URSUS Environmental
Wildlife and Environmental Resource Consulting

Salmon River Diversion Wildlife Overpass Pilot Project
(BCRP Project No. 01.W.08)
Final Report

November 30, 2004

Prepared by
Joe Materi, R.P.Bio.
Charlene Forrest, M.Sc.

Prepared with financial support from
The Bridge Coastal Fish & Wildlife Restoration Program
6911 Southpoint Drive (E 16)
Burnaby, B.C.
V3N 4X8

2126 Newcastle Lane, Nanaimo, British Columbia V9R 5X9 Ph./Fax (250) 753-0097
e-mail: ursusnanaimo@telus.net

Salmon River Diversion Wildlife Overpass Pilot Project
(BCRP Project No. 01.W.08)
2004 Final Report

EXECUTIVE SUMMARY

A two year (2002-2004) wildlife overpass study was conducted on BC Hydro's 2.5 km Salmon River Diversion canal, located 30 km northwest of Campbell River, Vancouver Island. The project investigated potential canal footprint impacts on movement and dispersal patterns of terrestrial wildlife, ranging from amphibians to ungulates. A newly constructed wildlife overpass, and an existing (>40 years) BC Hydro maintenance bridge (350 m downstream), were monitored for evidence of wildlife travel. Construction of the 3.5 m x 14.6 m temporary wooden wildlife overpass was completed in the fall of 2002. Overpass design loading was set at 10,000 lbs. (20 lbs./sq. ft.) for wildlife, and 20,000 lbs. (40 lbs./sq. ft.) for snow.

The objectives of this study were to:

- identify species which may potentially benefit from an overpass
- summarize overpass design criteria from existing information sources
- locate, design and construct a temporary wildlife overpass
- assess wildlife utilization by monitoring for 2 years post-construction

Data on species-specific travel, intervals between overpass construction and first-use, and level of use were documented. Rates of wildlife use were assessed over the entire study period, annually, seasonally and daily on both the constructed wildlife overpass and the existing maintenance bridge. Eight species common to the area: Roosevelt elk, Columbian black-tailed deer, cougar, black bear, grey wolf, marten, red squirrel and deer mice, were predicted to make use of the overpass. Review of existing information suggested that the location, rigidity, deck covering, "openness" and lead fencing are important design elements for achieving wildlife use of an overpass. To document wildlife use, remote camera systems, opportunistic sightings, track beds, track plates and pit fall traps were used.

Of the eight mammal species predicted to benefit from the overpass, seven made successful crossings. Only the grey wolf was undetected on or near the site. Use by the eastern cottontail and raccoon were unexpected and increased the total number of species detected to nine. Within 12 months, approximately 75% of wildlife approaches lead to successful crossings. Evidence of crossings by all nine species was recorded within 17 months of construction completion. The interval between construction completion and first use of the overpass ranged from 6 days for deer to 502 days for red squirrels.

In total, 123 wildlife crossing events were recorded at the overpass. A large majority of these were single animals, however small groups of deer, elk and cougars were also noted. Marten presented the highest rate of use (53%), followed by deer (17 %)

and squirrels (10 %). Remaining species accounted for 1 to 6 % of recorded crossings. In the second year there was a 28% increase in total use. Deer crossing rate increased by 180% in the second year, and data suggested a habituation occurred. In contrast, and although they continued to have the highest rate of use, marten activity decreased by 40% in 2004.

The highest rate of overpass use occurred in summer months (45%), followed by spring (25%), fall (20%) and winter (10%). Some results demonstrated expected relationships between species travel and their seasonal activities. In both years, the high rate of marten use in July and August could be related to females entering estrus. Similarly, the absence of marten activity in April could be related to den-bound females in the birthing period. With the remote camera data, species-specific daily travel times could be determined. For example, 64-65% of deer and marten crossings occurred in darkness, 14-15% at dusk or dawn and 21% in daylight.

Seven of the nine species that used the wildlife overpass also made successful crossings of the maintenance bridge. Only two species, Roosevelt elk and eastern cottontail failed to be detected at the maintenance bridge. This could be attributed to interruptions of remote camera service. Black bear use of the well-established maintenance bridge was notably higher than at the recently constructed overpass.

The Salmon River Diversion Wildlife Overpass Pilot Project demonstrated that potential footprint impacts on wildlife can be addressed through the installation of passage structures. Within two years, the overpass in this study supported considerable wildlife use. However, the overpass service life is estimated to be 10 years, therefore replacement of this temporary structure with a permanent, low maintenance one is recommended. To facilitate permanent overpass site-selection, a monitoring study employing consistent techniques, at all potential crossing areas and through all seasons, should be conducted.

Salmon River Diversion Wildlife Overpass Pilot Project
(BCRP Project No. 01.W.08)
2004 Final Report

Table of Contents **Page**

List of Figures

List of Tables

APPENDICES

Salmon River Diversion Wildlife Overpass Pilot Project
(BCRP Project No. 01.W.08)
2004 Final Report

1.0 INTRODUCTION

1.1 Background

The Salmon River Diversion (SRD) is an integral component of BC Hydro's Campbell River power Generation Facility on Vancouver Island. The SRD is a 2.5 km long, steep-walled concrete canal (Figure 1) located approximately 30 km northwest of the City of Campbell River (Figure 2). It directs intake water from the middle reaches of the Salmon River into Lower Campbell Lake, which functions as a reservoir for the Ladore Dam. Water flows into Lower Campbell Lake through Blair Ross, Brewster, Gray and Fry Lakes, and a series of linear wetland complexes (Figure 3). Although there are periods when the canal is dry, flow rates average 11 m^3/sec. Maximum flow rates may exceed 40 m^3/sec.

1.2 Project Rationale

Few species of wildlife are able to meet all their basic requirements in a small area. Daily, weekly or seasonal movement across the landscape is a necessity for most terrestrial wildlife species. As such, the location, size, and flow rates of the SRD suggest a significant potential to impact traditional movement and dispersal patterns of wildlife in the area. The canal may present a physical or psychological barrier, limiting access to reproductive partners which could result in sub-populations of limited genetic diversity and, over the long-term, increased vulnerability of extirpation.

The potential for wildlife entrainment in the diversion canal (Figure 4) has been noted by Blood (1993), the BC Ministry of Water, Land and Air Protection (K. Brunt *pers. comm.* 2001), and BC Hydro's Strategic Plan for the Campbell River Watershed (BC Hydro 2000). There are also anecdotal reports of Roosevelt elk drowning in the Salmon River Diversion canal following a heavy snowfall event in the 1960's. Blood (1993) recommended that BC Hydro install wildlife overpass structures across the canal as a means of mitigating such impacts.

