accompanied with an *animal detection system* at fence ends (see *Wildlife underpass with waterflow*, Appendix B, Sheet I).

6.1.3 Fernie–Morrissey 1

This site is one of two sites with the highest score for land-use security (= 5) and is recognized for its importance for carnivore population connectivity across the lower Elk Valley. It has moderately high scores for local and regional conservation values (=4); however, mitigation opportunities are limited.

As indicated, short-term mitigation alternatives are few. Efforts should be made to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.

In the long-term, if the highway is reconstructed, there will be opportunities to mitigate the highway to reduce mortality and improve wildlife movement. A *wildlife underpass* could be situated in this area as slopes are gentle and the highway is raised. The recommended minimum dimension for the wildlife underpass is 4 m high x 7 m wide (see *Wildlife underpass*, Appendix B, Sheet G). Wing *fencing* (ca. ≥ 200 m) should be used with an *animal detection system* (Appendix B, Sheet A) at fence ends to warn motorists when animals cross the highway. *Boulders between fence* and roadway should be used to keep ungulates from entering the fenced area. *Jump-outs* also may be required depending on the terrain.

6.1.4 Elko–Morrissey 1

Elko–Morrissey 1 is particularly important in terms of local conservation and highway mitigation opportunities (=4). Similarly, it is an area of very high rates of WVC (= 5), primarily with deer, elk, bears and bighorn sheep. There is an existing 1.2 m-diameter steel culvert at the site. It is uncertain whether Alberta Transportation plans to replace the culvert with a new below-grade structure.

Being an area of high WVCs, short-term recommendations include using *variable message signs* to warn motorists of regular occurrence of wildlife on the highway and use of *de-icing alternatives* (Appendix B, Sheet C) by maintenance in winter rather than road salt. Efforts also should be made to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity across Highway 3.

In the long-term, if the highway is reconstructed, this is an opportunity to mitigate the highway to reduce mortality and improve wildlife movement. A *wildlife underpass* could be situated in this area as a culvert is in place and will need to be replaced, likely with a bridge or larger culvert structure. Slopes are gentle and fill below the highway where the culvert lies. The recommended minimum dimension for the wildlife underpass is 4 m high x 7 m wide (see *Wildlife underpasses*, Appendix B, Sheet G). Wing *fencing* (ca. ≥ 200 m) should be used with an *animal detection system* (Appendix B, Sheet A) at fence ends to warn motorists when animals cross the highway.

6.1.5 Elko–Morrisey 3

This site has moderately high scores for local conservation, land-use security and mitigation opportunities (all = 4); however, it is a high collision area for bighorn sheep.

In the short-term, efforts should be made to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity. Recommendations for reducing wildlife–vehicle collisions in the area include installing *variable message signs* warning motorists of wildlife on the highway. Also, during winter, replace road salt with other *de-icing agents* (Appendix B, Sheet C) to reduce bighorn sheep attraction to the roadway.

In the long-term, if the highway is reconstructed, there will be opportunities to mitigate the highway to reduce mortality and improve wildlife movement. A *wildlife underpass* could be situated in this area as slopes are gentle and the highway is raised. Recommended minimum dimensions for the wildlife underpass is 4 m high x 7 m wide (see *Wildlife underpass*, Appendix B, Sheet G). Wing *fencing* (ca. ≥ 200 m) should be used and end at the rock cut. If the rock cut isn't suitable for a fence end, an *animal detection system* (Appendix B, Sheet A) should be placed at fence ends to warn motorists when animals cross the highway.

6.1.6 Trench 6

Trench 6 has high rates of WVCs, primarily with deer and elk. However, the opportunities for mitigating the highway for large mammals are limited.

Short-term recommendations to reduce WVCs in the area include: (1) use of *de-icing alternatives* (Appendix B, Sheet C) rather than road salt in winter, and (2) install *variable message signs* to warn motorists of wildlife on the highway. Grizzly bears are known to move across the highway, therefore efforts should be made to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity. The area is also important for local badger populations and mitigation recommendations for badgers are discussed below.

In the long-term, if the highway is reconstructed this may be an opportunity to mitigate the highway for wildlife movement, including badgers. For large mammals a *wildlife underpass* is recommended and could be placed below the road with some scouring at both ends to provide a suitable approach to the underpass. Recommended minimum dimensions for the wildlife underpass is 4 m high x 7 m wide (see *Wildlife underpass*, Appendix B, Sheet G). Wing *fencing* (ca. ≥ 200 m) should be used with an *animal detection system* (Appendix B, Sheet A) at fence ends to warn motorists when animals cross the highway.

6.1.7 Fernie–Morrisey 4

This site has high scores for regional and local conservation significance (both=5) and moderately high rates of WVCs. The opportunities for highway mitigation are limited however.

In the short-term, efforts should be made to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity. The access road to the ski area is problematic and disturbance along that road likely affects animal movement through the area. Fencing as mitigation for highway mortality is not recommended as it would also affect movement through the area.

In the long-term, if the highway is reconstructed and a new highway interchange is built for the ski area, this may be an opportunity to mitigate the highway to reduce mortality and improve wildlife movement.

6.1.8 Hosmer–Sparwood 2

Hosmer–Sparwood 2 has moderately high scores for regional conservation and land-use security (both = 4). It is an area with good potential for highway mitigation (=4).

In the short-term there are three recommendations to reduce WVCs in area: (1) Remove the existing carcass pit to keep bears and other carnivores away from the highway, (2) use *de-icing alternatives* (Appendix B, Sheet C) rather than road salt in winter, and (3) install *variable message signs* warning motorists of wildlife on highway. Efforts also should be made to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.

In the long-term, if the highway is reconstructed, this is an opportunity to mitigate the highway to reduce mortality and improve wildlife movement. A *wildlife underpass* is recommended with minimum dimensions of 4 m high x 7 m wide (see *Wildlife underpass*, Appendix B, Sheet G). Wing *fencing* (ca. ≥ 200 m) should be used with an *animal detection system* (Appendix B, Sheet A) at fence ends to warn motorists when animals cross the highway.

6.2 Alberta

The average score for the matrix valuation of the nine sites in Alberta was 3.2 (see **Table 2**). Six of the nine sites (66 percent) had scores equal to or above the average score:

- Rock Creek (4.2)

- Leitch Collieries (3.8)
- Crowsnest West (3.6)
- Crowsnest Lakes (3.4)
- Crowsnest East (3.4)
- Iron Ridge (3.2)

We discuss each of these sites and their mitigation recommendations in light of their respective attributes associated with local and regional conservation values and the safety of motorists traveling Highway 3. General descriptions of each site are found in Appendix A and specific mitigation techniques are italicized and explained with more detail in Appendix B.

6.2.1 Rock Creek

Rock Creek has the highest matrix score for the Alberta sites (4.2). It is particularly important in terms of local conservation, land-use security and highway mitigation opportunities. Similarly, it is an area of very high rates of WVC (= 5), due to incorporation of high WVC rates on both sides of site. There is an existing 3 m-diameter steel culvert at the site, which Alberta Transportation plans to replace with a new below-grade structure in the near future.

In the short-term there are few mitigation alternatives other than improving the land-use security in the area and managing adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity across Highway 3. Being an area of high WVCs, recommendations include *variable message signs* (Appendix B, Sheet F) installed to warn motorists of the regular occurrence of wildlife on the highway, and use of *de-icing alternatives* (Appendix B, Sheet C) in winter rather than road salt.

If the existing fill is removed and the culvert is replaced with a new bridge structure, this is an excellent opportunity to improve terrestrial hydrologic flows in the area. A new bridge structure should be designed to maximize wildlife movement under Highway 3, allowing adequate space (≥ 3 m wide) and substrate for wildlife travel (see *Wildlife underpass with waterflow*, Appendix B, Sheet I). Wing *fencing* (minimum 200 m) should be used to guide wildlife to the bridge. An *animal detection system* (Appendix B, Sheet A) can be placed at fence ends to warn motorists when animals cross the highway. *Boulders between fence* and roadway and *jump-outs* may be required depending on the situation. As indicated, this work could be done as a culvert reconstruction project or major highway reconstruction project.

6.2.2 Leitch Collieries

Leitch Collieries along with Iron Ridge and Crowsnest West all have moderately high scores (= 4) for regional conservation significance. Similarly the Leitch Collieries site (with Crowsnest East and Iron Ridge) has moderately high rates of WVCs and opportunities for highway mitigation (=4).

In the short-term mitigation alternatives should focus on improving the land-use security in the area and managing adjacent lands in a way that ensures regional wildlife habitat conservation

and population connectivity across Highway 3. To reduce wildlife–vehicle collisions in this area *de-icing alternatives* (Appendix B, Sheet C) are recommended in winter.

In the long-term, a *multi-use wildlife overpass* (Appendix B, Sheet H) and *fencing* (Appendix B, Sheet D) are recommended should the highway be upgraded or expanded to four lanes. An overpass structure is most suitable given a suitable location east of the colliery where terrain bordering the highway is elevated on both sides, thus facilitating overpass construction. Recommended minimum dimensions are 15–20 m wide (see *Multi-use wildlife overpass* (Appendix B, Sheet H)). Wing *fencing* (minimum 200 m) should be used to guide wildlife to the overpass. An *animal detection system* (Appendix B, Sheet A) can be placed at fence ends to warn motorists when animals cross the highway. *Boulders between fence* and roadway and *jump-outs* may be required depending on the situation.

6.2.3 Crowsnest West

Crowsnest West is a site with high local conservation value (=5) along with Rock Creek. Crowsnest West, in addition to Iron Ridge and Leitch Collieries, has moderately high scores (= 4) for regional conservation significance. The Crowsnest West site has moderately high opportunities for highway mitigation (=4).

In the short-term, mitigation alternatives should focus on improving the land-use security in the area and managing adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity across Highway 3. Given the local conservation value it will be critical to retain vegetative cover and riparian habitat along the Crowsnest River.

Long-term solutions will depend on the extent of highway reconstruction and alignment. If Highway 3 is twinned and bypasses Coleman, the existing highway will remain two-lane, but with considerably reduced traffic volumes. The existing bridge may provide movement for some wildlife. But given the sloping bridge abutments and lack of level substrate, the underpass is suboptimal for moving most wildlife species.

If the existing highway alignment is twinned, a new bridge structure will be added and the existing bridge span can be reconstructed to allow for greater wildlife passage (and hydrologic flow). All bridge construction or reconstruction must be designed to enhance and improve wildlife movement (and hydrologic flow). Bridges should be designed with a wider span, allowing dry travel sections (≥ 3 m wide) above the high-water mark. Wing *fencing* (minimum 200 m depending on terrain) should be accompanied with *animal detection systems* (Appendix B, Sheet A) at fence ends (see *Wildlife underpass with waterflow*, Appendix B, Sheet I).

6.2.4 Crowsnest Lakes

This site is one of two sites with the highest rates of WVC (= 5), primarily due to vehicle collisions with bighorn sheep. Sheep come down to the highway to lick road salt. The area is moderately important for regional conservation, while the local conservation significance is mostly due to the local bighorn sheep population.

There are three recommendations in the short-term to reduce wildlife–vehicle collisions in area:

Install *variable message signage* (Appendix B, Sheet F) warning motorists of wildlife on the highway.

During winter, replace road salt with other *de-icing agents* (Appendix B, Sheet C) to reduce bighorn sheep attraction to roadway.

Install *fencing* (Appendix B, Sheet D) to funnel bighorn sheep movement towards Emerald Lake. On the south side of the highway, installing *fencing* and the placement of Jersey barriers, and the use of boulders to funnel bighorn sheep to the Emerald Lake undercrossing are recommended. On the north side of the highway, install fencing that borders the highway and lake.

In the long-term, if the highway is reconstructed, fencing and construction of a *wildlife underpass* is recommended west of the site near the quarry. Recommended minimum dimensions for the underpass is 4 m high x 7 m wide (see *Wildlife underpass*, Appendix A, Sheet G). Wing *fencing* (100–300 m) should be used and end at rock cuts or steep slopes.

6.2.5 Crowsnest East

Of all sites in Alberta, Crowsnest East has the best opportunity for highway mitigation (=5). It also has a moderately high rate of WVCs, primarily deer (=4). The Crowsnest River flows under the highway through a large span bridge. Alberta Transportation has no plans to replace the bridge without being part of a highway reconstruction project.

Short-term mitigation solutions consist of *fencing* part of the highway, directing wildlife to the bridge to keep animals from crossing at-grade. It is important that adequate wing-fencing is used. Fence length should be long enough to encompass the most problematic WVC locations in the area. Fencing should follow specifications shown in the Appendix (see *Fencing*, Appendix B, Sheet D).

In the long-term, if the bridge is reconstructed it is an opportunity to lengthen the bridge span, install more suitable substrate and provide room for wildlife movement (≥ 3 -m-wide section) above the high-water mark (see *Wildlife underpass with waterflow*, Appendix B, Sheet I). This work could be done as a bridge reconstruction project or highway twinning project. Wing *fencing* (minimum 200 m) should be used to guide wildlife to the bridge with *animal detection systems* (Appendix B, Sheet A) situated at fence ends.

6.2.6 Iron Ridge

Iron Ridge has moderately high scores (= 4) for local conservation and regional conservation significance. It is a high collision area for deer and elk. Land use security is low (=2) compared to the high conservation value of the area.

In the short-term it will be most important to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.

Long-term solutions will depend on the extent of highway reconstruction and realignment. If Highway 3 is twinned and bypasses Coleman, the highway will remain two-lane, but with reduced traffic volumes. Thus, transportation conflicts with wildlife will become less of a conservation and

motorist safety issue. If the existing alignment is twinned, two locations are suitable for mitigation with the following measures:

Multi-use wildlife overpass with fencing. A suitable location exists where the highway passes through a ridge-cut, resulting in raised embankments (elevated terrain) on both sides of the highway, facilitating the construction of an overpass structure. Recommended minimum dimension is 15–20 m wide (Appendix B, Sheet H).

Wildlife underpass. Remove fill at a location west of the road cut and replace with an open-span bridge structure designed to allow adequate space (≥ 3 m wide, ≥ 3 m high) and substrate for wildlife travel. Wing *fencing* (minimum 500 m) should be used to guide wildlife to the open-span bridge structure. Recommended minimum dimensions are 4 m high x 7 m wide (see *Wildlife underpass*, Appendix B, Sheet G). Wing *fencing* (minimum 200 m depending on terrain) should be accompanied with *animal detection systems* (Appendix B, Sheet A) at fence ends.

6.3 Highway Mitigation for Badgers

American badgers (*Taxidea taxus*) are “red-listed” in British Columbia (Cannings et al. 1999) and the subspecies (*T.t. jeffersonii*) is listed as an endangered species in Canada (COSEWIC 2006). Mortality of badgers from collisions with vehicles is significant and in some locations the main source of mortality (Weir et al. 2004, Packham and Hoodicoff 2007, Kinley and Newhouse 2008). Badgers often prefer to use habitats near roads and other open habitats associated with linear infrastructure, thus increasing risks of mortality (Apps et al. 2002). Reducing road-related mortality is a key action in the Canadian recovery strategy for this subspecies of badger. More culverts or badger tunnels appropriately placed along Highway 3 within their range would aid badger recovery and help maintain less-threatened badger populations in Alberta.

