Title
Wildlife Exclusion Systems for Accident Mitigation on British Columbia Highways

Author
Sielecki, Leonard E.

Publication Date
2005-08-02

WILDLIFE EXCLUSION SYSTEMS FOR ACCIDENT MITIGATION ON BRITISH COLUMBIA HIGHWAYS

Leonard E. Sielecki
British Columbia Ministry of Transportation
PO Box 9850 STN PROV GOVT
4B - 940 Blanshard Street
Victoria, B.C., Canada V8W 9T5
TEL: (250) 356-2255 / FAX: (250) 387-7735
E-mail address: leonard.sielecki@gov.bc.ca or leonard@sielecki.net

1. Abstract

The British Columbia Ministry of Transportation (BCMoT) has been addressing the issue of motor vehicle-related wildlife mortality on Provincial highways with wildlife exclusion fencing and related engineered structures since the 1980's. As a result, British Columbia wildlife are protected by the most extensive network of wildlife exclusion systems constructed by a transportation agency in North America. The BCMoT wildlife exclusion infrastructure consists of over 470 km of wildlife exclusion fencing complete with crossing structures designed to:

- protect the motoring public and wildlife;
- maintain operational efficiency of highways; and
- ensure wildlife habitat connectivity.

Wildlife exclusion systems are typically incorporated as an integral part of new highway construction to address projected potential wildlife mortality. As part of BCMoT's environmental assessment process, extensive wildlife identification and monitoring programs conducted by professional biologists and wildlife experts commence years before highway construction begins. When wildlife population clusters and migration routes are identified during environmental assessments, the habitat fragmenting potential of wildlife exclusion fencing is reduced with crossing structures. In some case, wildlife exclusion systems are retrofitted on existing highways where problematic wildlife accident locations which have developed over time are identified using BCMoT's Wildlife Accident Reporting System (WARS).

With each successive project, BCMoT has refined its fence and crossing structure designs and standards to increase the efficiency and effectiveness of its wildlife exclusion systems as the movement patterns and behavior of wildlife are better understood. BCMoT's approach to

reducing the potential for wildlife mortality has evolved from the application of simple engineered structures into more comprehensive integrated wildlife management systems as the knowledge about the dynamics of the highway/wildlife habitat interface in British Columbia has grown.

2. Protecting the motoring public and wildlife

One of BCMoT's mandates is to provide the motoring public in British Columbia with safe highways. Through contemporary highway designs and the use of standardized signage, BCMoT approaches highway safety in unison with other Canadian and U.S. highway agencies. As do its counterparts, BCMoT recognizes wildlife-related motor vehicle accidents as a serious threat to motorists and takes steps to reduce the potential of these accidents occurring (Figure 1).

Concurrently, the British Columbia Provincial Government has made "environmental stewardship" one of the goals of its administration. As a consequence, in order to support the Provincial Government's environmental objectives, BCMoT has the responsibility of protecting both the motoring public and wildlife within the Province highway system that falls under its jurisdiction. To fulfill its dual obligations, BCMoT has made significant investments in its highway infrastructure to reduce the potential for wildlife-related motor vehicle accidents. Over the last two decades, a major component of these investments has been the development of wildlife exclusion systems.

Figure 1. Wildlife-related motor vehicle accident

3. Maintaining operational efficiency of highways

Each year in British Columbia, trucks transport increasing larger amounts of cargo on Provincial highways. With the advent of "just-in-time" delivery and reduced inventories, businesses and industries have become increasingly reliant on trucks operating in a consistent, timely manner. In order for trucks to maintain this level of service, Provincial highways must enable traffic to flow as freely as possible to all regions of British Columbia. To foster the Provincial economy, BCMoT has been upgrading existing highways in the developing regions of British Columbia to decrease travel time and increase capacity. BCMoT has also been building new roadways, through previously undeveloped areas, to provide greater vehicular access in the Province.

Given the vast amount of frontier land in British Columbia, highway redevelopment and expansion has occurred in areas of rich wildlife habitat. As a consequence, the potential of wildlife-related motor vehicle accidents represents a threat to the safety of truck transport and the efficiency of the highway network. Accidents involving wildlife can result in significant damage to transport trucks and other motor vehicles and produce long traffic delays. This is especially true in remote areas where alternative highway routes are not readily available.

In order that consistent travel time and highway network efficiency be maintained the potential for incidents of wildlife-related motor vehicle accidents must remain low.
To ensure this, BCMoT develops wildlife exclusion systems on new expressways and on existing highways where the potential of wildlife-related accidents is considered to constitute a threat to the motoring public.