The rationale for the Salmon River Diversion Wildlife Overpass Pilot Project has two elements:

1) to restore pre-development wildlife movement patterns; and
2) to reduce wildlife entrainment in the canal.

Figure 1. Typical view of the Salmon River Diversion canal walls.

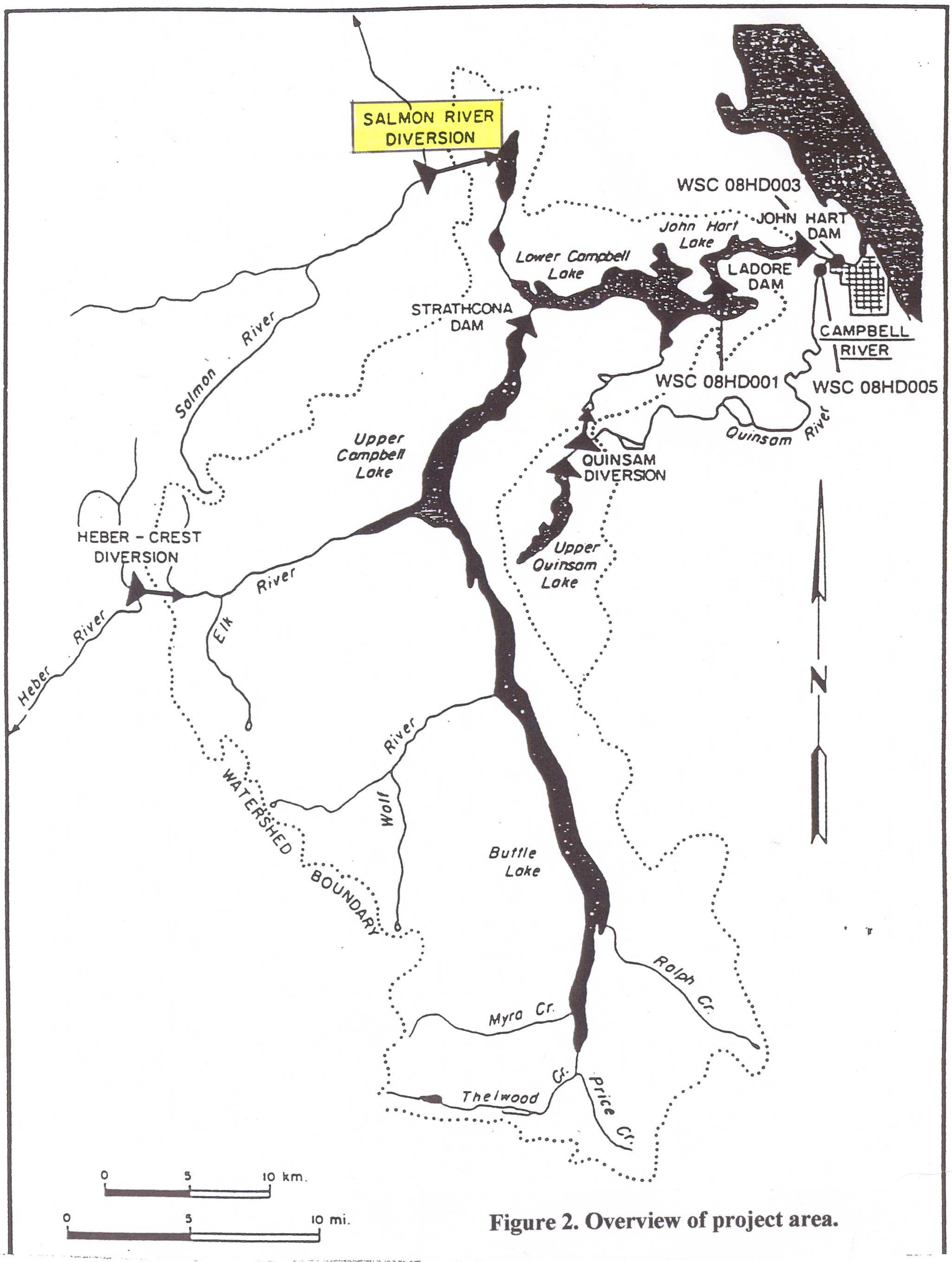


Figure 2. Overview of project area.

Figure 3. Project area location plan.