Recommendations provided by Kinley and Newhouse (2009) to increase the effectiveness of existing culverts and aid in the placement and design of new culverts has direct implications for mitigation work on Highway 3 in British Columbia and Alberta. The Trench 1, Trench 2, and Trench 6 sites were identified as locations to improve highway permeability and reduce mortality of badgers. Mitigation solutions should be considered in these areas in the short-term as opportunities arise, or in the long-term (see below). The Kinley and Newhouse (2009) recommendations consist of the following:

Passable culverts— Existing culverts need to be passable by badgers. Crushed and blocked culverts should be repaired and hanging culverts should have fill or boulders placed under the ends to allow badgers access. If culverts are replaced with larger culverts, dry platforms or walkways can be constructed on the lateral interior walls of the culvert and above the high-water mark.

Culvert visibility— Badgers need to be able to find suitable culverts and many are blocked by dense roadside vegetation. Clearing the vegetation around the entrances would increase visibility.

Install more culverts— Where data indicates there are high levels of road-related mortality, badger activity and preferred habitats, efforts should be made to install more culverts as part of

highway upgrade or reconstruction projects. Installing badger culverts during the latter is the most cost-effective, with little incremental cost to a project. Opportunities to bore under existing highways with new boring technology should be explored.

Drift fencing— Drift fencing is typically used to guide badgers to culverts to increase their use. Fencing should be considered where opportunities exist. Permanent badger-proof fencing over long areas may be needed where road-related mortality is high; however, fencing requirements may vary for each locale.

General guidelines for placement, design and maintenance of badger culverts is found in Appendix B, Sheet B, “Badger Culverts.”

6.4 Monitoring and Research

Monitoring and research are needed to inform agencies by providing the most current data and site-specific information to help prioritize and guide decisions regarding planning and design on Highway 3. These recommendations are limited to the scale of the transportation corridor and do not address the regional scale (outside corridor) research and monitoring needs for conservation and management of wide-ranging species and their requirements for landscape connectivity (see Apps et al. 2007).

6.4.1 Wildlife Mortality along Highway 3

Continue with Road Watch in the Pass in Alberta and coordinated activities aimed at collecting reliable and accurate information on wildlife–vehicle collisions and wildlife movement within the Highway 3 corridor. The development of a project to better track wildlife mortality on the British Columbia section of Highway 3 is advisable; this could include a citizen science approach. Information on wildlife–vehicle collisions is essential for helping identify key locations for evaluating the rate of wildlife–vehicle collisions, their severity, and for prioritizing mitigation efforts. Building on the existing data will provide sound information for agencies responsible for future highway mitigation along the Highway 3 study area.

6.4.2 Existing Below-grade Passage Structures

Wildlife may be able to safely cross Highway 3 using existing below-grade passage structures (i.e., culverts, creek bridge structures). Little is known regarding wildlife use of the structures and their potential for passing wildlife safely across the highway. Structures along Highway 3 should be identified and monitored to determine their efficacy for different wildlife species and species-specific responses to different structure design types. This information will be useful to agencies developing mitigation plans by identifying where wildlife are able to cross the highway and attributes of the structures that might facilitate wildlife passage. As part of this work, tracking wildlife movement in the snow, in and around the structures, will provide important information to agencies on individual behaviours associated with each passage structure type.

6.4.3 At-grade Highway Crossings by Wildlife

An effective, low-cost and non-invasive means of identifying key highway crossing locations of wildlife during winter is to carry out road surveys along Highway 3. Snowtracking wildlife from a moving vehicle will provide information on species occurrence and specific crossing locations in winter. Surveys conducted with vehicles allow large areas to be surveyed in a relatively short period of time, particularly after each snowfall event. This information will assist agencies in planning and designing mitigation along Highway 3.

6.4.4 Realignment of Highway 3 from Blairmore to Sentinel

The upgrade of Highway 3 may result in realignment from Blairmore to Sentinel, Alberta. Understanding wildlife movement and habitat preferences along the preferred route is important for Alberta Transportation and Alberta Sustainable Resource Development, Fish and Wildlife Division in the development of strategies to mitigate for human safety and wildlife conservation.

6.4.5 Aquatic Passage Assessment

Aquatic ecosystems are often severely fragmented due to improperly designed or maintained culverts and other structures that allow water to flow under the road. In special cases, aquatic barriers may be advisable to keep populations separate; for example, to protect imperiled native trout species from introgressive hybridization with non-native species. A review and analysis of existing Highway 3 infrastructure is needed to determine the impacts of the highway to aquatic connectivity, species movement and conservation.

6.4.6 Canadian Pacific Railway Strike Zone Assessment

A railway line runs parallel to Highway 3 for most of the study area. Recent increases in train volume and anecdotal feedback from wildlife professionals indicate wildlife train strikes are occurring on the railway. However, little is known about the frequency and location of wildlife mortality on the railway. Understanding how often and where strikes are occurring will help identify areas of concern and inform highway mitigation strategies. In addition, carcasses may be acting as an attractant to carnivore species, drawing them down to the transportation corridor and increasing the risks of wildlife mortality from strikes with trains or vehicles on Highway 3. As a response to this issue, CPR and Miistakis Institute have developed a research project to interview train engineers, maintenance staff and wildlife officers to identify through local knowledge where strike zones are common. The results of this project can be used to inform the development of a systematic survey aimed at understanding key problem areas along the railway.

6.4.7 Technology Transfer

Keeping current and informed about the most up-to-date and effective means of mitigating highways for wildlife will be important for agencies managing the Highway 3 infrastructure. Recent advances in road ecology and specifically mitigating highways for wildlife have shown that many techniques used by transportation agencies are proven ineffective, thus a waste of agency funding. We recommend that workshops and training courses be provided on a regular basis to transportation and resource management agencies working in the Crowsnest Pass area.

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APPENDIX A: MITIGATION EMPHASIS SITE SUMMARIES (1–31)

Informational summary sheets were prepared for each Mitigation Emphasis Site (MES) and describe all site-specific information with regard to mitigation importance, target species, wildlife objectives, and transportation mitigation recommendations. These Summary Information Sheets are a quick and easy reference that summarizes mitigation opportunities at each MES.

Italicized text indicates mitigation measures that are explained in detail in Appendix B. Short-term mitigation measures are those that can be implemented without delay; long-term mitigation measures are those that would best be incorporated into highway construction or reconstruction projects because they require highway infrastructure investments.

Trench 1 Summary	
Description	
Location: UTM: 633030 5463657	
Species: Multi-species	
Wildlife–vehicle collisions: 5	
Local conservation value: 3	
Regional conservation significance: 3	
Land use security: 4	
Transportation mitigation opportunities: 3	
Wildlife objectives	
<ul style="list-style-type: none"> • Reduce current high levels of wildlife–vehicle collisions in this section of highway, primarily deer, elk and badgers. • Provide safe movement for all wildlife species across highway, primarily deer, elk, bears and badgers. 	
Existing infrastructure	
<ul style="list-style-type: none"> • None 	
Target species for mitigation planning	
<p>WVC reduction: Common species, including badgers.</p> <p>Regional conservation and connectivity: Common species primarily, but grizzly bear movements across highway have been documented, likely related to Kokanee salmon in fall.</p>	
Land use security	
Score: 4	
Current land use: Land on both sides of highway is under private ownership.	
Transportation mitigation opportunities	
Score: 3	
<p>Short-term:</p> <p>Recommendations to reduce WVCs in the area include: (1) use of <i>de-icing alternatives</i> rather than road salt in winter, and (2) install <i>variable message signage</i> to warn motorists of wildlife on highway. Grizzly bears are known to move across the highway, therefore efforts should be made to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity. The area is also important for local badger populations. Mitigation recommendations for badgers are discussed in section titled “Highway Mitigation for Badgers.”</p>	
<p>Long-term:</p> <p>If the highway is reconstructed this may be an opportunity to mitigate the highway for wildlife movement, including badgers. For large mammals a <i>wildlife underpass</i> is recommended and could be placed below the road with some scouring at both ends to provide suitable approaches. Recommended minimum dimension for the wildlife underpass is 4 m high x 7 m wide. <i>Wing fencing</i> (ca. ≥200 m) should be used with an <i>animal detection system</i> at fence ends to warn motorists when animals cross the highway.</p>	

Trench 2 Summary	
Description	
Location: UTM: 629876 5468962	
Species: Multi-species	
Wildlife–vehicle collisions: 5	
Local conservation value: 3	
Regional conservation significance: 4	
Land use security: 3	
Transportation mitigation opportunities: 2	
Wildlife objectives	
<ul style="list-style-type: none"> • Reduce current high levels of wildlife–vehicle collisions in this section of highway, including badgers. • Provide safe movement for all wildlife species across highway, primarily deer, elk, bears and badgers. 	
Existing infrastructure	
<ul style="list-style-type: none"> • None 	
Target species for mitigation planning	
<p>WVC reduction: Common species, including badgers.</p> <p>Regional conservation and connectivity: Common species primarily, but grizzly bear movements across highway have been documented.</p>	
Land use security	
Score: 3	
Current land use: Private lands south of highway and public lands on north side.	
Transportation mitigation opportunities	
Score: 2	
<p>Short-term:</p> <ul style="list-style-type: none"> • Efforts should be made to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity. • Install <i>variable message signage</i> warning motorists of wildlife on highway if level of WVCs becomes a safety concern. • The area is also important for local badger populations. Mitigation recommendations for badgers are discussed in section titled “Highway Mitigation for Badgers.” 	
<p>Long-term:</p> <p>Even if the highway is reconstructed, local topography and the proximity of railway do not facilitate the installation of crossing structures. Fencing with <i>animal detection system</i> at fence ends may be considered if collisions with deer and elk reach high levels and become a concern for motorist safety.</p>	

Trench 3 Summary	
Description	
Location: UTM: 627783 5470290	
Species: Multi-species	
Wildlife–vehicle collisions: 5	
Local conservation value: 2	
Regional conservation significance: 2	
Land use security: 2	
Transportation mitigation opportunities: 1	
Wildlife objectives	
<ul style="list-style-type: none"> • Reduce current high levels of wildlife–vehicle collisions in this section of highway. • Provide safe movement for all wildlife species across highway, primarily deer and elk. 	
Existing infrastructure	
<ul style="list-style-type: none"> • Open-span bridge for Sand Creek. 	
Target species for mitigation planning	
WVC reduction: Common species Regional conservation and connectivity: Common species	
Land use security	
Score: 2	
Current land use: Surrounded by private land and the community of Jaffray.	
Transportation mitigation opportunities	
Score: 1	
Short-term: Efforts should be made to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity. Install <i>variable message signage</i> warning motorists of wildlife on highway if level of WVCs becomes a safety concern.	
Long-term: Fencing with <i>animal detection system</i> at fence ends may be considered if collisions with deer and elk reach high levels and become a concern for motorist safety.	

Trench 4 Summary	
Description	
Location: UTM: 623974 5470871	
Species: Multi-species	
Wildlife–vehicle collisions: 5	
Local conservation value: 1	
Regional conservation significance: 1	
Land use security: 1	
Transportation mitigation opportunities: 1	
Wildlife objectives	
<ul style="list-style-type: none"> • Reduce current high levels of wildlife–vehicle collisions in this section of highway. • Provide safe movement for all wildlife species across highway, primarily deer and elk. 	
Existing infrastructure	
<ul style="list-style-type: none"> • None. 	
Target species for mitigation planning	
WVC reduction: Common species. Regional conservation and connectivity: Fragmentation-sensitive species and common species	
Land use security	
Score: 1	
Current land use: Lands to the north are private, while lands south of highway are public lands surrounded by private lands.	
Transportation mitigation opportunities	
Score: 1	
Short-term: Efforts should be made to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity. Install <i>variable message signage</i> warning motorists of wildlife on highway if level of WVCs becomes a safety concern.	
Long-term: Fencing with <i>animal detection system</i> at fence ends may be considered if collisions with deer and elk reach high levels and become a concern for motorist safety.	

Trench 5 Summary	
Description	
Location: UTM: 620659 5472519	
Species: Multi-species	
Wildlife–vehicle collisions: 4	
Local conservation value: 3	
Regional conservation significance: 2	
Land use security: 4	
Transportation mitigation opportunities: 3	
Wildlife objectives	
<ul style="list-style-type: none"> • Reduce current high levels of wildlife–vehicle collisions in this section of highway. • Provide safe movement for all wildlife species across highway, primarily deer and elk. 	
Existing infrastructure	
<ul style="list-style-type: none"> • None. 	
Target species for mitigation planning	
WVC reduction: Common species.	
Regional conservation and connectivity: Common species.	
Land use security	
Score: 4	
Current land use: Public lands on both sides of highway.	
Transportation mitigation opportunities	
Score: 3	
Short-term: Efforts should be made to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity. Install <i>variable message signage</i> warning motorists of wildlife on highway if level of WVCs becomes a safety concern.	
Long-term: If highway is reconstructed, there will be opportunities to mitigate the highway to reduce mortality and improve wildlife movement. A <i>multi-species wildlife underpass</i> could be situated at the low spot in highway. Slopes are gentle and fill below highway. <i>Wing fencing</i> (100–200 m) should be used to guide wildlife to bridge with <i>animal detection system</i> at fence ends.	

Trench 6 Summary	
Description	
Location: UTM: 617101 5474207	
Species: Multi-species	
Wildlife–vehicle collisions: 4	
Local conservation value: 3	
Regional conservation significance: 2	
Land use security: 4	
Transportation mitigation opportunities: 4	
Wildlife objectives	
<ul style="list-style-type: none"> • Reduce current high levels of wildlife–vehicle collisions in this section of highway, including badgers. • Provide safe movement for all wildlife species across highway, primarily deer, elk, bears and badgers. 	
Existing infrastructure	
<ul style="list-style-type: none"> • None 	
Target species for mitigation planning	
<p>WVC reduction: Common species, including badgers.</p> <p>Regional conservation and connectivity: Common species primarily, but grizzly bear movements across highway have been documented.</p>	
Land use security	
Score: 4	
Current land use: Land north of highway is public. Mostly public land south of highway but some private lands exist.	
Transportation mitigation opportunities	
Score: 4	
<p>Short-term:</p> <ul style="list-style-type: none"> • Efforts should be made to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity. • Install <i>variable message signage</i> warning motorists of wildlife on highway if level of WVCs becomes a safety concern. • The area is also important for local badger populations. Mitigation recommendations for badgers are discussed in section titled “Highway Mitigation for Badgers.” 	
<p>Long-term:</p> <p>If the highway is reconstructed, there will be opportunities to mitigate the highway to reduce mortality and improve wildlife movement. A <i>multi-use wildlife underpass</i> could be situated in this area. Slopes are gentle and fill below highway. Wing <i>fencing</i> (100–200 m) should be used to guide wildlife to bridge with <i>animal detection system</i> at fence ends.</p>	

Elko–Morrisey 1 Summary	
Description	
Location: UTM: 639082 5463564	
Species: Multi-species	
Wildlife–vehicle collisions: 5	
Local conservation value: 4	
Regional conservation significance: 3	
Land use security: 3	
Transportation mitigation opportunities: 4	
Wildlife objectives	
<ul style="list-style-type: none"> • Reduce current high levels of wildlife–vehicle collisions in this section of highway. • Provide safe movement for all wildlife species across highway, primarily deer, elk, bighorn sheep and bears. 	
Existing infrastructure	
<ul style="list-style-type: none"> • 1.2-m-diameter culvert 	
Target species for mitigation planning	
WVC reduction: Common species, including bighorn sheep and bears	
Regional conservation and connectivity: Common species	
Land use security	
Score: 3	
Current land use: Public land south of river but strip of private land directly south of highway. Potential subdivision north of highway, but not confirmed.	
Transportation mitigation opportunities	
Score: 4	
Short-term: Recommendations include using <i>variable message signs</i> to warn motorists of regular occurrence of wildlife on the highway, and use of <i>de-icing alternatives</i> by maintenance in winter rather than road salt. Efforts also should be made to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity across Highway 3.	
Long-term: If the highway is reconstructed, this is an opportunity to mitigate the highway to reduce mortality and improve wildlife movement. A <i>wildlife underpass</i> could be situated in this area as culvert is in place and will be replaced, likely with bridge or larger culvert structure. Slopes are gentle and fill below highway where culvert lies. Recommended minimum dimension for wildlife underpass is 4 m high x 7 m wide. Wing <i>fencing</i> (ca. ≥ 200 m) should be used with an <i>animal detection system</i> at fence ends to warn motorists when animals cross the highway.	