4. Ensuring wildlife habitat connectivity

As British Columbia's vast hinterland becomes subject to development, the demand grows for increased motor vehicle access for recreation, commerce and industry. The fragmenting impact of highways on wildlife habitat is a significant issue. Highways have the potential to sever access to critical breeding, rearing and foraging areas for wildlife. For some, small, slow-moving species, highways can become an impermeable barrier to movement. Maintaining habitat connectivity has become increasingly necessary to provide continued access of wildlife to food, water and shelter for the immediate survival needs of individual animals, and continued genetic diversity necessary for the long-term survival of wildlife species as a whole. This is particularly critical in areas where the habitat of small numbers of rare or endangered species has been severed by highway development. BCMoT strives to maintain habitat connectivity by incorporating crossing structures, such as underpasses, in its wildlife exclusion systems.

5. Wildlife exclusion systems in British Columbia

The greatest investment in wildlife accident mitigation by BCMoT has been its wildlife exclusion systems, incorporating specialized fencing designs and crossing structures. Approximately 470 km of fencing and 30 crossing structures have been installed on the Coquihalla Highway (Highway 5), the Okanagan Connector Freeway (Highway 97C), Highway 97 and the Vancouver Island Highway (Highway 19).

MoT's wildlife exclusion systems on the Coquihalla and the Okanagan Connector were pioneering efforts for their time. The first wildlife overpass in Canada was built for the Okanagan Connector. The recently completed Vancouver Island Highway wildlife exclusion installations are state of the art initiatives. With each successive project, the Ministry has refined its designs and standards, to improve the efficiency and effectiveness of its wildlife exclusion systems. Both fence and crossing structure designs have evolved over time.

BCMoT has found exclusion fencing to be the most effective means of keeping wildlife off highway right-of-ways. BCMoT's experience with 2.4 m high fencing on both sides of right-of-ways show it is 97-99% effective in preventing wildlife-vehicle accidents (Sielecki, 2004). BCMoT has also found wildlife exclusion fencing appears to be effective when installed on only one side of a highway, if the unfenced side of the highway has pre-existing barriers to animal movement, such as a cliff face.

For BCMoT, there are five main stages in the development of a wildlife exclusion system:

1) ongoing data collection,
2) pre-design analysis,
3) design,
4) construction and materials, and
5) post-construction monitoring.

6. Ongoing data collection

For almost 30 years, highway-related wildlife mortality data has been collected on a daily basis on all numbered Provincial highways that fall under the British Columbia Ministry of Transportation's jurisdiction (Figure 2). As part of their contracts, BCMoT's network of private maintenance contractors are responsible for the systematic data collection in support of BCMoT's Wildlife Accident Reporting System (WARS). This is a relatively unique situation among transportation agencies in North America.

Figure 2. Highway-related wildlife mortality

The WARS database provides a detailed historical record of wildlife mortality that is used as a tool for supporting decision-making with regards to the development of wildlife exclusion systems on existing and planned highways. For existing highways, WARS data is used to identify the magnitude and locations of highway-related wildlife mortality to focus BCMoT's wildlife accident mitigation efforts in the most cost-effective manner. For planned highways, WARS data is used as a surrogate data source to guide Ministry engineers and planners and private consultants in their evaluation of potential wildlife accident risks.

7. Pre-design analysis

Prior to the design of a wildlife exclusion system, whether as part of a new highway, or the large-scale redevelopment of an existing one, wildlife biologists are contracted by BCMoT to collect detailed wildlife population and habitat information. Aerial and ground surveys are used to quantify the numbers of wildlife and their movement patterns on lands adjacent to existing and planned highway corridors. Detailed information on the topography and biophysical components of the landscape is used to analyze resident and migratory wildlife movements related to critical life activities, such as breeding, rearing, and seasonal foraging. Data from the WARS database is used to identify locations where wildlife accident potential may be high. For new highway development and large-scale redevelopment of existing highways, these activities form an integral part of the environmental assessment (EA) process used by BCMoT.

The information provided by the wildlife biologists is one of the factors BCMoT's planners and engineers consider for selecting a highway alignment. Once the alignment has been selected, detailed plans are developed to incorporate the key components of a wildlife exclusion system necessary to protect those species of animals identified by the wildlife biologists.

8. Design

Depending on the highway project, wildlife exclusion systems can vary greatly in scale and complexity. A wildlife exclusion system can be as simple as a fence for a single species, used to connect existing or planned structures, such as bridges and culverts; or more complex when multi-species oriented crossing structures, such as underpasses, and wildlife habitat features, such as ponds are incorporated into the design.

Wildlife biologists provide vital information about the physical and behavioral characteristics of wildlife to BCMoT's engineers so that appropriate structures can be designed to meet species-specific wildlife needs and encourage their use of the structures. In British Columbia, large ungulates, such as moose and elk can weigh in excess of 700 kg and stand in excess of 1.5 metres in height (Figure 3.). They represent a formidable obstacle for typical passenger motor vehicles.