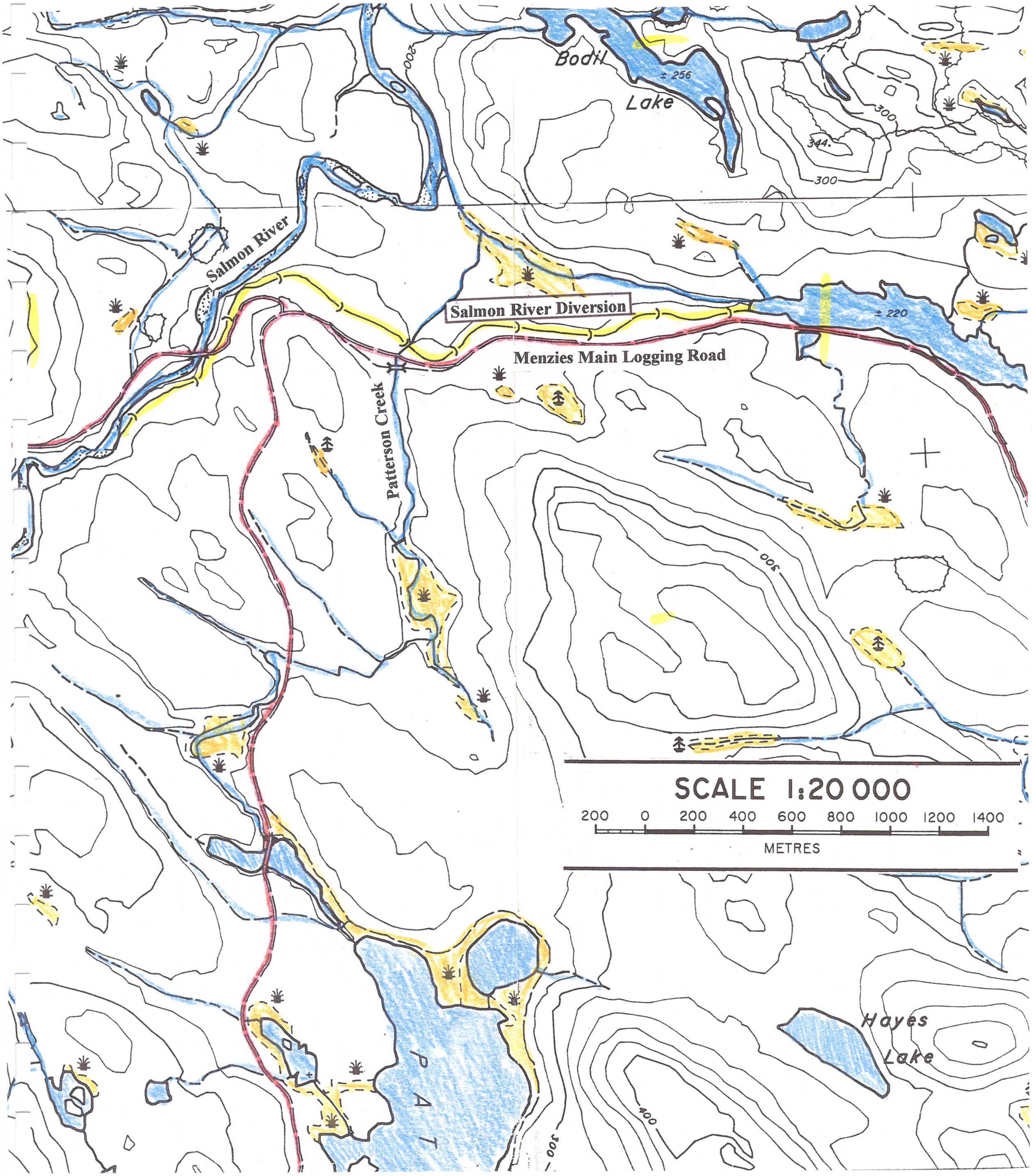
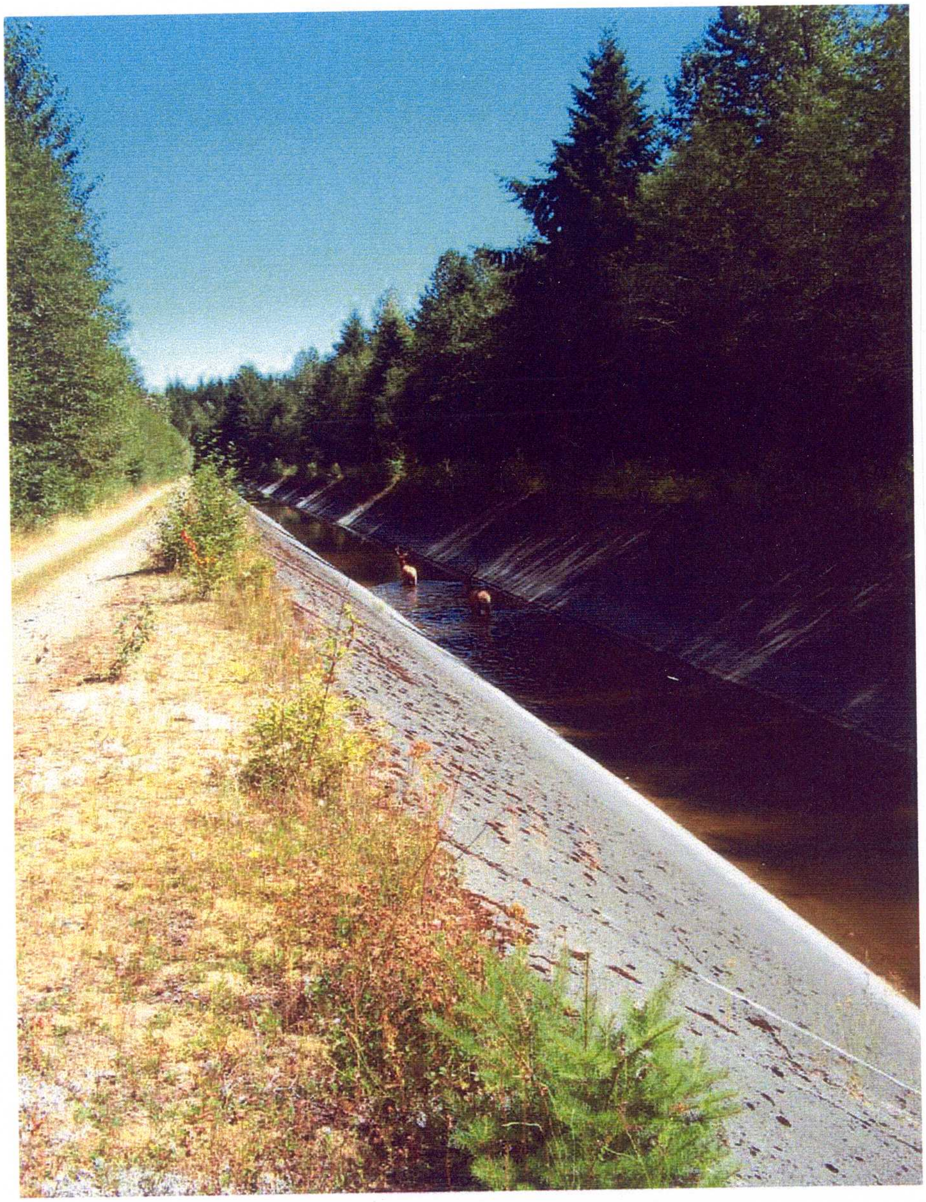


Figure 4. Roosevelt elk bulls in Salmon River Diversion canal, August 2003.



1.2 Project Objectives

The Salmon River Diversion Wildlife Overpass Pilot Project was designed to:

- identify species which may potentially benefit from an overpass;
- summarize overpass design criteria from existing information sources;
- locate, design and construct a temporary wildlife overpass; and
- assess wildlife utilization by monitoring for 2 years post-construction.

Specific objectives of the monitoring program were to:

1) document the range of wildlife species using the overpass
2) determine the time lag between construction and first-use by various species
3) determine species-specific crossing frequencies
4) assess wildlife habituation to the overpass by comparing 1^{st} to 2^{nd} year data
5) investigate species-specific patterns of use by season, time-of-day and direction of travel; and
6) gather preliminary data on wildlife use of an existing BC Hydro maintenance bridge <500 m downstream of the wildlife overpass.

2.0 STUDY AREA

2.1 Location

The SRD Wildlife Overpass is located approximately 30 km northwest of the City of Campbell River, near the 24 km marker on the Menzies Main logging road. It is approximately 1 km downstream of the diversion intake from the Salmon River, and 350 m west of the Patterson Creek crossing of the SRD.

2.2 Environmental Setting

The project area is situated within the undulating terrain of the Leeward Island Mountains Ecosection. Elevations along the SRD range from approximately 220 m to 225 m above sea level (ASL), while surrounding hills extend from 320 m to 350 m ASL. Elevations within the project area are classified as a Moderate Snowpack Zone by Nyberg and Janz (1990). In this zone, snowfall accumulations are usually shallow but persistent, with winters severe enough to threaten ungulate survival occurring every 5 to 15 years on average.