Elko–Morrisey 2 Summary	
Description	
Location: UTM: 640980 5463850	
Species: Multi-species	
Wildlife–vehicle collisions: 5	
Local conservation value: 4	
Regional conservation significance: 3	
Land use security: 3	
Transportation mitigation opportunities: 3	
Wildlife objectives	
<ul style="list-style-type: none"> • Reduce wildlife–vehicle collisions with bighorn sheep in this section of highway. • Provide safe movement for all wildlife species across highway, primarily deer, elk and bears. 	
Existing infrastructure	
<ul style="list-style-type: none"> • None 	
Target species for mitigation planning	
WVC reduction: Common species	
Regional conservation and connectivity: Common species	
Land use security	
Score: 3	
Current land use: Public land north of highway. Some private land south of highway. Mix of public and private land south of Elk River.	
Transportation mitigation opportunities	
Score: 3	
<p>Short-term:</p> <p>Efforts should be made to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity. There are two recommendations to reduce wildlife–vehicle collisions in area:</p> <ul style="list-style-type: none"> • Install <i>variable message signs</i> warning motorists of wildlife on highway. • During winter, replace road salt with other <i>de-icing agents</i> to reduce bighorn sheep attraction to roadway. 	
<p>Long-term:</p> <p>When the existing alignment is twinned there will be opportunities to mitigate the highway to reduce mortality and improve wildlife movement. <i>Wildlife underpass</i> could be situated in this area as slopes are gentle and highway is raised. Secondary wildlife underpass is recommended; could be placed near curve in road. Recommended minimum dimension for <i>wildlife underpass</i> is 4 m high x 7 m wide. Wing <i>fencing</i> (ca. ≥ 200 m) should be used with <i>animal detection system</i> at fence ends.</p>	

Elko–Morrisey 3 Summary	
Description	
Location: UTM: 644329 5467206	
Species: Bighorn sheep	
Wildlife–vehicle collisions: 5	
Local conservation value: 4	
Regional conservation significance: 3	
Land use security: 4	
Transportation mitigation opportunities: 4	
Wildlife objectives	
<ul style="list-style-type: none"> • Reduce wildlife–vehicle collisions with bighorn sheep in this section of highway. • Provide safe movement for all wildlife species across highway, primarily deer, elk and bears. 	
Existing infrastructure	
<ul style="list-style-type: none"> • None 	
Target species for mitigation planning	
WVC reduction: Bighorn sheep	
Regional conservation and connectivity: Common species including bighorn sheep	
Land use security	
Score: 4	
Current land use: Public land to the west and NCC owns land east of highway and Elk River.	
Transportation mitigation opportunities	
Score: 4	
<p>Short-term:</p> <p>Efforts should be made to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity. There are two recommendations to reduce wildlife–vehicle collisions in area:</p> <ul style="list-style-type: none"> • Install <i>variable message signs</i> warning motorists of wildlife on highway. • During winter, replace road salt with other <i>de-icing agents</i> to reduce bighorn sheep attraction to roadway. 	
<p>Long-term:</p> <p>If the highway is reconstructed, there will be opportunities to mitigate the highway to reduce mortality and improve wildlife movement. A <i>wildlife underpass</i> could be situated in this area as slopes are gentle and highway is raised. Recommended minimum dimension for wildlife underpass is 4 m high x 7 m wide. <i>Wing fencing</i> (ca. ≥200 m) should be used and end at rock cut. If rock cut isn't suitable for a fence end, an <i>animal detection system</i> should be placed at fence ends to warn motorists when animals cross the highway.</p>	

Fernie–Morrisey 1 Summary	
Description	
Location: UTM: 643618 5471890	
Species: Multi-species	
Wildlife–vehicle collisions: 3	
Local conservation value: 4	
Regional conservation significance: 4	
Land use security: 5	
Transportation mitigation opportunities: 3	
Wildlife objectives	
<ul style="list-style-type: none"> • Reduce wildlife–vehicle collisions in this section of highway. • Provide safe movement for all wildlife species across highway, primarily deer, elk and bears. 	
Existing infrastructure	
<ul style="list-style-type: none"> • None 	
Target species for mitigation planning	
WVC reduction: Common species	
Regional conservation and connectivity: Fragmentation-sensitive species and common species	
Land use security	
Score: 5-	
Current land use: High land-use security in area (=5). Low human activity in area. Public land to the west and NCC lands to the east.	
Transportation mitigation opportunities	
Score: 3+	
Short-term: Mitigation alternatives are few. Efforts should be made to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.	
Long-term: If the highway is reconstructed, there will be opportunities to mitigate the highway to reduce mortality and improve wildlife movement. A <i>wildlife underpass</i> could be situated in this area as slopes are gentle and highway is raised. Recommended minimum dimension for wildlife underpass is 4 m high x 7 m wide. Wing <i>fencing</i> (ca. ≥ 200 m) should be used with <i>animal detection system</i> at fence ends to warn motorists when animals cross the highway. <i>Boulders between fence</i> and roadway should be used to keep ungulates from entering the fenced area. <i>Jump-outs</i> also may be required depending on the situation.	

Fernie–Morrisey 2 Summary	
Description	
Location: UTM: 643618 5471890	
Species: Multi-species	
Wildlife–vehicle collisions: 4	
Local conservation value: 3	
Regional conservation significance: 4	
Land use security: 3	
Transportation mitigation opportunities: 3	
Wildlife objectives	
<ul style="list-style-type: none"> • Reduce level of wildlife–vehicle collisions in this section of highway. • Provide safe movement for all wildlife species across highway, primarily deer, elk and bears. 	
Existing infrastructure	
<ul style="list-style-type: none"> • Small culvert 	
Target species for mitigation planning	
<p>WVC reduction: Common species—elk, deer, black bears.</p> <p>Regional conservation and connectivity: Grizzly bears have moved through area but emphasis should be on common species.</p>	
Land use security	
Score: 3	
Current land use: Private lands on both sides of highway and predominate in the area.	
Transportation mitigation opportunities	
Score: 3	
<p>Short-term:</p> <p>In the short term, mitigation alternatives should focus on improving the land-use security in the area and managing adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity across Highway 3. To reduce wildlife–vehicle collisions in this area <i>de-icing alternatives</i> are recommended in winter.</p>	
<p>Long-term:</p> <p>Even if the highway is reconstructed, the side slopes are relatively steep and local topography does not facilitate the installation of crossing structures.</p>	

Fernie–Morrisey 3 Summary	
Description	
Location: UTM: 641467 5476409	
Species: Multi-species	
Wildlife–vehicle collisions: 3	
Local conservation value: 3	
Regional conservation significance: 4	
Land use security: 3	
Transportation mitigation opportunities: 2	
Wildlife objectives	
<ul style="list-style-type: none"> • Reduce number of wildlife–vehicle collisions in this section of highway. • Provide safe movement for all wildlife species across highway, primarily deer, elk, moose and bears. 	
Existing infrastructure	
<ul style="list-style-type: none"> • None 	
Target species for mitigation planning	
<p>WVC reduction: Common species, primarily deer, elk and bear.</p> <p>Regional conservation and connectivity: Fragmentation-sensitive species and common species. Female grizzly bear movement documented across highway in this area.</p>	
Land use security	
Score: 2	
Current land use: NCC covenant and sale lands east of river, and public lands are found to west of river. Small parcel of private land is integral to maintaining local and regional-scale connectivity.	
Transportation mitigation opportunities	
Score: 2	
<p>Short-term:</p> <p>In the short term, mitigation alternatives should focus on improving the land-use security in the area and managing adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity across Highway 3. To reduce wildlife–vehicle collisions in this area <i>de-icing alternatives</i> are recommended in winter.</p>	
<p>Long-term:</p> <p>If the highway is reconstructed, the local topography does not facilitate the installation of crossing structures. Fencing should not be considered since mortality rates are low and need for cross-highway movement is high.</p>	

Fernie–Morrisey 4 Summary	
Description	
Location: UTM: 639490 5481077	
Species: Multi-species	
Wildlife–vehicle collisions: 4	
Local conservation value: 5	
Regional conservation significance: 5	
Land use security: 2	
Transportation mitigation opportunities: 2	
Wildlife objectives	
<ul style="list-style-type: none"> • Reduce number of wildlife–vehicle collisions in this section of highway. • Provide safe movement for all wildlife species across highway, primarily deer, elk, moose and bear. 	
Existing infrastructure	
<ul style="list-style-type: none"> • None 	
Target species for mitigation planning	
<p>WVC reduction: Common species.</p> <p>Regional conservation and connectivity: Fragmentation-sensitive species and common species are priority. Important multi-species movements associated with Lizard Creek have been documented. Core grizzly bear habitat nearby and highway crossings have been detected. Believed to be dispersal corridor for grizzly bears and other fragmentation-sensitive species.</p>	
Land use security	
Score: 2	
<p>Current land use: High amounts of human activity associated with ski area and private lands. Land ownership is mostly private with varied land use ranging from agricultural to rural/residential with 2–4 hectare parcels. Land-use security (=2) needs to be improved in order to meet potential for wildlife movement through the area and for regional connectivity (=5).</p>	
Transportation mitigation opportunities	
Score: 2	
<p>Short-term:</p> <p>Efforts should be made to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity. The access road to ski area is problematic and disturbance likely affects animal movement through area. Fencing as mitigation for highway mortality is not recommended, as it would also affect carnivore movement through the area.</p>	
<p>Long-term:</p> <p>If the highway is reconstructed and new highway interchange built for the ski area, this may be an opportunity to mitigate the highway to reduce mortality and improve local wildlife movement.</p>	

Hartley Creek Summary	
Description	
Location: UTM: 643570 5490325	
Species: Multi-species	
Wildlife–vehicle collisions: 4	
Local conservation value: 4	
Regional conservation significance: 4	
Land use security: 1	
Transportation mitigation opportunities: 4	
Wildlife objectives	
<ul style="list-style-type: none"> • Provide safe movement for all wildlife species across highway, primarily elk and deer. • Reduce number of wildlife–vehicle collisions in this section of highway. 	
Existing infrastructure	
<ul style="list-style-type: none"> • Culvert 	
Target species for mitigation planning	
<p>WVC reduction: Site is within high collision zone for wildlife and motorists, primarily deer and elk.</p> <p>Regional conservation and connectivity: Fragmentation-sensitive species (grizzly bear, lynx, wolverine) and common species are priority. Believed to be dispersal corridor for grizzly bears and other fragmentation-sensitive species.</p>	
Land use security	
Score: 1	
Current land use: Problematic for wildlife connectivity. Private land and adjacent land in the Dicken Road area are zoned for 2 hectare and 8 hectare parcels.	
Transportation mitigation opportunities	
Score: 4	
<p>Short-term:</p> <p>Amount of private land in area make fencing problematic. There are few mitigation alternatives. Improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity. Two recommendations to reduce wildlife–vehicle collisions in area: (1) less <i>road salt</i> should be used in winter and (2) <i>variable message signs</i> installed warning motorists of wildlife on highway.</p>	
<p>Long-term:</p> <p>Highway mitigation to improve regional and local connectivity will be difficult given the amount and placement of private land in area. If the highway is reconstructed and adjacent lands can be protected to ensure movement of wildlife through the area, fencing and construction of a <i>wildlife underpass</i> is recommended. Selection of design type is dependent on terrain and engineering constraints. Minimum dimension for underpass is 4 m high x 7 m wide. <i>Wing fencing</i> (100–200 m depending on terrain) should be accompanied by <i>animal detection system</i> at fence ends.</p>	

Hosmer Summary	
Description	
Location: UTM: 646735 5494555	
Species: Multi-species	
Wildlife–vehicle collisions: 2	
Local conservation value: 2	
Regional conservation significance: 3	
Land use security: 3	
Transportation mitigation opportunities: 5	
Wildlife objectives	
<ul style="list-style-type: none"> • Provide safe movement for all wildlife species across highway, primarily elk, deer and bears. 	
Existing infrastructure	
<ul style="list-style-type: none"> • Open-span bridge. 	
Target species for mitigation planning	
WVC reduction: Common species. Regional conservation and connectivity: Locally common species primarily.	
Land use security	
Score: 3	
Current land use: Lands are under private ownership on both sides of highway.	
Transportation mitigation opportunities	
Score: 5	
Short-term: <i>Fencing</i> on the south side of the bridge to direct wildlife movement under the bridge.	
Long-term: If the highway is reconstructed, a new bridge will be added and the existing bridge span can be rebuilt to allow for wildlife passage (and hydrologic flow). All bridge construction or reconstruction must be designed with wildlife movement (and hydrologic flow) in mind. Bridges should be designed with a wider span, allowing dry travel sections (≥ 5 m wide) above high-water mark. <i>Wing fencing</i> (100–200 m depending on terrain) should be accompanied by animal detection system at fence ends.	