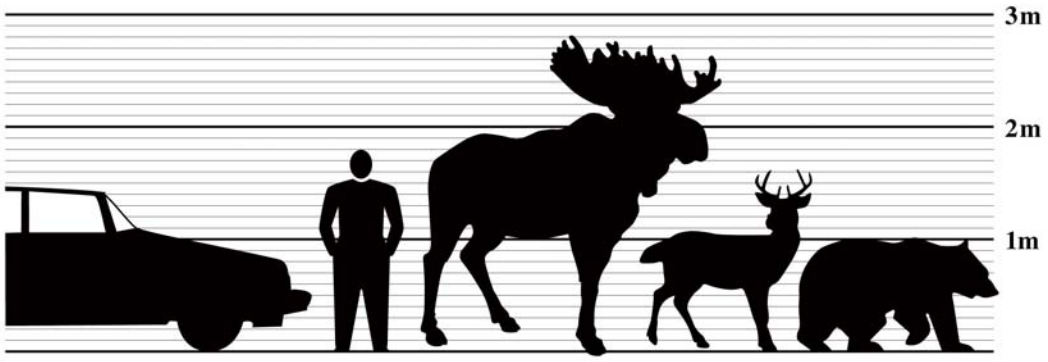

Figure 3. Relative size of moose, deer and bear compared to a 1.8 metre human and compact auto (adapted from Maine Interagency Work Group on Wildlife/Motor Vehicle Collisions, 2001)

Wildlife exclusion systems are designed for specific species which represent the greatest potential hazard to the motoring public. The structural components of the fencing is designed to withstand the forces of the largest animals and prevent the smallest animals from breaching gaps in the fence. The structural strength requirements are designed to withstand the force of the largest ungulates, usually bull elk or bull moose.

Large, aggressive animals, such as moose require heavier metal or wooden posts, spaced closely, and heavier fence mesh held onto the posts with heavy clamps. Heavy snow loading

requires heavier metal or wooden posts, spaced closely, and heavier fence mesh held onto the posts with heavy clamps. Steep, rocky terrain, which prevents the use of heavy equipment and makes the installation of wooden poles difficult, requires the use of metal posts placed in drilled holes. Soft, swampy soils require the use of concrete to stabilize posts. The spacing of posts ranges from 2.5 metres to 3.5 metres. Wider spacing is uses for smaller animals, such as deer, in areas with little relief and low snow accumulation. A wildlife exclusion system that promotes long term survival of the animals it protects relies on establishing and maintaining habitat connectivity. Animals must be able to exit the highway right-of-way and successfully reach their habitat. To facilitate the movement of wildlife away from highway right-of-way, BCMoT has invested considerable effort in the design of one-way gates to accommodate the size, shape and movement characteristics of deer, moose and elk (Figure 4).

The design of one-way gate tynes has been evolving as their use by ungulates has been become better understood (Figure 5). The original straight tyne was found to be an impalement hazard. Early in their application, a moose reversed its direction of movement while passing through a one-way gate and impaled itself. The moose's movement backward in the one-way gate had not been anticipated when the original "straight" tyne design was developed. The next version of the one-way gate tyne, the "looped" tyne was also found to be defective as the loops became ensnarement hazards when deer passing through the gates were found to raise their front legs and catch them in the loops (Figures 6 and 7). The "looped" design has been replaced with the "disked" and "ball" tyne designs, which prevent impalement and ensnarement. The use of the "disked" and "ball" tyne designs is currently being monitored to determine if they are operating properly.

Underpasses are another component of wildlife exclusion systems that have been evolving. The early underpasses constructed were approximately 3.7 metres in diameter (Figure 8.) Although monitoring of wildlife tracks indicated these structures were used by deer, BCMoT designed structures, in excess of 5 metres, to increase deer use, and better accommodate elk and moose (Figure 9.) In an effort to make underpasses more suitable for ungulates, BCMoT has been building larger structures and incorporating features to accommodate the needs of more species, including fish (Figure 10).

The BCMoT wildlife exclusion fencing specifications are designed to produce a fence with a 15 to 20 year lifespan. The remote locations of some wildlife exclusion fencing makes daily inspection and maintenance impractical, if not impossible.