Subdued topography and wet climate have resulted in the creation of several marshes, swamps and fens in the proximity of the SRD. The largest of such areas is a hardhack fen 7 ha in size, located approximately 200 m north of the SRD. The middle reaches of the Salmon River occur at the western edge of the project area, while Patterson Creek runs north under the SRD, near its mid-point. The diversion canal drains east into Blair Ross Lake, a shallow lake approximately 20 ha in size.

The forests bordering the SRD and adjacent Menzies Main logging road are predominantly young mixed deciduous-coniferous stands. The deciduous component is dominated by red alder trees 10 cm to 20 cm in diameter, with the occasional black cottonwood tree. Conifer composition is a combination of Douglas-fir, western hemlock and western red cedar, with a minor amount of lodgepole pine and amabilis fir. Understory vegetation near the SRD is quite varied, abundant sword fern in some areas and juvenile conifers and grasses dominating other areas. Nearly continuous conifer cover is present 30 m beyond the diversion.

3.0 REVIEW OF EXISTING INFORMATION SOURCES

A review of wildlife crossing structure studies was completed in September of 2001. Given the multi-disciplinary approach used to design most wildlife crossing structures, both biology and engineering information sources were reviewed. Previous studies have involved various forms of crossing structures, such as culverts and underpasses, however the focus of this review was on information relating to wildlife overpasses. The following sources were consulted:

- scientific journals (e.g. Regulated Rivers; Journal of Wildlife Management);
- internet searches (e.g. Infra Eco Network Europe; U.S. Dept. of Transportation);
- wildlife conference proceedings (e.g. Intl. Conf. on Wildlife & Transportation);
- government representatives.

Information review results are presented as an annotated bibliography organized into three topic areas: 1) wildlife use of overpasses, 2) site selection considerations, and 3) wildlife overpass design elements.

3.1 Wildlife Use of Overpasses

Simpson, K. and L. Gyug. 1991. *Effects of the Okanagan Connector Freeway on Wildlife and Effectiveness of Mitigation Techniques.* Keystone Wildlife Research, Whiterock. Prepared for Ministry of Highways, Victoria. 41 pp.

This report discusses mule deer use of an ungulate overpass (54 m long; 5.9 m wide) across Hwy 8, a four-lane highway in British Columbia. Site selection for the structure was based on several seasons of radio-tracking deer to understand their seasonal movement patterns. The authors reported an overall passage rate of 0.3 deer/tracking day for the structure (total of 275 tracking days). In the first year (1989/90), prior to the installation of lead fencing, there were only 9 crossings. Deer approached, but failed to cross the structure on five occasions in 1989/90. A higher crossing frequency (67 crossings) and low refusal rate (12 % of all attempts) in the second year (1990/91), suggested fairly rapid habituation to overpasses by this species.

Forman, R.T.T. and A.M. Hersperger. 1996. *Road Ecology and Road Density in Different Landscapes, with International Planning and Mitigation Solutions.* In. Proceedings of the Transportation Related Wildlife Mortality Seminar, Tallahassee, Florida, June 1996.

In this summary of major mitigation techniques for traffic-related wildlife mortality, the authors found that all of the faunal overpasses they reviewed had achieved a measure of success. A large overpass constructed across a highway in Holland was utilized by at least 10 species of mammals, ranging in size from mice to deer. Medium-sized carnivores including ermine, marten and foxes were also recorded at that location.

Clevenger, A. P. 1999. *Ecological Effects of Roads in the Bow River Valley, Alberta.* In. Banff National Park Research Updates, Vol. 2 Issue 2. 7 pp.

The author summarizes monitoring results of almost two years of data gathered while monitoring two large (50 m wide) wildlife overpasses installed across the Trans Canada Highway in Banff National Park. He notes that vegetation planted on the structure had not become established at the time of writing. A total of 1147 crossings were recorded, approximately half were by deer and one-third (34 %) were by Rocky Mountain elk. Wide-ranging large carnivores also used the structures, but less frequently. Only six crossings were recorded for black bears, four for cougars and two by wolves. The smaller and more abundant coyote appeared to habitually use the wide overpasses, accounting for approximately 15 % of all recorded crossings. Cougars utilized all crossing structures more frequently during the winter and spring months.

Jackson, S.D. and C.R. Griffin. 1998. *Toward a Practical Strategy for Mitigating Highway Impacts on Wildlife.* In. Proceedings of the International Conference on Wildlife Ecology and Transportation, Fort Myers, Florida, February 1998.

These authors reviewed reports on animal passage systems across highways and found that, in many cases, their effectiveness had not been evaluated for the majority of species expected to use them. Based on the available data, they concluded that wildlife overpasses appear to accommodate more species of wildlife than underpasses. They suggest that such broader use results from the fact that overpasses are less confining and maintain ambient rainfall, temperature and light levels better than underpasses. For smaller wildlife (e.g. reptiles, amphibians and small mammals), the maintenance of ambient environmental conditions on overpasses often allows them to serve as both travel ways and as "bridging" (or intermediate) habitat. Several studies were cited suggesting mammals are both capable of learning to use overpass systems, and of transferring that knowledge to their offspring.

Land, D. and M. Lotz. 1996. *Wildlife Crossing Designs and Use by Florida Panthers and Other Wildlife in Southwest Florida.* In. Proceedings of the Transportation Related Wildlife Mortality Seminar, Tallahassee, Florida, June 1996.

Although this article presents data on use of wildlife underpasses, it is included as the authors noted a significant increase in use by Florida panthers over the first year as the structures gained greater acceptance by older individuals and learning by younger felids.

3.2 Site Selection Considerations

Jackson, S.D. and C.R. Griffin. 1998. ***Toward a Practical Strategy for Mitigating Highway Impacts on Wildlife*** **In. Proceedings of the International Conference on Wildlife Ecology and Transportation, Fort Myers, Florida, February 1998.**

In reviewing reports on wildlife passage structures across highways, these authors point out that many researchers believe placement to be the single most important factor affecting their success rate. Site selection may be particularly important for small wildlife (e.g. reptiles and amphibians), which have limited home ranges and therefore may never reach a passage structure under normal conditions. However, even amongst larger wildlife with greater mobility, some species will be very sensitive to site selection considerations. Because highways span large areas, they advocate the use of landscape-level analysis to identify key "connectivity zones", where mitigation efforts should be concentrated. Such an analysis would involve identifying the most valuable habitats for wildlife and wildlife movement in a localized area of interest.