Hosmer–Sparwood 1 Summary	
Description	
Location: UTM: 648507 5497590	
Species: Multi-species	
Wildlife–vehicle collisions: 4	
Local conservation value: 5	
Regional conservation significance: 5	
Land use security: 5	
Transportation mitigation opportunities: 4	
Wildlife objectives	
<ul style="list-style-type: none"> • Provide safe movement for all wildlife species across highway, primarily elk, deer and bears. • Reduce number of wildlife–vehicle collisions in this section of highway. 	
Existing infrastructure	
<ul style="list-style-type: none"> • Twin culverts drain wetland. 	
Target species for mitigation planning	
<p>WVC reduction: Common species, including elk, deer and bears.</p> <p>Regional conservation and connectivity: Common species primarily, but habitat suggests that some fragmentation-sensitive species are passing through area.</p>	
Land use security	
Score: 5	
<p>Current land use: This site has the highest matrix score of the B.C. sites and the entire study area. It is particularly important in terms of regional and local conservation and the land-use security is high, as NCC lands abut both sides of the highway. Elk Valley Provincial Park is to the north.</p>	
Transportation mitigation opportunities	
Score: 4	
<p>Short-term:</p> <p>It will be most important to conserve and manage the existing network of lands for wildlife habitat and movements through the area and across Highway 3. WVCs are not high in this area, therefore fencing is not recommended.</p>	
<p>Long-term:</p> <p>A <i>wildlife overpass</i> and <i>fencing</i> are recommended should the highway be upgraded or expanded to four lanes. A wildlife overpass structure is most suitable design given the high water table in the area. Recommended minimum dimension for wildlife overpass is 25–30 m wide. Wing <i>fencing</i> (minimum 200 m) should be used to guide wildlife to the overpass. An <i>animal detection system</i> can be placed at fence ends to warn motorists when animals cross the highway. <i>Boulders between fence</i> and roadway and <i>jump-outs</i> may be required depending on the terrain.</p>	

Hosmer–Sparwood 2 Summary	
Description	
Location: UTM: 650838 5501796	
Species: Multi-species	
Wildlife–vehicle collisions: 5	
Local conservation value: 3	
Regional conservation significance: 4	
Land use security: 4	
Transportation mitigation opportunities: 4	
Wildlife objectives	
<ul style="list-style-type: none"> • Provide safe movement for all wildlife species across highway, primarily elk, deer and bears. • Reduce number of wildlife–vehicle collisions in this section of highway. 	
Existing infrastructure	
<ul style="list-style-type: none"> • None. 	
Target species for mitigation planning	
WVC reduction: Elk, deer, bears.	
Regional conservation and connectivity: Common species primarily, but habitat suggests that some fragmentation-sensitive species are passing through area.	
Land use security	
Score: 4	
Current land use: Moderately high value for cross-highway connectivity. East of highway is NCC land . West of site are mainly NCC sale lands.	
Transportation mitigation opportunities	
Score: 4	
Short-term: Three recommendations to reduce WVCs in area: (1) Remove existing carcass pit to keep bears and other carnivores away from the highway, (2) use <i>de-icing alternatives</i> rather than road salt in winter, and (3) install <i>variable message signage</i> warning motorists of wildlife on highway. Efforts also should be made to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.	
Long-term: If the highway is reconstructed, this is an opportunity to mitigate the highway to reduce mortality and improve wildlife movement. A <i>wildlife underpass</i> is recommended with minimum dimensions of 4 m high x 7 m wide. <i>Wing fencing</i> (ca. ≥ 200 m) should be used with an <i>animal detection system</i> at fence ends to warn motorists when animals cross the highway.	

Hosmer–Sparwood 3 Summary	
Description	
Location: UTM: 652274 5505216	
Species: Multi-species	
Wildlife–vehicle collisions: 4	
Local conservation value: 2	
Regional conservation significance: 2	
Land use security: 3	
Transportation mitigation opportunities: 3	
Wildlife objectives	
<ul style="list-style-type: none"> • Provide safe movement for all wildlife species across highway, primarily elk, deer and bears. • Reduce number of wildlife–vehicle collisions in this section of highway. 	
Existing infrastructure	
<ul style="list-style-type: none"> • None. 	
Target species for mitigation planning	
WVC reduction: Elk, deer, bears.	
Regional conservation and connectivity: Common species primarily.	
Land use security	
Score: 3	
Current land use: Lands to the west are public. Lands to the east are private industrial lands, while there are private lands to the north (no existing conservation covenant).	
Transportation mitigation opportunities	
Score: 3	
Short-term: Mitigation alternatives should focus on: (1) improving the land-use security in the area and managing adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity, and (2) searching for ways to utilize below-grade structures (e.g., creek undercrossings) and fencing to direct wildlife movement under highway and reduce collisions with wildlife.	
Long-term: If highway reconstruction takes place and WVC levels remain high, install fencing with <i>animal detection systems</i> at fence ends to warn motorists of wildlife on highway.	

Michel Creek Summary	
Description	
Location: UTM: 660039 5504528	
Species: Multi-species	
Wildlife–vehicle collisions: 2	
Local conservation value: 5	
Regional conservation significance: 2	
Land use security: 2	
Transportation mitigation opportunities: 3	
Wildlife objectives	
<ul style="list-style-type: none"> • Provide safe movement for all wildlife species across highway • Reduce number of wildlife–vehicle collisions in this section of highway. 	
Existing infrastructure	
<ul style="list-style-type: none"> • Open-span bridge. 	
Target species for mitigation planning	
<p>WVC reduction: Common species.</p> <p>Regional conservation and connectivity: Fragmentation-sensitive species (grizzly bear, lynx, wolverine) may move through area. Elk wintering and calving habitats lie on both sides of highway, and many other common species use the area.</p>	
Land use security	
Score: 2	
Current land use: High potential for moving fragmentation-sensitive and common species through the area. Private industrial lands on both sides of highway.	
Transportation mitigation opportunities	
Score: 3	
<p>Short-term: Bridge has been rebuilt with span widened, which will help accommodate movement of common wildlife species.</p>	
<p>Long-term: If highway is reconstructed there will be an opportunity to build a bridge structure with spans similar to or larger than reconstructed Corbin Creek Bridge. Performance of both bridge structures as wildlife crossings will be limited by the smaller span structure.</p>	

Carbon Creek Bridge Summary	
Description	
Location: UTM: 661166 5504150	
Species: Bighorn sheep	
Wildlife–vehicle collisions: 3	
Local conservation value: 3	
Regional conservation significance: 2	
Land use security: 3	
Transportation mitigation opportunities: 2	
Wildlife objectives	
<ul style="list-style-type: none"> • Provide safe movement for all wildlife species across highway, primarily bighorn sheep. • Reduce number of bighorn sheep–vehicle collisions. 	
Existing infrastructure	
<ul style="list-style-type: none"> • None. 	
Target species for mitigation planning	
WVC reduction: Bighorn sheep. Regional conservation and connectivity: Common species.	
Land use security	
Score: 3	
Current land use: Primarily private industrial lands in area.	
Transportation mitigation opportunities	
Score: 2	
Short-term: Remove Jersey barriers as bighorn sheep are on road for salt. Use <i>salt licks</i> to keep sheep off road and funnel movement across road to area with better motorist visibility.	
Long-term: Same as for short-term mitigation. Depending on alignment of highway reconstruction, it may be possible to use fencing with <i>animal detection systems</i> at fence ends.	

Alexander–Michel 1 Summary	
Description	
Location: UTM: 665841 5502255	
Species: Multi-species	
Wildlife–vehicle collisions: 2	
Local conservation value: 4	
Regional conservation significance: 5	
Land use security: 3	
Transportation mitigation opportunities: 3	
Wildlife objectives	
<ul style="list-style-type: none"> • Provide safe movement for all wildlife species across highway, particularly fragmentation-sensitive species (grizzly bears, lynx, and wolverine). • Reduce number of wildlife–vehicle collisions in this section of highway. 	
Existing infrastructure	
<ul style="list-style-type: none"> • None. 	
Target species for mitigation planning	
<p>WVC reduction: Common species.</p> <p>Regional conservation and connectivity: Fragmentation-sensitive species (grizzly bear, lynx, wolverine) and common species are priority. Believed to be dispersal corridor for grizzly bears and other fragmentation-sensitive species.</p>	
Land use security	
Score: 3	
Current land use: Private industrial lands adjacent to highway on the north and south. Proposal for quarry development to the south but status is unknown.	
Transportation mitigation opportunities	
Score: 3	
<p>Short-term:</p> <p>Mitigation alternatives should focus on improving the land-use security in the area and managing adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.</p>	
<p>Long-term:</p> <p>If the highway is reconstructed, fencing and construction of <i>wildlife underpass or wildlife overpass</i> recommended. Selection of design type is dependent on terrain and engineering constraints. Minimum dimension for underpass is 12 m wide x 4 m high, while for wildlife overpass, minimum 25–30 m wide. <i>Wing fencing</i> (100–200 m depending on terrain) should be accompanied by <i>animal detection system</i> at fence ends.</p>	

Alexander–Michel 2 Summary	
Description	
Location: UTM: 663874 5502357	
Species: Multi-species	
Wildlife–vehicle collisions: 2	
Local conservation value: 5	
Regional conservation significance: 5	
Land use security: 3	
Transportation mitigation opportunities: 4	
Wildlife objectives	
<ul style="list-style-type: none"> • Provide safe movement for all wildlife species across highway • Reduce number of wildlife–vehicle collisions in this section of highway. 	
Existing infrastructure	
<ul style="list-style-type: none"> • Culvert and creek passing below highway. 	
Target species for mitigation planning	
<p>WVC reduction: Site is within low collision zone for wildlife and motorists.</p> <p>Regional conservation and connectivity: Fragmentation-sensitive species (grizzly bear, lynx, wolverine) and common species are priority. Believed to be dispersal corridor for grizzly bears and other fragmentation-sensitive species.</p>	
Land use security	
Score: 3	
<p>Current land use: Site is most optimal for highway mitigation and restoring regional scale movements of fragmentation-sensitive species. Primarily private industrial lands to the north and south of highway. Land north of highway and west of Alexander Creek privately owned. Gun range situated west of Alexander Creek but has little impact on animal movements through area.</p>	
Transportation mitigation opportunities	
Score: 4	
<p>Short-term:</p> <p>This is the most critical habitat linkage in the entire Highway 3 corridor. It is the most important site to preserve, from a conservation and management standpoint, for local and regional-scale movements of wildlife, particularly fragmentation-sensitive species such as grizzly bears, wolverines and lynx. Mitigation alternatives should focus on improving the land-use security in the area and managing adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.</p>	
<p>Long-term:</p> <p>Potential opportunities in long term consist of bridge reconstruction or highway twinning (bridge construction) project. All bridge construction or reconstruction must be designed with wildlife movement (and hydrologic flow) in mind. Bridges should be designed with a wide span, allowing dry travel sections (7–10 m wide) above high-water mark and ≥ 4 m vertical clearance. Wing <i>fencing</i> (100–200 m depending on terrain) should be accompanied by <i>animal detection system</i> at fence ends.</p>	

Crowsnest Lakes Summary	
Description	
Location: UTM: 669373 5499430	
Species: Bighorn sheep	
Wildlife–vehicle collisions: 5	
Local conservation value: 4	
Regional conservation significance: 3	
Land use security: 3	
Transportation mitigation opportunities: 2	
Wildlife objectives	
<ul style="list-style-type: none"> • Provide safe movement for all wildlife species across highway, primarily bighorn sheep. • Reduce number of bighorn sheep–vehicle collisions. 	
Existing infrastructure	
<ul style="list-style-type: none"> • None. 	
Target species for mitigation planning	
<p>WVC reduction: Bighorn sheep.</p> <p>Regional conservation and connectivity: Common species, including deer, elk, bighorn sheep, black bears and cougars.</p>	
Land use security	
Score: 3	
Current land use: To the north is public land, while lands to the south are privately owned.	
Transportation mitigation opportunities	
Score: 2	
<p>Short-term:</p> <p>There are three recommendations to reduce wildlife–vehicle collisions in area:</p> <ul style="list-style-type: none"> • Install <i>variable message signs</i> warning motorists of wildlife on highway. • During winter, replace road salt with other <i>de-icing agents</i> to reduce bighorn sheep attraction to roadway. • Install <i>fencing</i> to funnel bighorn sheep movement towards Emerald Lake. On the south side of highway: <i>fencing</i> and placement of Jersey barriers and boulders to funnel bighorn sheep to the Emerald Lake undercrossing. On the north side of highway: install fencing that borders highway and lake. 	
<p>Long-term:</p> <p>If the highway is reconstructed, fencing and construction of a <i>wildlife underpass</i> is recommended west of site near the quarry. Recommended minimum dimension for the underpass is 4 m high x 7 m wide. Wing <i>fencing</i> (100–300 m) should be used and end at rock cuts or steep slopes.</p>	

Crowsnest West Summary	
Description	
Location: UTM: 673117 5500419	
Species: Multi-species	
Wildlife–vehicle collisions: 2	
Local conservation value: 5	
Regional conservation significance: 4	
Land use security: 3	
Transportation mitigation opportunities: 4	
Wildlife objectives	
<ul style="list-style-type: none"> • Provide safe movement for all wildlife species under highway along Crowsnest River and through bridge. • Reduce number of wildlife–vehicle collisions in this section of highway. 	
Existing infrastructure	
<ul style="list-style-type: none"> • Open-span bridge on the Crowsnest River. 	
Target species for mitigation planning	
<p>WVC reduction: Common species, predominantly deer.</p> <p>Regional conservation and connectivity: Common species and some fragmentation-sensitive species (believed to be area of carnivore movement and dispersal across Highway 3).</p>	
Land use security	
Score: 3	
<p>Current land use: Moderate human use in area and relatively low amounts of security cover. Area has high potential for conservation, as land to south is privately owned with conservation easement in place, while on the north side NCC is the primary landowner.</p>	
Transportation mitigation opportunities	
Score: 4	
<p>Short-term:</p> <p>Mitigation alternatives should focus on improving the land-use security in the area and managing adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity across Highway 3. Given the local conservation value, it will be critical to retain vegetative cover and riparian habitat along the Crowsnest River.</p>	
<p>Long-term:</p> <p>Long-term solutions will depend on extent of highway reconstruction and alignment. If Highway 3 is twinned and bypasses Coleman, the existing highway will remain two-lane, but with considerably reduced traffic volumes. The existing bridge may provide movement for some wildlife. But given the sloping bridge abutments and lack of level substrate, the underpass is suboptimal for moving most wildlife species.</p> <p>If the existing highway alignment is twinned, a new bridge structure will be added and the existing bridge span can be reconstructed to allow for greater wildlife passage (and hydrologic flow). All bridge construction or reconstruction must be designed to enhance and improve wildlife movement (and hydrologic flow). Bridges should be designed with a wider span, allowing dry</p>	

travel sections (≥ 3 m wide) above high-water mark. Wing <i>fencing</i> (minimum 200 m depending on terrain) should be accompanied by an <i>animal detection system</i> at fence ends.	
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Iron Ridge Summary	
Description	
Location: UTM: 677604 5501050	
Species: Multi-species	
Wildlife–vehicle collisions: 4	
Local conservation value: 4	
Regional conservation significance: 4	
Land use security: 2	
Transportation mitigation opportunities: 2	
Wildlife objectives	
<ul style="list-style-type: none"> • Provide safe movement for all wildlife species across highway • Reduce number of wildlife–vehicle collisions in this section of highway. 	
Existing infrastructure	
<ul style="list-style-type: none"> • None. 	
Target species for mitigation planning	
WVC reduction: Common species, primarily deer. Regional conservation and connectivity: Locally common species.	
Land use security	
Score: 2	
Current land use: High potential for land conservation as north of highway under ownership of NCC, Dept. of Highways and public. South of highway mostly public land with quarter section of private land.	
Transportation mitigation opportunities	
Score: 2	
Short-term: It will be most important to improve the land-use security in the area and manage adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity.	
Long-term: Long-term solutions will depend on extent of highway reconstruction and alignment. If Highway 3 is twinned and bypasses Coleman, the highway will remain two-lane, but with reduced traffic volumes. If the existing alignment is twinned, two locations are suitable for mitigation with the following measures: <ul style="list-style-type: none"> • <i>Multi-use wildlife overpass with fencing.</i> A suitable location exists where the highway passes through a ridge cut resulting in raised embankments (elevated terrain) on both sides of the highway, facilitating the construction of an overpass structure. Recommended minimum dimension is 15–20 m wide (see <i>Multi-use overpass</i> Hot sheet). • <i>Wildlife underpass.</i> Remove fill at location west of the road cut and replace with open-span bridge structure designed to allow adequate space (≥ 3 m wide, ≥ 3 m high) and substrate for wildlife travel. <i>Wing fencing</i> (minimum 500 m) should be used to guide wildlife to open-span bridge structure. Recommended minimum dimensions are 4 m high x 7 m wide. <i>Wing fencing</i> (minimum 200 m depending on terrain) should be accompanied by an <i>animal</i> 	