Figure 4. One-way gate designed for moose and deer

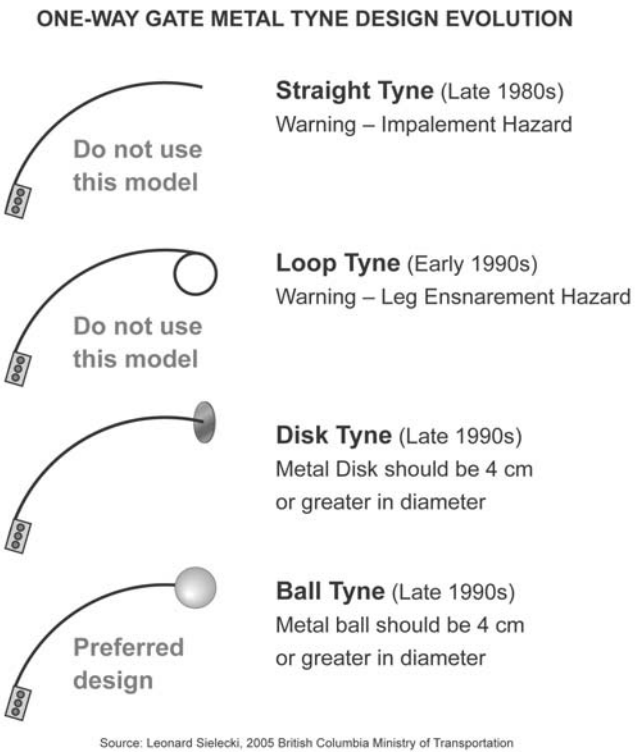

Figure 5. One-way gate metal tyne design evolution

Figure 6. One-way gate with “looped” tynes

Figure 7. Deer ensnared on “looped” tyne

Figure 8. Wildlife underpass designed for deer on the Okanagan Connector (early 1990’s)

Figure 9. Wildlife underpass designed for elk and deer on the Vancouver Island Highway (1999)

Figure 10. Multi-species wildlife underpass on the Vancouver Island Highway (1999)

The BCMoT has examined the use of earthen ramps or jumps to enable wildlife to leave fenced highway rights-of-way in other jurisdictions (Figure 11). At this time, the Ministry does not use earthen ramps because provincial highway rights-of-way are accessible to the public. Although earthen ramps may be more effective than one-way gates for use by large ungulates, unresolved safety issues, relating to the activities of mountain bikers, all terrain vehicle users and hikers, have delayed the use of earthen ramps.

Figure 11. Earthen ramp designed for deer in Belgium

9. Construction and materials

Workmanship and materials are vital components of the construction phase for wildlife exclusion systems. Attention to design details by workers and the use of good quality materials help ensure the systems will operate as designed for an extended period of time. This is especially important because wildlife exclusion systems are usually located in remote areas where daily maintenance is difficult to perform.

BCMoT specifications for materials have been developed to produce fences with an expected design life of 15 to 20 years. All metal components are either stainless steel or heavily galvanized. Metal fence poles and fence mesh are heavily galvanized. In areas of heavy snowfall and/or aggressive large ungulates, heavy-duty stainless steel clamps are used to attach fence mesh to the poles. Wooden fence posts are typically 18cm to 22cm in diameter, and pressure treated for periods in excess of conventional construction standards.

Quality control and quality assurance are critical. During construction, inspections occur regularly to ensure correct materials are being used and construction techniques will result in a durable structure that meets design specifications. Upon completion of the projects, careful examination and testing of the structures occurs before the project is accepted.

10. Post-construction monitoring and maintenance

In a natural mountainous setting, severe climate and aggressive vegetation can create operational problems for wildlife exclusion systems. As a consequence, these systems must be

monitored on a regular basis to ensure they function as designed and deficiencies can be identified and addressed in a timely manner.

In early 2005, comprehensive audits of BCMoT's wildlife exclusion systems were conducted for BCMoT by professional wildlife biologists (Demarchi, 2005; Harper, 2005; Hartwig and Demarchi, 2005; and Hayward, 2005). The audits were intended to provide a detailed inventory on the design and condition of the fencing, one-way gates, ungulate guards and crossing structures. The audits also reported on the use of each component of the system by wildlife.

The audits found the wildlife exclusion systems were functioning as designed. However, in a number of locations, repairs. Fence mesh damage was caused by tree and rock falls, motor vehicle accidents, snow loading, and vandals. In some areas, small trees were found to be growing into the fence mesh. Similarly, trees were also found growing inside some one-way gates, hence impeding their operation. While fence poles were subject to ground subsidence, physical damage was limited to motor vehicle accidents. In all cases, repairs were most necessary in locations where severe winter conditions and heavy snowfall accumulations preclude year-round maintenance.

Evidence of wildlife use of one-way gates and crossing structures was shown by tracks, hair and fecal droppings. A number of wildlife underpasses were found to be used by humans as temporary shelter, as evidence of food wrappers and packaging was found. The effect of this material on the use of underpasses by wildlife is unknown. However, it is believed wildlife avoid using the underpasses when humans are in them.

At most wildlife exclusion system installations, the remains of dead deer were found near one-way gates, exiting the highway right-of-way. The causes of death could not be determined because the remains were in poor condition. Further investigation is required to determine if the deer were using the one-way gates after being struck by motor vehicles on the highway, or if the deer were attacked by predators as they passed through the gates.