Land, D. and M. Lotz. 1996. ***Wildlife Crossing Designs and Use by Florida Panthers and Other Wildlife in Southwest Florida.*** **In. Proceedings of the Transportation Related Wildlife Mortality Seminar, Tallahassee, Florida, June 1996.**

These researchers compared two wildlife underpass structures designed to facilitate the safe passage of Florida panthers across highways in that state. The site selection of individual crossing structures was determined by tracking radio-collared panthers to their habitual crossing locations. In the process of monitoring the structures, they found that a variety of other medium to large-sized mammals made use of the underpass structure. They discovered that because both types of underpass structures were used by a variety of wildlife, their design was likely less important than the location. They concluded that either crossing design would be successful when placed at sites where animals habitually cross.

Clevenger, A. P. 1998. ***Permeability of the Trans-Canada highway to wildlife in Banff National Park: importance of crossing structures and factors influencing their effectiveness.*** **In. Proceedings of the International Conference on Wildlife Ecology and Transportation, Fort Myers, Florida, February 1998.**

In his ongoing research of 11 crossing structures installed along the Trans Canada Highway, the author found that use by ungulates was best predicted by high levels of human activity, while the opposite was true for large carnivores. Although none of the landscape variables in his analyses were found to be statistically significant predictors of effectiveness, this researcher states that topography and vegetation are probably important determining factors. In his words, "location is likely the most critical factor in guaranteeing success [of wildlife underpasses]. For example, large carnivores cross high-speed motorways not through the best designed underpass, but rather through the underpass that is best aligned with a major drainage."

Ruediger, B. 1996. ***The Relationship Between Rare Carnivores and Highways. In.*** **Proceedings of the Transportation Related Wildlife Mortality Seminar, Tallahassee, Florida, June 1996.**

This researcher points out that large carnivores have significant spatial requirements and that individual animals must cross many linear developments to fulfill their biological needs. He uses this concept to argue for the installation of multiple crossing structures. Ruediger recommends that crossing structures be spaced approximately one mile (1.6 km) apart to accommodate the passage needs of large mammals such as elk, bears and wolves. He argues that fine-scale site selection and distribution of crossing structures should ultimately be determined by on-site habitat analysis and understanding of wildlife movement and behaviour patterns.

Roof, J. and J. Wooding. 1996. ***Evaluation of the S.R. 46 Wildlife Crossing in Lake County, Florida. In.*** **Proceedings of the Transportation Related Wildlife Mortality Seminar, Tallahassee, Florida, June 1996.**

These authors studied the effectiveness of a wildlife underpass across a two-lane highway in Florida. Like most underpasses, the structure was connected to wildlife exclusion fencing along the highway. They observed that most bears encountering the fence walked alongside it for less than 25 m. The greatest distance a bear was observed to walk the fence line was 500 m. They recommended that, in a situation where multiple crossings were merited, crossings structures be spaced no further than 1 km apart. They note that actual site selection of the passage structures should be based on field documentation of wildlife movement patterns and analysis of landscape features.

Cole, E.K., M.D. Pope, and R.G. Anthony 1997. ***Effects of Road Management on Movement and Survival of Roosevelt Elk (Cervus elaphus roosevelti).*** **Journal of Wildlife Management 61 (4): 1115 – 1126.**

These researchers provide evidence that elk can abandon preferred habitats if human disturbance is excessive. In 7 Road Management Areas in Southern Oregon they installed gates to restrict vehicle access to 4 or less trips per week. When they compared the home range movements of radio-collared elk in areas with and without access restrictions, they found that home ranges were smaller in the latter. From this they inferred that elk experienced fewer disturbances and consequently, optimized their foraging time.

Foster, M.L. and S.R. Humphrey. 1993. ***Use of Highway Underpasses for Panthers.*** **Florida Museum of Natural History, University of Florida, Gainesville, FL. 13 pp. + Figures.**

The authors of this report note that most successful deer passage structures have been constructed in close proximity to their traditional paths. Field data suggested that panther crossing points in Florida were strongly associated with the presence of adjacent forest and existing human recreational trails.

3.3 Wildlife Overpass Design Elements

Simpson, K. and L. Gyug. 1991. *Effects of the Okanagan Connector Freeway on Wildlife and Effectiveness of Mitigation Techniques.* Keystone Wildlife Research, Whiterock. Prepared for Ministry of Highways, Victoria. 41 pp.

In this study on the effectiveness of a wildlife crossing structures on the Okanagan Connector, the authors found that all structures associated with high use by moose offered a clear view of forested habitat on opposite side of the structure.

Clevenger, A. P. 1999. *Ecological Effects of Roads in the Bow River Valley, Alberta.* In. Banff National Park Research Updates, Vol. 2 Issue 2. 7 pp.

This researcher questioned the appropriateness of the double-arched design employed for the wildlife overpasses across the Trans Canada Highway in Banff National Park. He pointed out that each arch obstructs the cross-highway field of view, forcing wildlife climb into the "unknown" while attempting a crossing.

Jackson, S.D. and C.R. Griffin. 1998. *Toward a Practical Strategy for Mitigating Highway Impacts on Wildlife. In.* Proceedings of the International Conference on Wildlife Ecology and Transportation, Fort Myers, Florida, February 1998.

In their review of features affecting the use of wildlife underpasses, the authors noted that underpass layouts which ensured that the opposite end of a passage could be viewed, were positively correlated with wildlife use.

Forman, R.T.T. and A.M. Hersperger. 1996. *Road Ecology and Road Density in Different Landscapes, with International Planning and Mitigation Solutions. In.* Proceedings of the Transportation Related Wildlife Mortality Seminar, Tallahassee, Florida, June 1996.

These researchers contend that, from an animal's perspective, width may be the most important variable determining whether a crossing is attempted at a crossing structure. They analyzed early data from crossing structures installed across highways in 8 European countries, and Australia. Across a broad range of widths, there was a general relationship between the width of the structure and the size of animals using the structure. However, few differences in use were noted between 17 overpasses ranging in width from 8 m to 200 m. The authors suggest that narrow passages may permit small numbers of medium-sized to large animals to cross, which may be sufficient for gene flow, but may not be sufficient to mitigate population fluctuations severe enough to threaten a local population with extirpation.

Jackson, S.D. and C.R. Griffin. 1998. ***Toward a Practical Strategy for Mitigating Highway Impacts on Wildlife*** ***In.*** **Proceedings of the International Conference on Wildlife Ecology and Transportation, Fort Myers, Florida, February 1998.**

In their review of factors affecting the use of wildlife crossing structures, these researchers noted that size thresholds for use likely vary between species. Some mammals, particularly ungulates, have demonstrated sensitivity to the openness of the structure, while some small mammals appear to prefer small, confining underpasses. Their review suggests that, as a general rule, wider is better for a single structure to accommodate the widest range of species.