<i>detection system</i> at fence ends.	
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McGillivray Creek Summary	
Description	
Location: UTM: 678927 5501028	
Species: Multi-species	
Wildlife–vehicle collisions: 3	
Local conservation value: 3	
Regional conservation significance: 3	
Land use security: 2	
Transportation mitigation opportunities: 3	
Wildlife objectives	
<ul style="list-style-type: none"> • Provide safe movement for all wildlife species across highway • Reduce number of wildlife–vehicle collisions in this section of highway. 	
Existing infrastructure	
<ul style="list-style-type: none"> • 1.8-m-diameter steel culvert. 	
Target species for mitigation planning	
WVC reduction: Common species, primarily deer. Regional conservation and connectivity: Locally common species	
Land use security	
Score: 2	
Current land use: Land on both sides of the highway is private; conservation potential has not been explored.	
Transportation mitigation opportunities	
Score: 3	
Short-term: No mitigation alternatives other than preserve adjacent lands for wildlife habitat conservation.	
Long-term: Remove highway fill and replace culvert with open-span bridge allowing adequate space (≥ 3 m wide, ≥ 2 m high) and substrate for wildlife travel. <i>Wing fencing</i> (minimum 200 m) should be used to guide wildlife to bridge with an <i>animal detection system</i> at fence ends. Could be done as culvert or highway reconstruction project.	

Crowsnest Central Summary	
Description	
Location: UTM: 682383 5500451	
Species: Multi-species	
Wildlife–vehicle collisions: 2	
Local conservation value: 2	
Regional conservation significance: 2	
Land use security: 2	
Transportation mitigation opportunities: 1	
Wildlife objectives	
<ul style="list-style-type: none"> • Provide safe movement for all wildlife species across highway • Reduce number of wildlife–vehicle collisions in this section of highway. 	
Existing infrastructure	
<ul style="list-style-type: none"> • None. 	
Target species for mitigation planning	
WVC reduction: Common species, primarily with deer. Regional conservation and connectivity: Locally common species	
Land use security	
Score: 2	
Current land use: Land to the north is private and selected parcels have recently been developed; land to the south is under conservation easement.	
Transportation mitigation opportunities	
Score: 1	
Short-term: No mitigation alternatives other than preserve adjacent lands for wildlife habitat conservation.	
Long-term: No mitigation alternatives other than preserve adjacent lands for wildlife conservation. If the highway is twinned and the alignment passes through Blairmore, a <i>multi-use wildlife underpass</i> is recommended. <i>Wing fencing</i> (100–200 m) should be used to guide wildlife to bridge with an <i>animal detection system</i> at fence ends.	

East Blairmore Bridge Summary	
Description	
Location: UTM: 686001 5498025	
Species: Bighorn sheep	
Wildlife–vehicle collisions: 2	
Local conservation value: 3	
Regional conservation significance: 2	
Land use security: 3	
Transportation mitigation opportunities: 3	
Wildlife objectives	
<ul style="list-style-type: none"> • Provide safe movement for all wildlife species across highway, primarily bighorn sheep. • Reduce number of bighorn sheep–vehicle collisions. 	
Existing infrastructure	
<ul style="list-style-type: none"> • Two open-span bridges over Crowsnest River. 	
Target species for mitigation planning	
WVC reduction: Bighorn sheep. Regional conservation and connectivity: Common species.	
Land use security	
Score: 3	
Current land use: Land on the north is public; land to the south is private—no conservation efforts are underway.	
Transportation mitigation opportunities	
Score: 3	
Short-term: Mitigation alternatives should focus on improving the land-use security in the area and managing adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity across Highway 3.	
Long-term: Long-term solutions will depend on extent of highway reconstruction and alignment. If Highway 3 is twinned and bypasses Coleman, the existing highway will remain two-lane, but with considerably reduced traffic volumes. The existing bridge may provide safe movement for some wildlife. All bridge construction or reconstruction must be designed to enhance and improve wildlife movement (and hydrologic flow). Bridges should be designed with a wider span, allowing dry travel sections (≥ 3 m wide) above high-water mark. Wing <i>fencing</i> (minimum 200 m depending on terrain) should be accompanied by an <i>animal detection system</i> at fence ends.	

Leitch Collieries Summary	
Description	
Location: UTM: 693956 5492905	
Species: Multi-species	
Wildlife–vehicle collisions: 4	
Local conservation value: 4	
Regional conservation significance: 4	
Land use security: 3	
Transportation mitigation opportunities: 4	
Wildlife objectives	
<ul style="list-style-type: none"> • Provide safe movement for all wildlife species across highway • Reduce number of wildlife–vehicle collisions in this section of highway. 	
Existing infrastructure	
<ul style="list-style-type: none"> • None. 	
Target species for mitigation planning	
<p>WVC reduction: Common species, predominantly deer and elk.</p> <p>Regional conservation and connectivity: Common species and some fragmentation-sensitive species (believed to be area of grizzly bear movement and dispersal around the Crownsnest Pass Municipality).</p>	
Land use security	
Score: 3	
Current land use: Conservation lands exist on both sides of highway under NCC ownership.	
Transportation mitigation opportunities	
Score: 4	
<p>Short-term:</p> <p>Mitigation alternatives should focus on improving the land-use security in the area and managing adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity across Highway 3. To reduce wildlife–vehicle collisions in this area <i>de-icing alternatives</i> are recommended in winter.</p>	
<p>Long-term:</p> <p>A <i>multi-use wildlife overpass</i> and <i>fencing</i> are recommended should the highway be upgraded or expanded to four lanes. An overpass structure is most suitable given a suitable location east of the colliery where terrain bordering the highway is elevated on both sides, thus facilitating overpass construction. Recommended minimum dimensions are 15–20 m. <i>Wing fencing</i> (minimum 200 m) should be used to guide wildlife to overpass. An <i>animal detection system</i> can be placed at fence ends to warn motorists when animals cross the highway. <i>Boulders between fence</i> and roadway and <i>jump-outs</i> may be required depending on the situation.</p>	

Rock Creek Summary	
Description	
Location: UTM: 700183 5495741	
Species: Multi-species	
Wildlife–vehicle collisions: 5	
Local conservation value: 5	
Regional conservation significance: 3	
Land use security: 4	
Transportation mitigation opportunities: 4	
Wildlife objectives	
<ul style="list-style-type: none"> • Provide safe movement for all wildlife species under or over highway along Crowsnest River and under bridge. • Reduce number of wildlife–vehicle collisions in this section of highway. 	
Existing infrastructure	
<ul style="list-style-type: none"> • 3-m-diameter corrugated steel culvert. This may be replaced in near future. 	
Target species for mitigation planning	
WVC reduction: Common species, predominantly deer.	
Regional conservation and connectivity: Common species are a priority; however area is believed to be dispersal corridor for grizzly bears and other fragmentation-sensitive species.	
Land use security	
Score: 4	
Current land use: Public parcels are north and south of highway, followed by sections of private land on both sides, some under conservation easement.	
Transportation mitigation opportunities	
Score: 4	
<p>Short-term:</p> <p>In the short term there are few mitigation alternatives other than improving the land-use security in the area and managing adjacent lands in a way that ensures regional wildlife habitat conservation and population connectivity across Highway 3. However, most of the adjacent lands are secured, which helps ensure regional wildlife habitat conservation and population connectivity. Being an area of high WVCs, recommendations include <i>variable message signs</i> installed to warn motorists of regular occurrence of wildlife on the highway, and use of <i>de-icing alternatives</i> in winter rather than road salt.</p> <p>If the existing fill is removed and culvert is replaced with a new bridge structure this is an excellent opportunity to improve terrestrial hydrologic flows in the area. A new bridge structure should be designed to maximize wildlife movement under Highway 3, allowing adequate space (≥ 3 m wide) and substrate for wildlife travel. <i>Wing fencing</i> (minimum 200 m) should be used to guide wildlife to bridge. An <i>animal detection system</i> can be placed at fence ends to warn motorists when animals cross the highway. <i>Boulders between fence</i> and roadway and <i>jump-outs</i> may be required depending on the situation. As indicated, this work could be done as a culvert reconstruction project or major highway reconstruction project.</p>	
Long-term:	

See above. Long-term recommendations could be met in short term if highway or bridge reconstruction takes place.	
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Crowsnest East Summary	
Description	
Location: UTM: 703327 5497024	
Species: Multi-species	
Wildlife–vehicle collisions: 4	
Local conservation value: 3	
Regional conservation significance: 2	
Land use security: 3	
Transportation mitigation opportunities: 5	
Wildlife objectives	
<ul style="list-style-type: none"> • Provide safe movement for all wildlife species under highway along Crowsnest River and under bridge. • Reduce wildlife–vehicle collisions in this section of highway, particularly to the west near intersection of highways 22 and 3. 	
Existing infrastructure	
<ul style="list-style-type: none"> • Open-span bridge over Crowsnest River. 	
Target species for mitigation planning	
WVC reduction: Common species, predominantly deer.	
Regional conservation and connectivity: Common species (deer, elk, black bear, cougars).	
Land use security	
Score: 3	
Current land use: Land on both sides of highway is private; conservation potential has not been explored.	
Transportation mitigation opportunities	
Score: 5	
Short-term: Wing fencing directing wildlife to bridge may keep animals from crossing at-grade, if there is suitable substrate at the bridge and wing fencing is properly placed and designed. Fence length should be long enough to prevent most wildlife–vehicle collisions in area. Fencing should follow specifications shown in <i>Fencing</i> information sheet (Appendix B, Sheet D).	
Long-term: Bridge reconstruction would allow for wider bridge span and dry walkways for wildlife. Walkways under bridge need to be ≥ 3 m wide and above high-water mark. This work could be done as reconstruction or highway twinning project. <i>Wing fencing</i> (minimum 200 m) should be used to guide wildlife to bridge with <i>animal detection system</i> at fence ends.	

APPENDIX B: MITIGATION MEASURE INFORMATION SHEETS (A–J)

Mitigation measure information sheets are based on the *Handbook for Design and Evaluation of Wildlife Crossing Structures in North America* (Clevenger and Huijser 2009).

Sheet A: Animal Detection Systems

Sheet B: Badger Culverts

Sheet C: De-icing Alternatives

Sheet D: Fencing

Sheet E: Gates and Ramps

Sheet F: Variable Message Signs

Sheet G: Wildlife Underpasses

Sheet H: Multi-use Wildlife Underpasses

Sheet I: Wildlife Underpasses with Water Flow

Sheet J: Wildlife Overpasses

Animal Detection Systems

SHEET A

General purpose

Animal detection systems use sensors to detect large animals that approach the road. Once a large animal is detected, warning signals are activated to inform the drivers that a large animal may be on or near the road at that time. The warning signals are time specific—that is, they warn of specific detection events rather than warn of the possibility that animals may be in the area. These systems have been installed in more than 30 locations in North America and Europe.



Animal detection system along Highway 191 in Yellowstone National Park, Montana (Photo: Marcel Huijser, WTI).

System types

Two broad categories are commonly used in animal detection systems: area-cover systems and break-the-beam systems. Area-cover systems detect large animals within a certain range of a sensor. Area coverage systems can be passive or active. Passive systems detect animals by only receiving signals. The two most common systems are passive infrared and video detection. These systems require algorithms that distinguish between, e.g., moving vehicles with warm engines

and moving pockets of hot air, and movements of large animals. Active systems send a signal over an area and measure its reflection. The primary active area coverage system uses microwave radar. Break-the-beam sensors detect large animals when their body blocks or reduces a beam of infrared, laser or microwave radio signals sent by a transmitter to a receiver.

Effectiveness

The effectiveness of animal detection systems has been investigated with regard to a potential reduction in vehicle speed and a potential reduction in animal–vehicle collisions. Previous studies have shown variable results: substantial decreases in vehicle speed, minor decreases in vehicle speed, and no decrease or even an increase in vehicle speed. This variability in the results appears to be related to various conditions, namely, type of warning signal and signs, whether the warning signs are accompanied with advisory or mandatory speed limit reductions, road and weather conditions, whether the driver is a local resident, and perhaps also cultural differences that may cause drivers to respond differently to warning signals in different regions.

Some work in Switzerland has been done reporting on the number of animal–vehicle collisions before and after seven infrared area cover detection systems were installed. These systems reduced the number of animal–vehicle collisions by 82 percent on average.

While the data on the effectiveness of animal detection systems are encouraging, animal detection systems should still be regarded as an experimental mitigation measure rather than a measure that will reduce wildlife–vehicle collisions in the short term with a high degree of certainty (Huijser et al. 2006c).

Case studies and contacts

For a general overview of technology, reliability and effectiveness, contact Marcel Huijser, Western Transportation Institute, PO Box 174250, Bozeman, Montana 59717-4250, (406)543-2377, mhuijser@coe.montana.edu.

For information about a field study on the effectiveness of animal detection systems, contact Christa Mosler-Berger, Wildtier Schweiz, Strickhofstrasse 39, 8057 Zürich, Switzerland, wild@wild.unizh.ch.

For more information about the animal detection system and wildlife fencing along State Route 260 in Arizona, contact Norris Dodd, Wildlife Research Biologist, Arizona Game and Fish Department, Research Branch, P.O. Box 2326, Pinetop, Arizona 85935, (928)368-5675, doddbenda@cybertails.com.

Manufacturer: Terry Wilson, Sensor Technologies and Systems, Inc., 8900 East Chaparral Road Scottsdale, Arizona 85250, (480)483-1997, (fax (480)483-2011), terry_wilson@sensor-tech.com, <http://www.sensor-tech.com/> (accessed 25 January 2007).

Manufacturer: Calonder Energy AG's representative in USA: Willy Bärchtold, Swiss Army Vehicles, 1436 Van Asche Drive, Fayetteville, Arkansas 72704, (479)521-0056, cars@sav.ms.

Direct benefits

The only available data on the effectiveness of animal detection systems show a reduction in collisions with large animals of 82 percent. This percentage may change as more data become available.