For the most part, it appears the deficiencies identified in the 2005 audits of BCMoT's wildlife exclusion systems can be remedied with simple repairs of fence mesh and the elimination of gaps between fencing and underpasses. Regular maintenance is essential for ensuring that wildlife exclusion systems operate properly. In British Columbia, roadside fence maintenance is a part of the BCMoT’s highway maintenance contracts maintenance specifications. Damage done to fencing by falling trees, motor vehicles, vandals and heavy snow loads must be repaired in an expedient manner. In areas where trees are located close to wildlife exclusion fencing, the potential for a treefall on top of the fence is ever present. Where mature trees do not exist, the potential exists for new trees to grow through the fence or block one-way gates. One-way gates

must be kept clear of growing trees and broken tynes must be replaced as quickly as possible. In areas subject to heavy snow accumulations, inspections and maintenance earlier in the Spring should reduce the potential for motor vehicle-related ungulate mortality.

Unlike the effects of nature, such as falling trees, ground subsidence and heavy snow, vandalism is a manmade issue that has the potential to become a serious problem. Uncontrolled human access by hunters and poachers, mountain bike enthusiasts, and all terrain vehicles (ATVs) by way of holes cut into fences or the disabling of one-way gates compromise the integrity of wildlife exclusion systems. While such activities are difficult to detect when they occur, regular monitoring and maintenance should reduce the time the effects of vandalism compromise the wildlife exclusion systems. Without regular monitoring and maintenance, the motoring public is provided with a false sense of security by wildlife exclusion systems which are compromised.

11. Case studies

From the mid 1980's until the mid-1990's, BCMoT designed and constructed two new, major sections of highway that transected large tracts of wildlife habitat in the southern interior of British Columbia. The construction of the Coquihalla Highway (Highway 5) occurred in two phases, while the construction of the Okanagan Connector (Highway 97C) was completed in one (Figure 12). The wildlife exclusion systems developed on these highways were the first projects of their kind in British Columbia. The Coquihalla Highway is an example of a retro-fit installation on an existing highway, while the Okanagan Connector is an example of integrating a wildlife exclusion system as a component of a new highway.

(a) Coquihalla Highway (Highway 5)

The Coquihalla Valley has long served as the major transportation route in British Columbia linking the West Coast to the Interior. The origins of the highway network originate with the Hope-Nicola Trail in 1876. The development of road access through the valley culminated with the construction of the Coquihalla Highway (Highway 5) in 1986 to coincide with the EXPO86 in Vancouver.

The Coquihalla Highway is a high speed (110 km/hr) toll road which extends north from Hope to Kamloops, via Merritt. It is the only toll road in British Columbia. At lower elevations, the highway passes through large stands of Douglas fir and ponderosa pine (Figure 13). As the highway climbs to higher elevations, through the Great Bear Snow Shed and to the summit of Coquihalla Pass at an elevation of 1240 metres, it passes through large stands of Engelmann

spruce, lodgepole pine, and subalpine fir. Once past the summit, the highway traverses the top of the Thompson Plateau, through expansive rolling countryside dotted with many small lakes. Extensive grasslands occur at low-elevation areas, particularly closer to Merritt in the north.