Clevenger, A. P. 1998. ***Permeability of the Trans-Canada highway to wildlife in Banff National Park: importance of crossing structures and factors influencing their effectiveness.*** ***In.*** **Proceedings of the International Conference on Wildlife Ecology and Transportation, Fort Myers, Florida, February 1998.**

In this evaluation of wildlife underpass use at Banff National Park, this author discovered that ungulates were wary of using underpasses narrower than 7 m. His field data suggests that underpasses with high openness ratios (i.e. a ratio of cross-sectional area to underpass length >0.6) were more favoured crossing structures for ungulates.

Woods, J.G. 1988. ***Effectiveness of Fences and Underpasses on the Trans Canada Highway and their Impact on Ungulate Populations – Second Progress Report.*** **Canadian Parks Service, Western Region, Revelstoke. 97 pp.**

This report provides interesting observations relating to the minimum width of crossing structures acceptable for elk. During fence construction along the Trans Canada Highway at Banff, two elk ranges were completely isolated from each other except for a train trestle bridge connecting the two (approx. 3 m in width). On several occasions the author observed bulls, cows and calves using this structure to move between the two ranges. He noted that despite the trestle height, the lack of guardrails and gaps between the railroad ties, "in all cases, the elk appeared to be very calm", while crossing the trestle. In the same period, white-tailed deer and coyotes utilized the trestle.

Pursello, B. Environmental Coordinator, B.C. Ministry of Transportation and Highways, Kamloops Region. ***Personal communication,*** **July 2001.**

Mr. Pursello conducted site inspections on the Okanagan Connector wildlife overpass across Highway 8. The concrete overpass measured 54 m in length and 5.9 m in width. Several deer tracks were observed leading up to the structure, as was a trail in the gravel covering the overpass deck, however increased evidence of use was noted along Trepanier Creek, a natural crossing located approximately 200 m east of the overpass.

Jackson, S.D. and C.R. Griffin. 1998. *Toward a Practical Strategy for Mitigating Highway Impacts on Wildlife.* In. Proceedings of the International Conference on Wildlife Ecology and Transportation, Fort Myers, Florida, Feb. 10-12, 1998.

These authors note that the choice of substrate on a wildlife passage structure can affect its utilization. They cite research on crossing structures in Florida, which attributed a low initial crossing rate by Florida panthers, in part, to the absence of natural substrates and cover. The authors' review of monitored passage structures in Europe indicated that rows of stumps on the passage surface appear to facilitate use by small mammals. They found that large overpass decks with soil from 0.5 m to 2 m depth allowed the establishment of herbage, shrubs and small trees.

Simpson, K. Principal, Keystone Wildlife Research, White Rock, B.C. personal communication, July 4, 2001.

Mr. Simpson was involved in studies relating to the Okanagan Connector Ungulate Overpass. He noted that overpass deck covering for the structure consisted of several centimeters of gravel. The Ministry of Transportation and Highways had tried to establish vegetation along the overpass, to encourage wildlife use, but due to the arid climate and rapid drainage, it was difficult to maintain enough moisture to support plant growth.

U.S. Department of Transportation website: *"An Overpass for Animals and Humans".*

This website describes the first "land bridge" constructed in the United States for the purpose of wildlife passage. This approximately 16 m wide, concrete structure spans 6 lanes of traffic. It is covered with sandy soils to mimic natural substrates of the region (Marion County, Florida). Irrigated planters (5.5 m in width) line each side of the structure. The bridge was completed in September 2000, however, no monitoring results were provided.

Jackson, S.D. and C.R. Griffin. 1998. *Toward a Practical Strategy for Mitigating Highway Impacts on Wildlife.* In. Proceedings of the International Conference on Wildlife Ecology and Transportation, Fort Myers, Florida, February 1998.

These researchers note that characteristics of the approach areas of overpasses may affect the use by some species. They cite studies which state that species associated with forested habitats, including black bears, prefer approach areas that are well vegetated. In other studies the presence of cover objects such as rocks, logs and vegetation enhance use by small to medium-sized mammals. The authors also note that lead fencing may be necessary for most species using highway overpasses. However, they caution that if fence and passage systems are not designed for use by a broad range of wildlife, projects which facilitate passage for one species might create a barrier for others.

Foster, M.L. and S.R. Humphrey. 1993. ***Use of Highway Underpasses for Panthers.*** **Florida Museum of Natural History, University of Florida, Gainesville, FL. 13 pp. + Figures.**

In their background review of wildlife underpass use, these authors describe a cautionary tale regarding the potential consequences of installing ungulate exclusion fencing along highways. Fencing along an 11 km stretch of the Trans Canada Highway led to instances of ungulate predation by wild canids (i.e. coyotes and wolves) through herding.

Lenert, M.E., L.A. Romin and J.A. Bissonnette. 1996. ***Mule Deer Highway Mortality in Northeastern Utah: Causes, Patterns, and a New Mitigative Technique In.*** **Proceedings of the Transportation Related Wildlife Mortality Seminar, Tallahassee, Florida, June 1996.**

These researchers describe a highway crosswalk system designed to reduce traffic-related deer mortality in Northeastern Utah. The system involved exclusion fencing with gaps and funnel fencing leading to well-marked level crosswalks. Highway safety standards precluded funnel fencing from being erected within 9 m of a pavement edge; therefore, river cobble fields were installed near the road and along grassed highway medians to guide deer movements. Although the cobble fields appeared to be effective in guiding deer that were interested in attempting a highway crossing, they were less effective for deer that were more interested in foraging in the funnel fencing area. Once inside the crosswalk area, the latter group often strayed to forage on roadside right-of-way vegetation, putting them at high risk of collisions with vehicles.

4.0 METHODS AND MATERIALS

4.1 Overpass Location, Design, and Construction

4.1.1 Assessment of Candidate Overpass Locations

Overpass site selection field investigation was conducted in early October 2001. Habitat adjacent to the SRD was divided into 13 transects, each 150 m in length and 15 m in width. . Habitat characteristic data collection included: dominant plants within tree, shrub and herb strata, estimates of relative forage production, and the abundance of snags and large organic debris

To document wildlife use within transects, sign searches were conducted along SRD maintenance roads and forest 15 m from the canal edge. Evidence of wildlife foraging, travel, bedding, maintenance activity and opportunistic wildlife sightings were recorded. Eight potential locations (Figure 5) were narrowed down to four on the basis of site-specific wildlife use, micro-topography, potential for vandalism and proximity to the main logging road. Final site selection involved input from Project Engineer Murray Johnson (P.Eng.), who inspected each of the four locations. The selected overpass site was located approximately 350 m west of the Patterson Creek crossing of the SRD. In November 2001, the site was surveyed using a differential GPS and a Licence of Occupation application was submitted to BC Hydro's Property Management Section for submission to Land and Water B.C. The Crown granted a five-year Licence of Occupation on May 30, 2002.