Indirect benefits

Animal detection systems do not restrict animal movements when deployed over long distances.

Undesirable effects

Animal detection systems can reduce collisions with large animals, but the presence of poles and equipment in the right-of-way is a potential hazard to vehicles that run off the road.

Costs

Estimated costs of these systems are \$40,000 to \$96,000 per km (\$65,000 to \$154,000 per mile) excluding installation costs (unpublished data, Marcel Huijser, Western Transportation Institute – Montana State University). The costs for the equipment will be higher if the road section concerned has curves or slopes, or if the line of sight in the right-of-way is blocked by objects.

Badger Culverts

SHEET B

General design

This crossing is designed specifically for passage by badgers, although other small and medium-sized vertebrates may use it as well. There are many different culvert designs to meet the specific requirements of badgers and other target species. Drift fences are required to guide badgers to the location of the culvert.



Culvert retrofitted as badger culvert with fencing, east of Cranbrook, BC (Photo: Trevor Kinley).

Use of the structure

Exclusively wildlife, primarily badgers.

General guidelines

- To ensure performance and function, culverts should be situated in areas that are known hot spots of badger road-kill and areas of badger habitat and movements.

- Badgers have few requirements for culvert design other than culverts being of adequate size, passable and accessible. Drift fences or walls play an important role directing them to the culverts.

De-icing Alternatives

SHEET C

General purpose

The principal deicers used by highway agencies are chloride-based salts such as sodium chloride (NaCl), calcium chloride (CaCl₂), and magnesium chloride (MgCl₂), and acetate-based deicers such as potassium acetate, sodium acetate, and calcium magnesium acetate (CMA) (Xianming Shi and Laura Fay, Western Transportation Institute – Montana State University, personal communication).

The use of chloride salts in winter maintenance can attract wildlife to the right-of-way and may increase WVCs, especially in areas without natural salt licks. A study of 11 radio-collared moose in New Hampshire determined that all of their home ranges converged on the area containing roadside salt (NaCl) licks formed by runoff of road salt. Reducing the amount of salt or using alternative deicers (without salt), especially in areas of high WVCs, may reduce the attractiveness of the right-of-way.

Lithium chloride, a gastrointestinal toxicant, was found to effectively discourage captive caribou from eating treated food and may prove useful in reducing WVCs by discouraging ungulates from licking road salt. CMA has been recommended as an alternative road deicer in Finland instead of NaCl. Attempts at discouraging animals from licking road salt by using CaCl₂ were unsuccessful in Jasper National Park, Canada (J. Bertwistle, personal communication).

Case studies and contacts

For further information on efforts using deicing alternatives, contact Jim Bertwistle, Warden, Jasper National Park, Alberta, Canada, (403)852-6155.

Direct benefits

Whether the reduction or elimination of the road salt would reduce WVCs remains unknown. Deicing salt alternatives are categorized as “experimental” (AASHTO) and “used but not studied for safety impacts” in a critical evaluation of WVC crash countermeasures.

Indirect benefits

The intake of road salt has been found to be toxic to several bird species, porcupines, rabbits, deer, and moose. Reduction or elimination of road salt may reduce or eliminate this toxicity.

Undesirable effects

While the reduction or elimination of road salt may benefit certain species, alternatives to chloride salts may also be toxic to wildlife (Xianming Shi, Western Transportation Institute – Montana State University, personal communication), but this has not yet been specifically studied.

Costs

No cost data are currently available.

Fencing

SHEET D

General purpose

Wildlife exclusion fencing keeps animals away from roadways. However, fencing alone can isolate wildlife populations, thus creating a barrier to movement, interchange and limiting access to important resources for individuals and affecting the long-term survival of the population. Fencing is one part of a two-part mitigation strategy—fencing *and* wildlife crossing structures. Fences keep wildlife away from the roadway and lead animals to wildlife crossings, thus allowing them to travel safely under or above the highway. Fences need to be impermeable to wildlife movement in order to keep traffic-related mortality to a minimum and ensure that wildlife crossings will be used. Defective or permeable fences result in reduced use of the wildlife crossings and increased risk of wildlife–vehicle collisions. Little research and best management practices exist regarding effective fence designs and other innovative solutions to keep wildlife away from roads.



Wildlife exclusion fencing and culvert design wildlife underpass (Photo: Tony Clevenger).

Configurations

Fencing configuration used to mitigate road impacts will depend on several variables associated with the specific location, primarily adjacent land use and traffic volumes. Both sides of the road must be fenced (not only one side) and fence ends across the road need to be symmetric and not offset or staggered.

- *Continuous fencing* – Most often associated with large tracts of public land with little or no interspersed private property or in-holdings. Advantages: Long stretches of continuous fencing have fewer fence ends and generally few problems of managing wildlife movement (“end-runs”) around multiple fence ends, as with discontinuous fencing (below). Disadvantages: Access roads with continuous fencing will need cattle guards or gates to block animal access to roads.
- *Partial (discontinuous) fencing* – More common with highway mitigation for wildlife in rural areas characterized by mixed land use (public and private land). Generally installed when private lands cannot be fenced. Advantages: Generally accepted by public stakeholders. Few benefits to wildlife and usually the only alternative when there is mixed land use. Disadvantages: Results in multiple segments of fenced and unfenced sections of road, each fenced section having two fence ends. Additional measures need to be installed and carefully monitored to discourage end-runs at fence ends and hasten wildlife use of new crossing structures (see Terminations below).

Interceptions

Fences invariably intersect other linear features that allow for movement of people or transport materials. This can include access roads, but also recreational trails (people) and water (creeks, streams). These breaks or interceptions in the fence require special modifications in order to limit the number of wildlife intrusions into the right-of-way.

Roads

- *Cattle guards* – Transportation and land management agencies commonly install cattle guards (“Texas gates” in Canada) where fences intersect access roads. Many different designs have been used, but few have been tested for their effectiveness with wildlife. Designs of cattle guards vary in dimension, grate material (flat or cylindrical steel grates), and grate adaptations for safe passage by pedestrians and cyclists. Recently a grate pattern was developed that was 95 percent effective in blocking Key deer movement and was safe for pedestrians and cyclists. A cattle guard roughly 1.8–2.4 m long and covering two lanes of traffic costs approximately \$CD 40,000 (Terry McGuire, Parks Canada, personal communication).



Cattle guard (Texas gate) in road (Photo: Tony Clevenger).

- *Electric cattle guards*– These electrified mats act like electric cattle guards to discourage wildlife from crossing at the gap in the fence. Pedestrians wearing shoes and bicyclists can cross the mats safely, but dogs, horses and people without shoes will receive an electric shock. The electro-mats are generally 1.2 m wide and built into access roads where they breach fences. ElectroBraid™ and GapZapper® are two companies that currently design and sell electric cattle guards.
- *Painted crosswalks*– Highway crosswalk structures have been used to negotiate ungulates across highways at grade level. White crosswalk lines are painted across the road to emulate a cattle guard. The painted crosswalk serves as a visual cue to guide ungulates directly across the highway. Painted crosswalks have not been tested, but if effective, they would be an inexpensive alternative to the more costly cattle guards.

Trails

- *Swing gates (for fishermen, hikers)*–Where fences impede public access to popular recreation areas, swing gates can be used to negotiate fences. Gates must have a spring-activated hinge that ensures that even if the gate is left open it will spring back and close. In areas of high snowfall, gates may be elevated and steps built to keep the bottom of the gate above snow.



Step gate with spring-loaded door situated at trailhead in Banff National Park, Alberta (Photo: Tony Clevenger).

- *Canoe/kayak landings*– There are no known simple gate solutions for transporting canoes/kayaks through fences. The swing gate described above is one solution, although the gate should be slightly wider than normal to allow a wide berth suitable for moving canoes/kayaks. Gates must have a spring-activated hinge that ensures they remain closed after use.

Watercourses

- *Rubber hanging drapes*– Watercourses pose problems for keeping fences impermeable to wildlife movement, as their flow levels tend to fluctuate throughout the year. When water

levels are low, gaps may appear under the fence material allowing wildlife to easily pass beneath. Having fencing material well within watercourses will cause flooding problems, as debris being transported will not pass through the fence and can eventually obstruct water flow. A solution to this problem would require having a device on the bottom of the fence that moves up and down with the water levels. This could be done by attaching hinged strips of rubber mat-like material, draping down from the bottom of the fence material into the water. The rubber strips are hinged, so they float on top of the water and move in the direction of flow.

Suggested design details

Mesh type, gauge and size

Fence material may consist of woven-wire (page-wire) or galvanized chain-link fencing. Fence material must be attached to the back (non-highway) side of the posts, so impacts will only take down the fence material and not the fence posts.

- *Woven- or page-wire fencing* – Woven-wire fences consist of smooth horizontal (line) wires held apart by vertical (stay) wires. Spacing between line wires may vary from 8 cm at the bottom for small animals to 15–18 cm at the top for large animals. Wire spacing generally increases with fence height. Mesh wire is made in 11, 12, 12 ½, 14, and 16 gauges and fences are available in different mesh and knot designs. The square-shaped mesh may facilitate climbing by some wildlife, such as bears. If climbing is a concern then use of a smaller mesh is recommended.

Wildlife fences along the Trans-Canada Highway in Banff National Park consist of 12 ½ gauge line wires with tensile strength of 1390 N/sq. mm. Stay wires have a tensile strength of 850 N/sq. mm. All wires had Class III zinc galvanized coating (see below) at a minimum of 260 gms/sq. m.

- *Chain-link fencing* – Chain-link fence is made of heavy steel wire woven to form a diamond-shaped mesh. It can be used in various industrial, commercial and residential applications. Chain-link was used for highway mitigation fencing along I-75 and SR 29 in Florida. There have been agency and public concerns about the visual aesthetics of chain-link fencing compared to woven-wire as it is less attractive and does not blend into the landscape. Steel posts are always used with chain-link fencing. Chain-link fence fabrics can be galvanized mesh, plastic-coated galvanized mesh or aluminum mesh.
- Most wire sold today for fencing has a coating to protect the wire from rust and corrosion. Galvanizing is the most common protective coating. The degree of protection depends on thickness of galvanizing and is classified into three categories; Classes I, II, and III. Class I has the thinnest coating and the shortest life expectancy. Nine-gauge wire with Class I coating will start showing general rusting in 8 to 10 years, while the same wire with Class III coating will show rust in 15 to 20 years.
- *Electrified fencing* – Electric fences are a safe and effective means to deter large wildlife from entering highway right-of-ways, airfields and croplands. The 2-m-high fence will

deliver a mild electric shock to animals that touch it, discouraging them from passing through. It is made of several horizontal strands of rope-like material about 1 cm in diameter that can deliver a quick shock that is enough to sting, but not seriously harm humans. Wildlife respond differently to standard electric fences; high voltage fences are generally required to keep bears away. There are public safety issues of having electrified fencing bordering public roads and highways as there is high likelihood that people will come into contact with the fence (fishermen, hikers, motorists that run into fence).

Post types

- *Wood*– Wood posts are commonly used and can be less expensive than other materials if cut from the farm woodlot or if untreated posts are purchased. Post durability varies with species. For example, osage orange and black locust posts have a lifespan of 20 to 25 years whereas southern pine and yellow poplar rot in a few years if untreated.
- The life expectancy of pressure-treated wooden posts is generally 20 to 30 years depending on the type of wood. Softwoods are the most common wood used for posts when fencing highways. Lodgepole pine and Jack pine are common tree species for fence posts. For Trans-Canada Highway wildlife fences, all round fence posts were pressure treated with a chromate copper arsenate (CCA) wood preservative.
- Wood posts are highly variable in size and shape. For typical 2.4-m-high fencing, non-sharpened wooden posts 3.7 m and 4.2 m long are supplied. The fence posts are then sharpened and installed by preparing a pilot hole approximately 125 mm in diameter, vibrating the post down to a specified post height and backfilling around the post with a compacted non-organic material to ground level. The strength of wood posts increases with top diameter. Post strength is especially important for corner and gate posts, which should have a top diameter of at least 16 cm. Line posts can be as small as 13 cm and should not need to be more than 14 cm on top diameter, although larger diameter posts make fences stronger and more durable.
- *Steel*– Steel posts are used to support fences when crossing rock substrate. They weigh less and last longer than wood posts; the main disadvantage is they are more expensive than wood posts. Steel posts are supplied in 3.7 m lengths and installed in concreted 1000-mm-long sleeves for the 3 m x 8 cm steel posts.
- *Tension* – Tension between posts can consist of metal tubing on metal posts and reinforced cable on wooden posts.

Reinforcements

- *Unburied fence* – Unburied fences are used in areas where resident wildlife are not likely to dig under the fence. The fence material should be flush with the ground to minimize animals crawling beneath the fence and reaching the right-of-way.
- *Buried fence* – This is strongly recommended in areas with wildlife capable of digging under the fence (e.g., bears, canids, badgers, wild boar). Buried fence in Banff National Park significantly reduced wildlife intrusions to the right-of-way compared to unburied

fence. Buried fence consists of a 1- to 1.2-m-wide section of galvanized chain-link fence spliced to the bottom of unburied fence material. The chain-link section is buried at a 45-degree angle away from the highway and is approximately 1.1 m below ground. Swing gates should have a concrete base to discourage digging under them.

- Cable (protective) – Trees blown onto fences can not only damage fence material but provide openings for wildlife to enter the right-of-way. This is typically a problem during the initial years after construction, but can continue over time. A high-tensile cable strung on top of fence posts to help break the fall of trees onto the fence material should reduce fence damage, repair costs and maintenance time.



Wildlife exclusion fence with buried apron (Photo: Tony Clevenger).



Concrete base of swing gate to prevent animal digging under wildlife fence (Photo: Tony Clevenger).



High tensile cable designed to break fall of trees onto fence material (Photo: Tony Clevenger).

Terminations

Fence ends are notorious locations for wildlife movements across roads and, thus, for accidents with wildlife. The problem is more acute soon after fence installation as wildlife are confused, unsure where to cross the road, and tend to follow fences to their termination, and then make end-runs across the road or graze inside the fence.

Each mitigation situation is different and will require a site-specific assessment, but as a general rule, fence ends should terminate at a wildlife crossing structure.

If a wildlife crossing cannot be installed at the fence ends, then fences should be designed to terminate in the least suitable location or habitat for wildlife movement—i.e., places wildlife are least likely to cross roads. Some examples are:

- Steep, rugged terrain such as rock-cuts (bighorn sheep and mountain goats excluded).
- Habitats that tend to limit movement, e.g., open areas for forest-dwelling species.
- Areas with regular human activity and disturbance.

Another consideration is motorist visibility and speed at fence ends. Fences should end on straight sections of highway with good motorist visibility. Lighting at fence ends may improve motorist visibility and actually enhance road crossings by ungulate species; however, it may deter movement by wary carnivore species. Regardless of the situation, proper signage must be installed to warn motorists of potential wildlife activity and crossings at fence ends.



Warning signage at end of wildlife exclusion fence (Photo: Tony Clevenger).