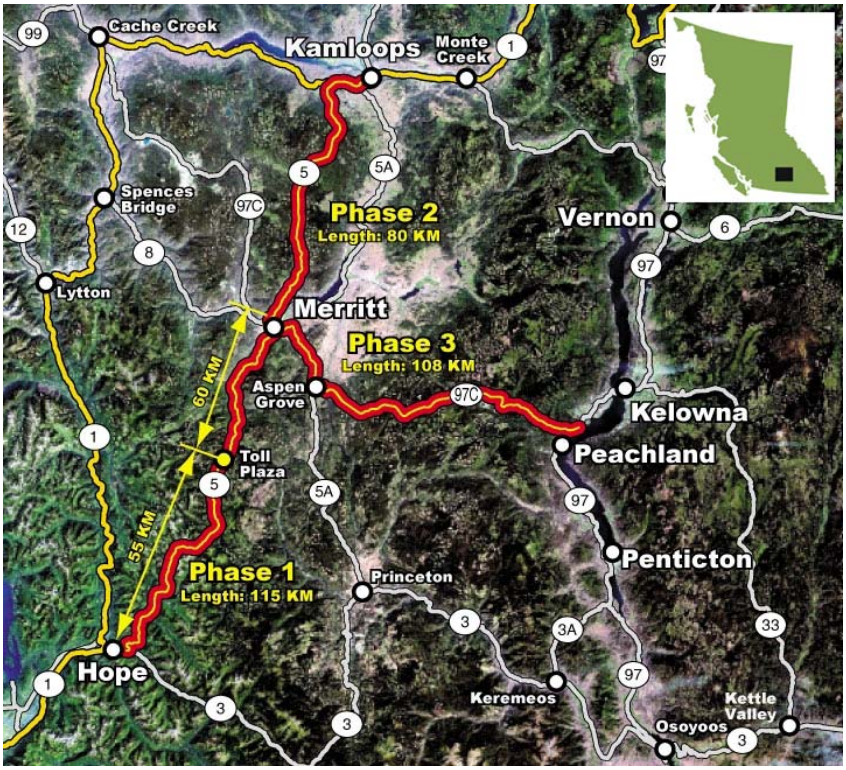

Figure 12. Location map of Highways 5 and 97C in southern British Columbia

Figure 13. Coquihalla Valley

The Coquihalla Valley contains prime wildlife habitat. The primary large ungulate species found throughout the area are mule deer and smaller numbers of moose. Small concentrations of elk and mountain goats are found in the southern reaches of the valley. The combination of large ungulates and high speed vehicle traffic prompted the British Columbia Ministry of Transportation to construct its first wildlife exclusion system to protect motorist and wildlife.

Between 1979 and 1981, prior to the construction of the Coquihalla Highway, winter wildlife studies were conducted (Kent, 2005, personal communication). The studies indicated few resident deer and moose resided in the area. Limiting the studies to the winter periods resulted in a serious shortfall in information regarding migratory animals. The winter tracking studies were unable to identify the annual Spring/Summer and Fall movements of large herds of deer from the Tulamene Valley to the Coldwater Valley and down to Boston Bar across the proposed highway alignment. The lack of information became apparent just after the highway opened. In 1986, when between May and July and between October and November, unexpectedly large numbers of deer were killed during their seasonal migrations.

In response to these deer-related accidents, BCMoT initially installed wildlife reflectors. When it became apparent the reflectors alone would not be able to reduce the high numbers of accidents on the highway, BCMoT began the design and construction of wildlife exclusion fencing on the first phase of the highway. By improving on the designs originally developed by Public Works Canada for Banff National Park, BCMoT was able to develop effective fencing and one-way gates. The total length of the Coquihalla Highway is approximately 187 kilometres (British Columbia Ministry of Transportation, 2004). Wildlife exclusion fencing was constructed for a distance of approximately 70 kilometres on both sides of the highway (Figures 14 and 15).

Fencing on the Coquihalla Highway was constructed to control deer primarily because of their numbers in the area, but was designed to handle moose because of their more significant potential accident severity risk (Figure 16).

Wildlife exclusion fencing has proven very effective in reducing wildlife accidents on the Coquihalla Highway (Highway 5) located between Hope and Merritt. On the 35 km portion of the Coquihalla Highway, between Dry Gulch Bridge and Kingsvale Bridge, wildlife exclusion fencing reduced wildlife accidents by 100%. Data from the WARS database indicates the number of wildlife accidents declined from 74, in the 1989 to 1993 period, to 0, in the 1994 to 1998 period.