4.1.2 Wildlife Overpass Design

Design of the Salmon River Diversion canal wildlife overpass began in September of 2002. M.M. Johnson Ltd. of Quadra Island were commissioned to design a sturdy, simple to construct structure that would not impact upon the operation of the SRD. The load limit for wildlife was set at 10,000 lbs. (20 lbs./sq. ft.), which is equivalent to a herd of approximately 15 elk occupying the bridge at the same time. The design load for snow cover was double that of elk, 20,000 lbs. (40 lbs./sq. ft.), which is equivalent to a continuous layer of snow over 60 cm thick. Decking and mulch cover loading was set at 15,000 lbs (30 lbs./sq.ft.). Upon completion, the overpass total load level was set at 45,000 lbs. (90 lbs./sq.ft.), with a total weight of approximately 20,000 lbs.

The 14.6 m long and 3.6 m wide (at mid-span) wildlife overpass design (Figure 6) is similar to that of a wooden logging bridge. Three 24" diameter stringers span the 14 m wide canal. Unlike a standard logging bridge, both ends of the overpass are flared to facilitate wildlife access/egress (Figure 7). Pressure treated deck planks 2" thick and 12' long were placed perpendicular to the stringers and attached to them with galvanized 6" spikes (Figure 8).

To protect the structural integrity of the diversion canal, overpass footings were placed 0.3 m beyond the top of the canal wall lining and drainage pipes were installed inboard of the overpass footings to direct runoff into the diversion.

Figure 5. Salmon River Diversion wildlife overpass candidate locations.

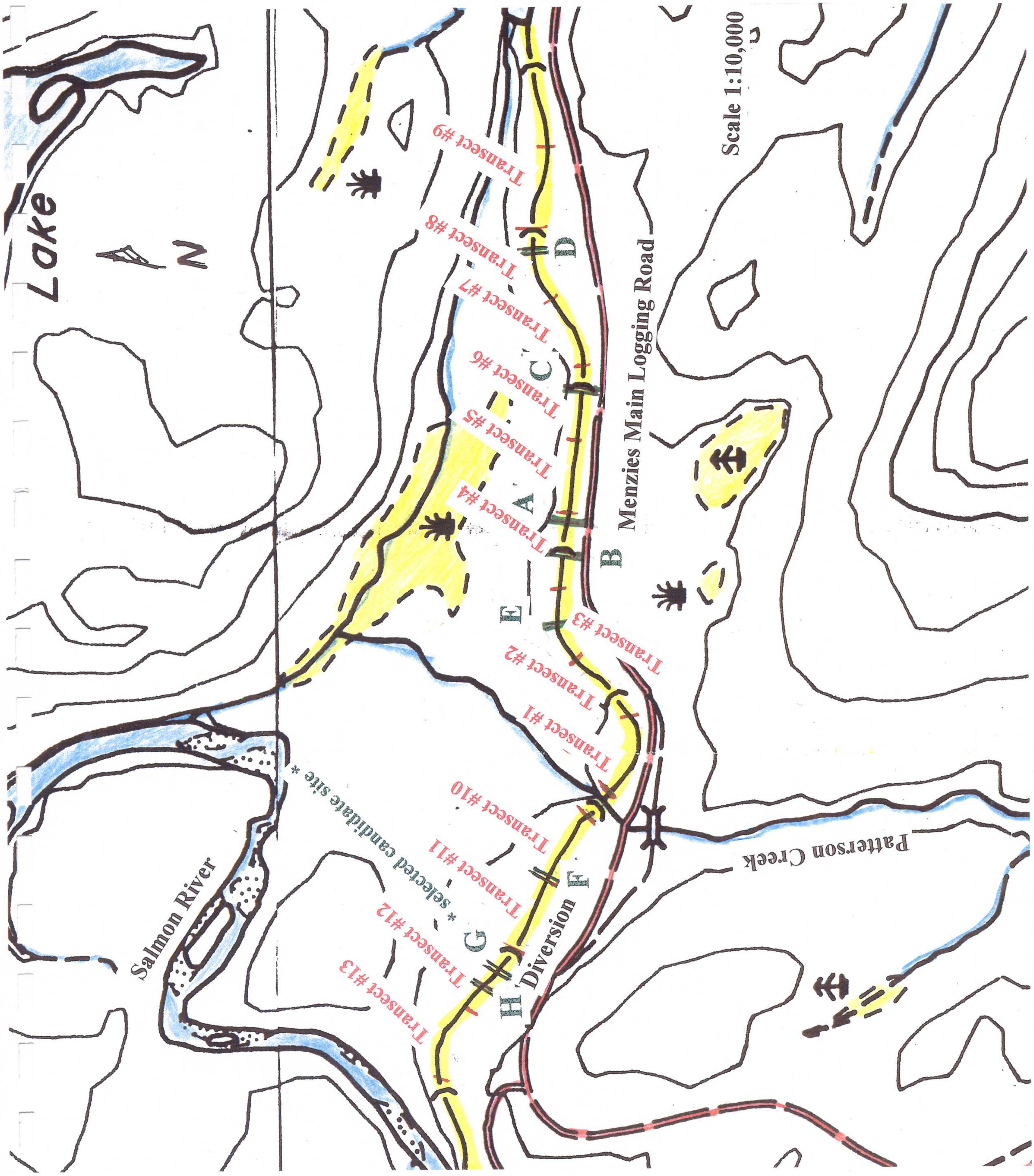


Fig. 6 General overpass design - Plan view.