Because fence ends create a hazardous situation for motorists and wildlife, it is important to discourage wildlife movement toward fence ends. Having wildlife locate and use wildlife crossings as soon as possible after construction is the best recommendation to discourage end-runs. Cutting trails to wildlife crossings, baiting or use of attractants should help direct wildlife to crossings and hasten the adaptation process.

Dimensions – General guidelines

Highway fencing for large mammals, including most native ungulate species of moose, elk, deer, and bighorn sheep, should be a minimum of 2.4 m high with post separation on average every 4.2 to 5.4 m. In some cases the fence height may not need to be designed for large ungulates. Alternate fence design and specifications will need to reflect not only requirements for species present, but also species that may re-colonize or disperse into the area in the future.

Possible variations

- *Boulders/terrain* – Boulders as a substitute for wildlife fencing has not proved to be effective; however, boulder fields or aprons have been used to effectively discourage wildlife entering the highway right-of-way at fence ends. The boulder apron is positioned on both road shoulders and at the ends of fencing (and median for four-lane highways) and can range from 50 to 100 m long (along roadway). The shoulder aprons vary in width from about 8 to 20 m, depending on how close the fence is positioned to the roadway—the boulders must extend from the edge of the pavement up to the fence to preclude any path for wildlife to skirt the boulders. Boulder aprons are made of subangular, quarried rock, ranging in size from 20 to 60 cm, however most should be larger than 30 cm. The boulder apron, at a depth of about 40 to 50 cm, is installed on geofabric on sub-excavated smoothed ground. The boulders project about 20 to 30 cm above local ground surface.



Boulder field at end of wildlife fence (Photo: Tony Clevenger).

- *Reduced fence height* – Lower-than-average fence height may be prescribed where there are commercial or residential concerns of visual effects and aesthetics of fencing. Reducing the fence height (e.g., to 1.8 m) with respect to the adjacent area by running the fence through a lowered or depressed area will make the fence appear lower and less obtrusive. Planting shrubs and low trees in front of the fence will also help the fence blend into the landscape.
- *Outriggers/overhangs* – Although never formally tested, outriggers or fence overhangs could discourage wildlife (bears, cat species) from climbing fences and reaching the right-of-way.
- *Barbed wire overhangs* – Similar to outriggers and fence overhangs, barbed wire overhangs are commonly used in urban areas to keep people out of areas. Overhangs of this type are found on I-75 in Florida and have apparently been effective in keeping panthers and black bears from climbing the fence.
- *Gap below fence material for Pronghorn* – The movement and migration of Pronghorn is affected by the network of fences they need to negotiate to meet their biological needs. Although not particular to wildlife fencing for wildlife crossing structures, it is worth noting that standard 1.1-m-high roadside fencing, typically of barbed-wire, can be modified to improve Pronghorn movement. Pronghorn do not jump over fences, even 1.1 m fences, but generally try to crawl underneath. Transportation agencies have had success in getting Pronghorn to move through their preferred crossing areas by removing the bottom strand of barbed-wire.

Maintenance

- Fences are not permanent structures, nor are they indestructible. They are subject to constantly occurring damage from vehicular accidents, falling trees, and vandalism. Natural events also cause damage and threaten the integrity of the fence. Soil erosion, excavation by animals, and flooding can loosen fence posts and collapse portions of fencing.
- Fences must be checked every six months by walking entire fence lines, identifying gaps, breaks and other defects caused by natural and non-natural events.

Gates and Ramps

SHEET E

General purpose

If wildlife become trapped inside the fenced area, they need to be able to safely exit the highway area. The most effective means of escape are through a steel swing gate, hinged metal door or earthen ramp or “jump-out”. The number, type and location of escape structures will depend on the target species, terrain and habitat adjacent to the highway fence.



Escape ramp (jump-out) for wildlife trapped inside highway right-of-way (Photo: Tony Clevenger).

Application

- *Swing gates* are generally used (with or without ramps) in areas where highways are regularly patrolled by wardens/rangers. As part of their job, if wildlife are found inside the fence, the nearest gates are opened and animals are moved towards the opened gate.

Double swing gates are more effective than single swing gates, especially for larger mammals such as elk or moose. Swing gates are used to remove ungulates and large carnivores (e.g., bears) as smaller wildlife can escape by hinged doors at ground level (see below) or through large mammal fence material.



Single swing gate in wildlife exclusion fence (Photo: Tony Clevenger).

- *Earthen ramps or jump-outs* allow wildlife (large and small) to safely exit right-of-ways on their own without the aid of wardens or rangers. Typically wildlife find the ramps and exit by jumping down to the opposite side of fence. Deer and elk are the most common users, but moose, bighorn sheep, bears and cougars use these structures as well. The outside walls of the escape ramp must be high enough to discourage wildlife from jumping up onto the ramp and accessing the right-of-way. However, the walls should not be so high they discourage wildlife from jumping off. The landing spot around the outside wall must consist of loose soil or other soft material to prevent injury to animals. The outside walls must be smooth to prevent bears or other animals from climbing up. For best use, escape ramps should be positioned in a setback in the fence, in an area protected with dense vegetative cover, so animals can calm down and look over the situation before deciding to use the jump out or continue walking along the fence. A right-angle jog in the fence is recommended for positioning the escape ramp but not necessary.



Wildlife "jump-out" escape ramp (Photo: Tony Clevenger).

- For small- and medium-sized mammals, *small, hinged doors* at ground level allow for escape from the right-of-way on their own.
- *Natural objects* are a simple and cost-effective way to help small and medium-sized mammals exit the right-of-way. Stacking of brush and woody debris against the fence line and to fence height will allow climbers to exit safely.
- Like fences, escape structures need to be carefully planned for the wildlife they are targeting, their location, design and maintenance over time.

Maintenance

- Like fences, gates and ramps are not permanent structures, neither are they indestructible. They are subject to constantly occurring damage from vehicular accidents, falling trees, and vandalism. Natural events also can cause damage, obstruct gates and affect how well they perform.
- Like fences, escape structures must be checked every six months to ensure that they are functioning properly and that they perform when needed. Maintenance checks should take place at the same time as fence inspections.



Hinged door for escape of medium-sized mammals (Photo: Tony Clevenger).

Variable Message Signs

SHEET F

General purpose

Roadway wildlife warning signs are perhaps the most commonly applied WVC mitigation measure. The signs alert drivers to the potential presence of wildlife on or near the road, and urge them to be more alert, to reduce the speed of their vehicle, or a combination of both. These signs attempt to prevent a collision, or to reduce the severity of a collision if one does occur by lowering vehicle speeds at impact.

Since the effectiveness of warning signs depends on driver response, it is critical that warning signs are reliable (i.e., the driver is warned when there is a high chance of WVC). The warning signs discussed below (standard warning signs, large or enhanced warning signs, seasonal wildlife warning signs, and animal detection systems) should be placed in road sections that exceed a certain minimum risk of WVC.

Driver awareness and response are influenced by the type of warning sign. Large and graphic signs, flags attached to wildlife warning signs, permanently flashing lights on top of or around wildlife warning signs, and messages displayed on variable message signs are designed to attract the attention of the driver and invoke a response to a greater extent than standard wildlife warning signs.

Hardy et al. (2006) found that wildlife advisory messages posted on permanent and portable variable message signs can reduce vehicle speeds. The greatest effect occurred during “dark” conditions, when the number of WVCs is higher.

Citation:

Hardy, A. R., S. Lee and A. F. Al-Kaisy. 2006. Effectiveness of animal advisory messages as a speed reduction tool: A case study in Montana. *Transportation Research Record: Journal of the Transportation Research Board*, No. 1973, pp. 64–72.

Case studies and contacts

For information about wildlife advisory messages posted on permanent and portable variable message signs, contact Marcel Huijser, Western Transportation Institute, (406) 543-2377, mhuijser@coe.montana.edu.

Direct benefits

Based on the available data, variable message signs appear to be promising measures that may reduce wildlife–vehicle collisions, in general, and deer–vehicle collisions, in particular. Additional

studies are needed to rigorously measure the performance of variable message signs in reducing collisions.

Indirect benefits

No indirect benefits have been identified.

Undesirable effects

No undesirable effects have been identified.

Costs

Costs are not available at this time.

Wildlife Underpasses

SHEET G

General design

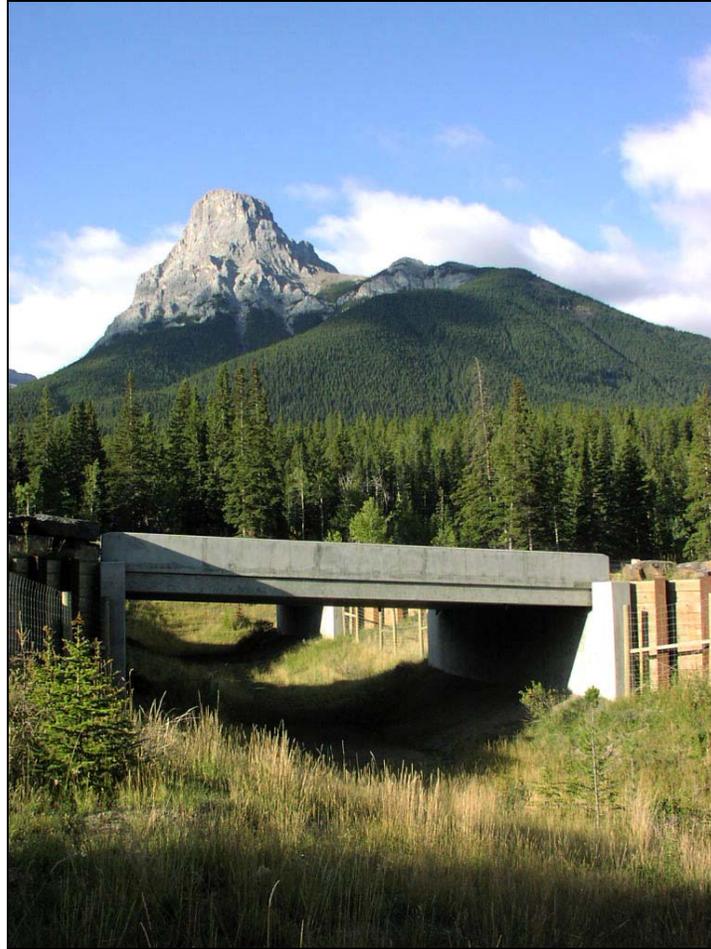
The wildlife underpass is not as large as most viaducts, but is the largest of underpass structures designed specifically for wildlife use. It is primarily designed for large mammals, but use by some large mammals will depend on how it may be adapted for their specific crossing requirements. Small- and medium-sized mammals (including carnivores) generally utilize these structures, particularly if cover is provided along walls of the underpass by using brush or root wads. These underpass structures can be readily adapted for amphibians, semi-aquatic and semi-arboreal species.

Use of the structure

The wildlife underpass is designed exclusively for use by wildlife.

General guidelines

- Being generally smaller than a viaduct or flyover, the ability to restore habitat underneath will be limited. Open designs that provide ample natural lighting will encourage greater development of native vegetation.
- To ensure performance and function, wildlife underpasses should be situated in areas with high landscape permeability that are known wildlife travel corridors and that experience only minimal human disturbance.
- Motor vehicle or all-terrain vehicle use should be prohibited. Eliminating public or any other human use, activity or disturbance at the underpass and adjacent area is recommended for its proper function and for maximizing wildlife use.
- Underpasses should be designed to conform to local topography. Design drainage features so flooding does not occur within the underpass. Highway runoff near structure should not be directed toward the underpass.
- Maximize continuity of native soils adjacent to and within the underpass. Avoid importation of soils from outside the project area.



Open span wildlife underpass (Photo: Tony Clevenger).

Dimensions – General guidelines

Width:

Minimum: 7 m

Recommended: >12 m

Height:

Minimum: 4 m

Recommended: >4.5 m

Types of construction

Span:

Concrete bridge span (open-span bridge)

Steel beam span

Arch:

Concrete bottomless arch

Corrugated steel bottomless arch

Elliptical multi-plate corrugated steel culvert

Box culvert:

Prefabricated concrete

Suggested design details

Crossing structure

- Structures should be designed to meet the movement needs of the widest range possible of species that live in the area or might be expected to re-colonize the area, e.g., high- and low-mobility species.
- Attempt to mirror habitat conditions found on both sides of the road and provide continuous habitat adjacent to and within the structure.
- Maximize microhabitat complexity and cover within the underpass using salvage materials (logs, root wads, rock piles, boulders, etc.) to encourage use by semi-arboreal mammals, small mammals, reptiles and species associated with rocky habitats.
- It is preferable that the substrate of the underpass is of native soils. If construction type has a closed bottom (e.g., concrete box culvert), a soil substrate ≥ 6 in (15 cm) deep must be applied to interior.
- Revegetation is possible in areas of the underpass closest to the entrance. Light conditions tend to be poor in the center of the structure.
- Design underpass to minimize the intensity of noise and light coming from the road and traffic.

Local habitat management

- Protect existing habitat. Design with minimal clearing widths to reduce impacts on existing vegetation. Where habitat loss occurs, reserve all trees, large logs, and root wads to be used adjacent to and within the underpass.
- Wildlife fencing is the most effective and preferred method to guide wildlife to the structure and prevent intrusions onto the right-of-way. Mechanically stabilized earth walls, if high enough, can substitute for fencing and are not visible to motorists.
- Encourage use of underpass by either baiting or cutting trails leading to the structure, if appropriate.
- Avoid building underpass in locations where a road runs parallel and adjacent to entrance, as it will affect wildlife use.

- If traffic volume is high on the road above the underpass it is recommended that sound attenuating walls be placed above the entrance to reduce noise and light disturbance from passing vehicles.



Brush and root wads placed along underpass wall to provide cover for mammals (Photo: Nancy Newhouse).

- Underpass must be within cross-highway habitat linkage zone and connect to larger corridor network.
- Existing or planned human development in adjacent area must be at sufficient distance to not affect long-term performance of underpass. Long-range planning must ensure that adjacent lands will not be developed and the wildlife corridor network is functional.

Possible variations

Divided road (two structures)

In-line

Off-set:

Undivided road (one structure)

Maintenance

- If wildlife underpass is not being monitored on a regular basis, periodic visits should be made to ensure that there are no obstacles or foreign matter in or near the underpass that might affect wildlife use.
- Fence should be checked, maintained and repaired periodically (minimum once per year, preferably twice per year).

Multi-use Wildlife Underpasses

SHEET H

General design

A multi-use wildlife underpass is similar in design to a wildlife underpass, however the management objective is to allow co-use by both wildlife and humans. These structures can be retrofit bridges for wildlife passage or designed specifically for co-use. They may be adequate for movement of some large mammals, but not all wildlife. Small- and medium-sized mammals will utilize the structures, particularly generalist species common in human-dominated environments (e.g., urban habitats). Structures may be able to be adapted for semi-arboreal species. Semi-aquatic and amphibian species may use them if they are located within their habitats.



Multi-use underpass in The Netherlands retrofitted for human use and wildlife passage (Photo: Marcel Huijser).

Use of the structure

Multi-use wildlife underpasses are designed for mixed wildlife and human use (recreational, agricultural, etc.).