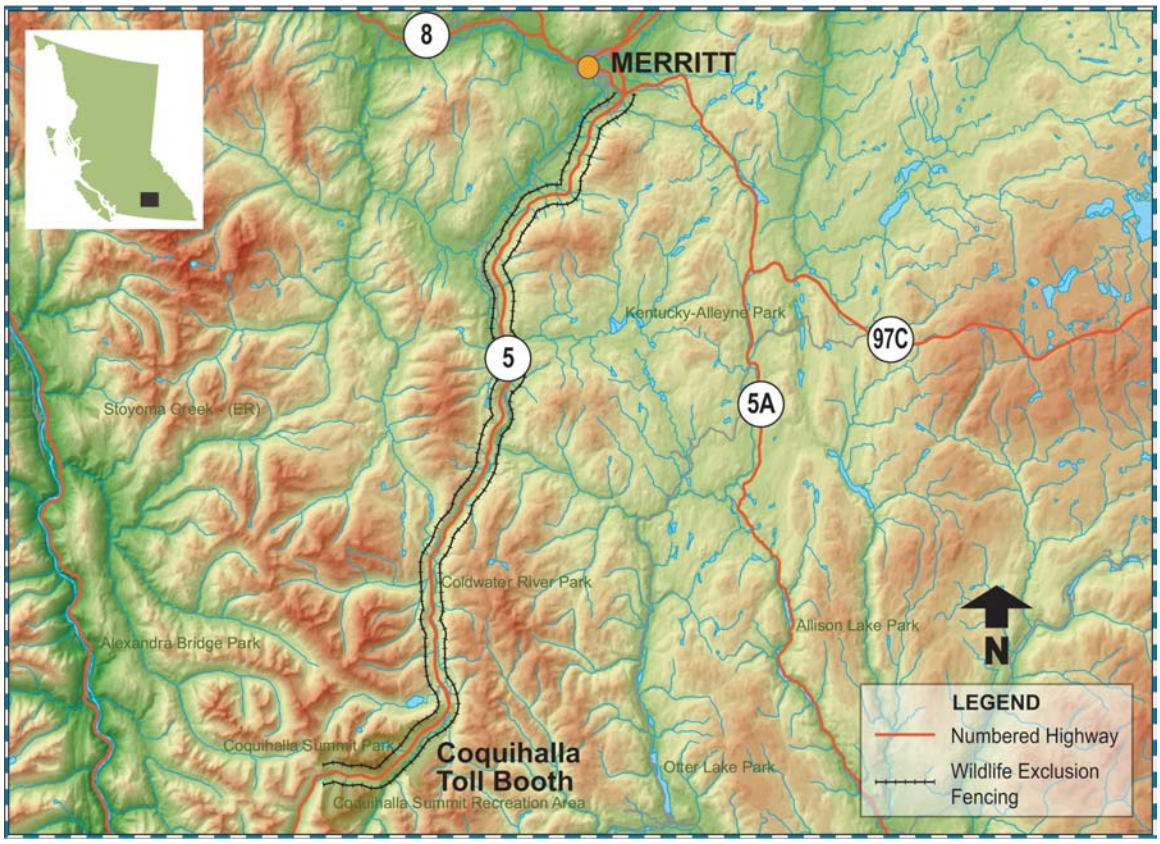

Figure 14. Location of wildlife exclusion fencing on the Coquihalla Highway

Figure 15. Wildlife exclusion fencing on Coquihalla Highway

Figure 16. Wildlife exclusion fencing designed for moose

b) Okanagan Connector (Highway 97C)

The Coquihalla Connector (Highway 97C) is a high speed freeway (110 km/hr posted speed limit) that links the Coquihalla Highway at Merrit to Highway 97 and the Okanagan communities of Kelowna and Peachland (Figure 17). The highway is approximately 188 kilometre long and provides a vital link in the province's highway network, connecting Vancouver and the Fraser Valley to the Okanagan Valley via the Coquihalla Highway. This highway is one of the highest elevation highways in Canada. At Pennask Summit the elevation of the Okanagan Connector is 1,728 metres.

The Okanagan Connector was opened in 1990 (Figure 18). It is a controlled access free way with no "at grade" intersections. Prior to its construction, the seasonal ranges and movements of moose were extensively studied between 1987 and 1989. Fourteen cow moose were radio-collared and relocated a total of 1212 times during this period (Gyug and Simpson, 1989). A fixed wing aircraft and helicopter were used to estimate population numbers. The studies were able to identify migration behavior that varied from some moose remaining in one location all year round; other moose had distinct winter ranges, but combined summer fall ranges; while, yet other moose had distinct winter, summer, and fall ranges. Moose were found to pass through a 7 metre diameter culvert. Tracking counts showed the passage rate by moose was 17%. Moose were found to migrate away from higher elevation habitats where snow depths exceeded 70 cm. Moose preferred lower elevation riparian or mixed deciduous-evergreen habitats where forage was abundant and thermal or security cover was available in nearby forests.

Figure 17. Location of wildlife exclusion fencing between Aspen Grove and Drought Hill

Figure 18. Okanagan Connector

Underpasses for critical moose passage in winter range were determined to be 6.5 metres by 7.4 metres (Abrams, 1986). Deer underpasses were determined to be 4.2 metres by 3.7 metres. The installed cost in 1989 for wildlife mitigation for the Okanagan Connector was estimated to be $5.75US million. For this project, BCMoT spent $390,000US on wildlife and mitigation studies (Stuart, 1989).

Annual wildlife-vehicle collisions for the entire alignment were estimated to at 500 deer and 100 moose. A total of 40 moose collisions were estimated for the section of highway between km 60 and km 90 annually. There are approximately 82 kilometres of wildlife exclusion fencing constructed on the Okanagan Connector on both sides of the highway. The fencing was designed to control moose, as the primary species, based on the size and weight of these animals, and deer, as the secondary species, based on their large population in the area (Figure 19).

As part of the exclusion system, a wildlife overpass was constructed near Trepanier Creek. It was the first wildlife overpass constructed in Canada (Figure 20). Since the wildlife exclusion system was constructed on the Coquihalla Connector Freeway (Highway 97C) in 1990 to 1998, no wildlife accidents were recorded in either the westbound or eastbound lanes of the highway which are protected by wildlife exclusion fencing.

Figure 19. Wildlife exclusion fencing and deer

12. Integrated Wildlife Management

It is becoming evident in British Columbia that approaching the issue of wild accident mitigation from a single species perspective does not provide the maximum benefit for motorists

or wildlife. For BCMoT, integrated wildlife accident management is becoming a greater component of new construction and rehabilitation projects. While, for over 20 years, BCMoT projects have focused on the accident issues associated with larger ungulates, primarily deer, elk and moose, new projects are increasingly becoming more responsive to the needs of smaller mammals, such as badgers, and amphibians, such as salamanders.

Figure 20. Trepanier wildlife overpass on Okanagan Connector

Wildlife exclusion systems are being designed and integrated with larger scale structures and alignment drainage schemes to provide protect an increasing number of animal species. The construction of larger underpasses, such as bridges and culverts, and the retention of natural watercourses, vegetation and landforms under these structures, increases their effectiveness for wildlife and fish passage. High quality wildlife habitat ponds are developed along highway alignments to lessen the impact of highways on wildlife habitat (Figure 21).

Most recently, on the Vancouver Island Highway Project, wildlife crossing structures and wildlife habitat ponds were carefully integrated with natural topography and drainage systems, to reduce the potential for wildlife-related motor vehicle accidents and limit the wildlife habitat fragmenting effects of highways.

13. Summary

BCMoT has found its wildlife exclusion systems to be very effective in reducing motor vehicle-related mortality on high speed highways for selected species of ungulates, primarily deer, elk and moose. Whether the systems are incorporated into the designs of new highways or

retrofitting into existing ones, they are becoming an integral component on BCMoT's approach to reducing the potential for wildlife accidents on its highways.

Figure 21. Man-made wildlife habitat pond adjacent to Vancouver Island Highway (1999)

Wildlife exclusion systems are most easily incorporated into the design and construction of new highways. In this way, the designs of major structures, such as bridges and culverts, can be modified to maximize their effectiveness for wildlife passage. Exclusion systems have been found to be the most effective means of keeping wildlife off highway rights-of-way when installed in conjunction with wildlife crossing structures. Underpasses increase the success of exclusion fencing by increasing the permeability and habitat connectivity across highways (Clevenger and Waltho, 2000).

Regular maintenance and monitoring are key factors to ensuring wildlife exclusion systems remain effective. BCMoT has found that the integrity of wildlife exclusion systems can be compsromised by poor fence designs, faulty construction and materials, extreme snow accumulation and tree falls and vandalism.

The Ministry's experience with 2.4 m high fencing on both sides of rights-of-way shows it is 97-99% effective in preventing wildlife-vehicle accidents (Sielecki, 2004). These results are appear higher than the 80% reductions in wildlife accidents experienced when wildlife exclusion fencing was installed along the Trans-Canada Highway in Banff National Park (Clevenger, Chruszez and Gunson, 2001).

References

a) Books and Books chapters

Sielecki, L.E. (2004) **WARS 1983 – 2002: wildlife accident reporting and mitigation in British Columbia: special annual report**, British Columbia Ministry of Transportation, Environmental Management Section, British Columbia, Canada, 222pp.

b) Journal papers

Clevenger, A.P., Chruszez B. and Gunson, K.E. (2001) Highway mitigation fencing reduces wildlife-vehicle collisions, **Wildlife Society Bulletin**, 29(2): 646-653.

c) Other documents

Abrams, A. (1986) British Columbia Ministry of Transportation and Highways Communication to D.G. Johnson, Senior Design Engineer, Special Project, British Columbia Ministry of Transportation and Highways.

British Columbia Ministry of Transportation (2004) **Quick Facts Book**, October 2004, Victoria, B.C. 32 pp.

Demarchi, M. (2005) **Wildlife Exclusion Fencing Audit: Coquihalla Highway (No. 5): Dry Gulch to Inks Lake Interchange**, LGL Limited, Sidney, BC. 17pp.

Gyug, L. and Simpson K. (1989) **Okanagan Connector Ungulate Telemetry and Inventory Progress Report, Seasonal Ranges and Movements of Moose**, Keystone Bioresearch, Surrey, B.C. 32 pp.

Harper, W.L. (2005) **Wildlife Exclusion Fencing on the Okanagan Connector Freeway (Highway 97C) Audit and Evaluation of Structures and Materials and Recommendations for Maintenance**, Osiris Wildlife Consulting, Victoria, B.C., 48pp.

Hartwig C.L. and Demarchi R.A. (2005) **Wildlife Exclusion Fencing Audit: Vancouver Island Highway No.19.**, Ecodomain Consulting, Duncan, B.C., 19pp.

Hayward, D. (2005) **Highway 97 Wildlife Exclusion Fence Audit**, Summit Environmental Consultants Ltd., Vernon, B.C., 33pp.

Stuart, K. (1989) British Columbia Ministry of Environment, Communication to Mike Kent, Senior Environmental Coordinator, British Columbia Ministry of Transportation and Highways

d) Personal Communication

Kent, M. (2005) British Columbia Ministry of Transportation Communication to L.E. Sielecki, WARS Manager, British Columbia Ministry of Transportation