General guidelines

- Being generally smaller than a viaduct or wildlife underpass, the ability to restore habitat underneath will be limited. Open designs that provide ample natural lighting will encourage greater development of native vegetation.
- May be located in prime wildlife habitat, but generally are near human use areas.
- If the structure is >12 m wide, human use (e.g., paths, riding trails) should be confined to one side, leaving greater space for wildlife use. Vegetation can be used to shield human use from wildlife.
- Frequent motor vehicle or all-terrain vehicle (ATV) use of underpass should be discouraged. High levels of disturbance from ATVs or other motorized vehicles at the underpass and adjacent area will likely disturb most wildlife in the area and negatively affect the ability of wildlife to use underpass for cross-road movements.
- Low-level vehicular traffic is acceptable through the underpass—e.g., rural or agricultural use. Keep the road unpaved and its margin vegetated to provide continuity through the underpass and adjacent habitats.
- Underpass should be designed to conform to local topography. Design drainage features so flooding does not occur within the underpass. Run-off from highway should not be directed toward the underpass.
- Maximize continuity of native soils adjacent to and within the underpass. Avoid importation of soils from outside the project area.

Dimensions – General guidelines

Width:

Minimum: 5 m

Recommended: >7 m

Height:

Minimum: 2.5 m

Recommended: >3.5 m

Types of construction

Concrete bottomless arch

Concrete bridge span (open-span bridge)

Steel beam span

Elliptical multi-plate metal culvert

Prefabricated concrete box culvert

Suggested design details

Crossing structure

- Attempt to mirror habitat conditions found on both sides of the road and provide continuous habitat adjacent to and within the structure.
- Revegetation is possible in areas of the underpass closest to entrances, as light conditions tend to be better than in the center of the structure.
- Design underpass to minimize the intensity of noise and light coming from the road and traffic.
- Maximize microhabitat complexity and cover within the underpass using salvage materials (logs, root wads, rocks, etc.) to encourage use by semi-arboreal mammals, small mammals, reptiles, and species associated with rocky habitats.
- It is preferable that the substrate of the underpass is of native soils. If the design has a closed bottom (e.g., concrete box culvert), a soil substrate ≥ 15 cm deep must be applied to the underpass interior.
- If rural traffic uses the underpass, do not install curbs or elevated margins of road that separate areas of vehicular use from wildlife use. The transition between the two areas should be natural and not present obstacles.
- Depending on the width of the underpass with vehicular traffic, wildlife paths could run along both sides (of a wide underpass) or along one side (of a narrow underpass); regardless of configuration, the wildlife paths should be > 2.4 m wide.

Local habitat management

- Protect existing habitat. Design with minimal clearing widths to reduce impacts on existing vegetation. Where habitat loss occurs, reserve all trees, large logs, and root wads to be used adjacent to and within the underpass.
- Wildlife fencing is the most effective and preferred method to guide wildlife to the structure and prevent intrusions onto the right-of-way.
- Discourage building underpass in locations with a road running parallel and adjacent to the entrance, as it will affect wildlife use.
- If traffic volume is high on the road above the underpass it is recommended that sound-attenuating walls be placed above the entrance to reduce noise and light disturbance from passing vehicles.

Possible variations

Divided road (two structures)

In-line

Off-set

Undivided road (one structure)

Maintenance

- If wildlife underpass is not being monitored on a regular basis, periodic visits should be made to ensure that there are no obstacles or foreign matter in or near the underpass that might affect wildlife use.
- Fence should be checked, maintained and repaired periodically (minimum once per year, preferably twice per year).

Wildlife Underpasses with Water Flow

SHEET I

General design

This is an underpass structure designed to accommodate dual needs of moving water and wildlife. Structures are generally located in wildlife movement corridors given their association with riparian habitats; however, some may be only marginally important. Structures aimed at restoring proper function and connection of aquatic and terrestrial habitats should be situated in areas with high landscape permeability, that are known wildlife travel corridors and that experience only minimal human disturbance. These underpass structures are frequently used by several large mammal species, yet use by some large mammals will depend on how it may be adapted for their specific crossing requirements. Small- and medium-sized mammals (including carnivores) generally utilize these structures, particularly if riparian habitat is retained or cover is provided along walls of the underpass by using logs, brush or root wads. These underpass structures can be readily adapted for amphibians, semi-aquatic and semi-arboreal species.



Wildlife underpass designed to accommodate water flow (Photo: Tony Clevenger).

Use of the structure

Exclusively for wildlife, but may have some human use.

General guidelines

- Underpass structure should span the portion of the active channel migration corridor of unconfined streams needed to restore floodplain, channel and riparian functions.
- If underpass structure covers a wide span, support structures should be placed outside the active channel.
- Design underpass structure with minimal clearing widths to reduce impacts on existing vegetation.
- Even with large span structures the ability to restore habitat underneath will be limited. Open designs that provide ample natural lighting will encourage greater development of important native riparian vegetation.
- Maximize the continuity of native soils adjacent to and within the underpass. Avoid importation of soils from outside project area.
- Motor vehicle or all-terrain-vehicle use should be prohibited. Eliminating public or any other human use, activity or potential disturbance at the underpass and adjacent area is recommended for proper function and maximizing wildlife use.
- Underpass should be designed to conform to local topography. Design drainage features so flooding does not occur within underpass. Run-off from highway near structure should not end up in underpass.

Dimensions – General guidelines

Dimensions will vary depending on width of active channel of water flow (creek, stream, river). Guidelines are given below for dimensions of wildlife pathway alongside active channel and height of underpass structure.

Minimum:

Width: 3 m pathway

Height: 3 m

Recommended:

Width: >3 m pathway

Height: >4 m

Types of construction

Concrete bridge span (open-span bridge)

Steel beam span

Concrete bottomless arch

Suggested design details

Crossing structure

- Structures should be designed to meet the movement needs of widest range possible of species that live in the area or might be expected to re-colonize the area—e.g., high- and low-mobility species.
- Attempt to mirror habitat conditions found on both sides of the road and provide continuous riparian habitat adjacent to and within the structure.
- Maximize microhabitat complexity and cover within underpass using salvage materials (logs, root wads, rock piles, etc.) to encourage use by semi-arboreal mammals, small mammals, reptiles and species associated with rocky habitats.
- Preferable that the substrate of underpass is of native soils.
- Revegetation will be possible in areas of underpass closest to the entrance, as light conditions tend to be poor in the center of the structure.
- Design underpass to minimize the intensity of noise and light coming from the road and traffic.

Local habitat management

- Protect existing habitat. Design with minimal clearing widths to reduce impacts on existing vegetation. Where habitat loss occurs, reserve all trees, large logs, and root wads to be used adjacent to and within the underpass.
- Wildlife fencing is the most effective and preferred method to guide wildlife to structure and prevent intrusions to the right-of-way. Mechanically stabilized earth walls, if high enough, can substitute for fencing and is not visible to motorists.
- Encourage use of underpass by either baiting or cutting trails leading to structure, if appropriate.
- Avoid building underpass in a location with road running parallel and adjacent to entrance, as it will affect wildlife use.
- If traffic volume is high on the road above the underpass it is recommended that sound attenuating walls be placed above the entrance to reduce noise and light disturbance from passing vehicles.
- Underpass must be within cross-highway habitat linkage zone and connect to larger corridor network.

- Existing or planned human development in adjacent area must be at sufficient distance to not affect long-term performance of underpass. Long-range planning must ensure that adjacent lands will not be developed and the wildlife corridor network is functional.



Mechanically stabilized earth wall serving as wildlife exclusion “fence” (Photo: Tony Clevenger).

Possible variations

Divided road (two structures)

In-line:

Undivided road (one structure)

Maintenance

- If the wildlife underpass is not being monitored on a regular basis, periodic visits should be made to ensure that there are no obstacles or foreign matter in or near the underpass that might affect wildlife use.
- Fence should be checked, maintained and repaired periodically (minimum once per year, preferably twice per year).



Pipes placed in culverts to provide cover for small mammal movement (Photo: Tony Clevenger).

Wildlife Overpasses

SHEET J

General design

Except for a landscape bridge, a wildlife overpass is the largest crossing structure to span highways. It is primarily intended to move large mammals. Small mammals, low-mobility medium-sized mammals and reptiles will utilize these structures if habitat elements are provided on the overpass. Semi-arboreal, semi-aquatic and amphibian species may use the structures if they are adapted for their needs. Types of vegetation and their placement can be designed to encourage crossings by bats and birds.



Recently completed wildlife overpass without landscaping (Photo: Tony Clevenger).

Use of the structure

Wildlife overpasses are intended for the exclusive use of wildlife. Prohibiting human use and human-related activities adjacent to the structure is highly recommended.

General guidelines

- To ensure performance and function, wildlife overpasses should be situated in areas with high landscape permeability, that are known wildlife travel corridors and that experience only minimal human disturbance.

- Maximize continuity of native soils adjacent to and on the wildlife overpass. Avoid importation of soils from outside the project area.
- Should be closed to public and any other human use/activities.
- Reduce light and noise from vehicles by using earth berms, solid walls, dense vegetation or a combination of these placed on the sides (lateral edges) of the structure.



Berm on wildlife overpass (Photo: Tony Clevenger).

Dimensions – General guidelines

Overpass Width:

Minimum: 25–30 m

Recommended: 30–50 m

Fence/berm height:

2.4 m

Soil depth:

1.0–1.5 m

Types of construction

Span:

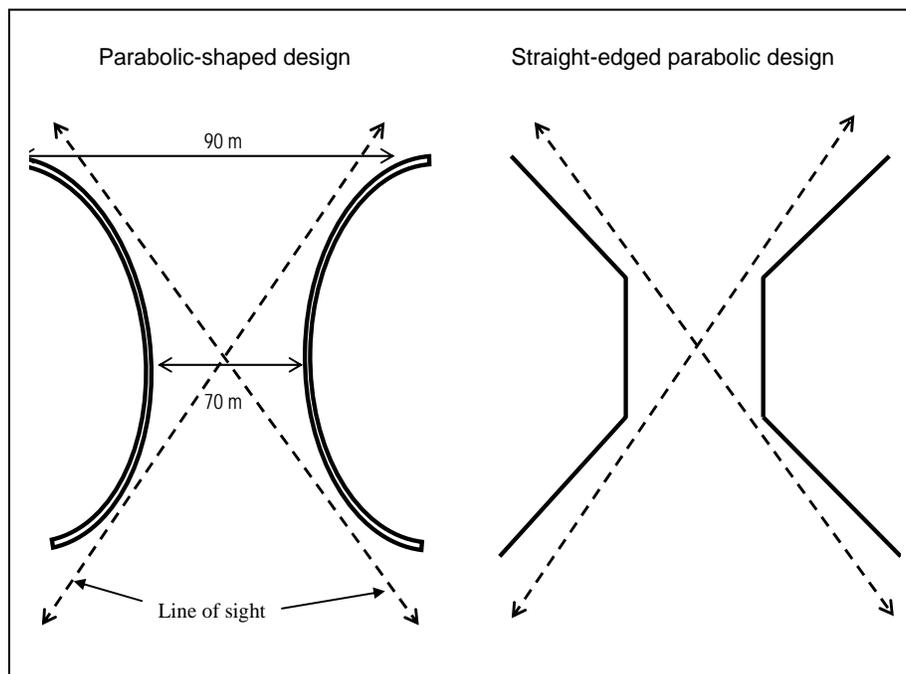
Bridge span (steel truss or concrete)

Arch:

Pre-fabricated cast-in-place concrete arches

Corrugated steel

Effective wildlife overpass design from Europe is a level, parabolic-shaped overpass, approximately 70 m wide at the centre and 90 m wide on the ends. The design allows for uninterrupted line of sight for animals approaching the overpass to view the opposite side of the overpass. The smooth-lined, true parabolic shaped overpass (left) is more expensive to build than the more economical straight-edged design (right).



Parabolic-shaped overpass design and straight-edged design.

Suggested design details

Crossing structure

- Wildlife overpass should be vegetated with native trees, shrubs and grasses. Species that match or are taxonomically close to existing vegetation adjacent to the structure should be employed. Site and environmental conditions (including climate) may require hardy, drought-tolerant species. Composition of trees, shrubs and grasses will vary depending on target species needs.
- Suggested design consists of planting shrubs on edges of the overpass to provide cover and refuge for small- and medium-sized wildlife. The center section of the overpass should

be left open with low-lying or herbaceous vegetation. Place piles of shrubs, woody debris (logs) or rock piles in stepping-stone fashion to provide microhabitat and refuge for small, cover-associated fauna. In arid locations, more piles of woody debris and rocks should be used to provide cover for small and medium-sized fauna.

- Soil depth should be sufficient to support 2.4–3.6-m-high trees. The structure should generally be vegetated with grasses and shrubs of varying height. Soil must be deep enough for water retention for plant growth. Structure must have adequate drainage.
- Local topography can be created on the surface with slight depressions and mounding of material used for fill.
- Amphibian habitat can be created in a stepping-stone fashion or by using isolated ponds. Pond habitat may be artificial with impermeable substrates to hold water from rainfall, or landscape designed areas for high water retention.
- Earth berms, solid walls, dense vegetation or a combination of these should be installed as sound- and light-attenuating walls on the sides of the structure. The walls should extend down to approach ramps and curve around to wildlife exclusion fence. The minimum height of walls should be 2.4 m.

Local habitat management

- Trees and shrubs should be located at the edges of approach ramps to guide wildlife to the structure entrance. The vegetation should integrate with the adjacent habitat. Adjacent lands should be acquired, zoned or managed as reserve or protected area into perpetuity.
- Wildlife overpasses are best situated in areas bordered by elevated terrain, enabling the approach ramps and surface of structure to be at the same level as the adjacent land. If the structure is built on level ground, then approach ramps should have gentle slopes (e.g., 5:1). One or both slopes may be steeper if built in mountainous areas.
- There is a trade-off between slope and retaining vegetative cover on approach ramps. A steep-sloped ramp will retain vegetative cover close to the overpass structure. Gentle slopes (3:1 or 4:1) generally require more fill, which extends the approach ramp farther out away from the structure and will bury vegetation, including trees.
- Wildlife fencing is the most effective and preferred method to guide wildlife to the structure and prevent intrusions onto the right-of-way. Mechanically stabilized earth walls, if high enough, can substitute for fencing and are not visible to motorists.
- Efforts should be made to avoid having roads of any type pass in front of or near the entrance to the wildlife overpass, as it will hinder wildlife use of the structure.
- Large boulders can be used to block any vehicle passage on the overpass.
- Existing or planned human development in adjacent areas must be at a sufficient distance to not affect long-term performance of the overpass. Long-range planning must ensure that adjacent lands will not be developed and the wildlife corridor network is functional.

Possible variations

- Vegetation for screening and fence

- Berms on approach ramps and in middle of overpass

Maintenance

- Relatively low maintenance. Walls and any fences may need to be checked and repaired.
- During first few years it may be necessary to irrigate vegetation on the structure, particularly if there are extended periods with little rainfall. Sufficient watering (assisted or rainfall) will allow vegetation to settle and take root.
- Monitor and document any human use in the area that might affect wildlife use of the structure and take action necessary to control.