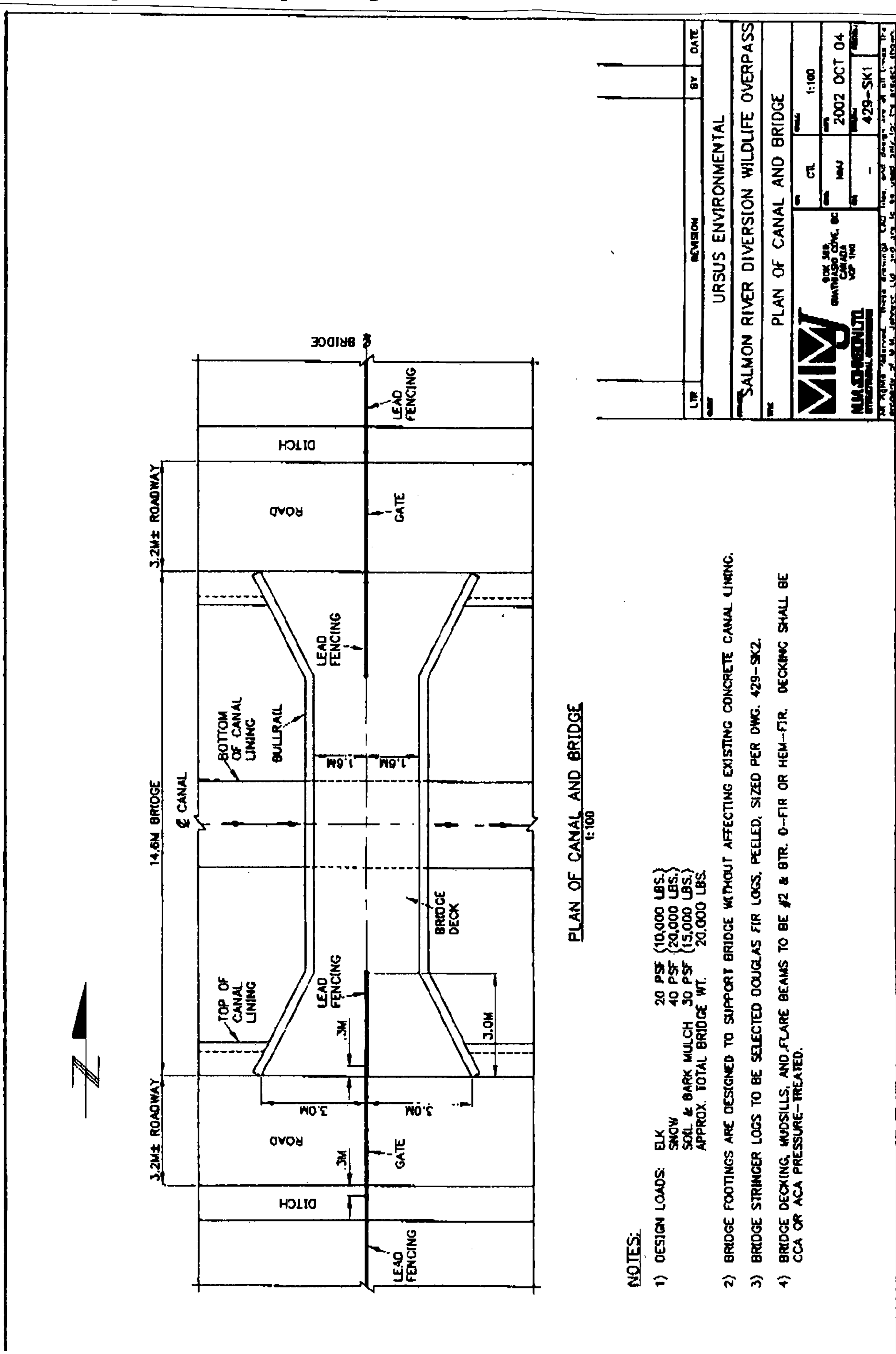


Fig. 7 Overpass design - Bridge framing detail.

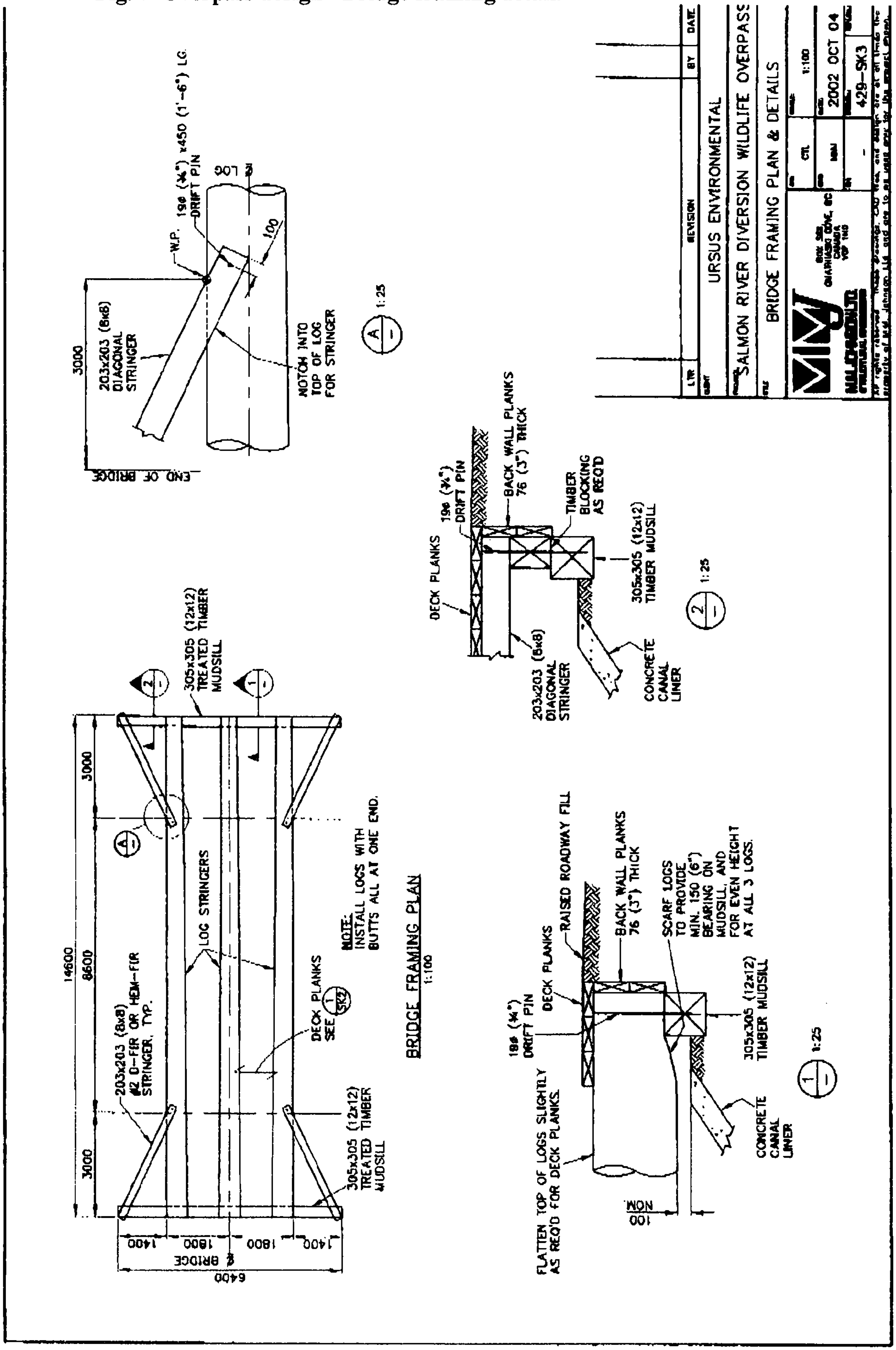
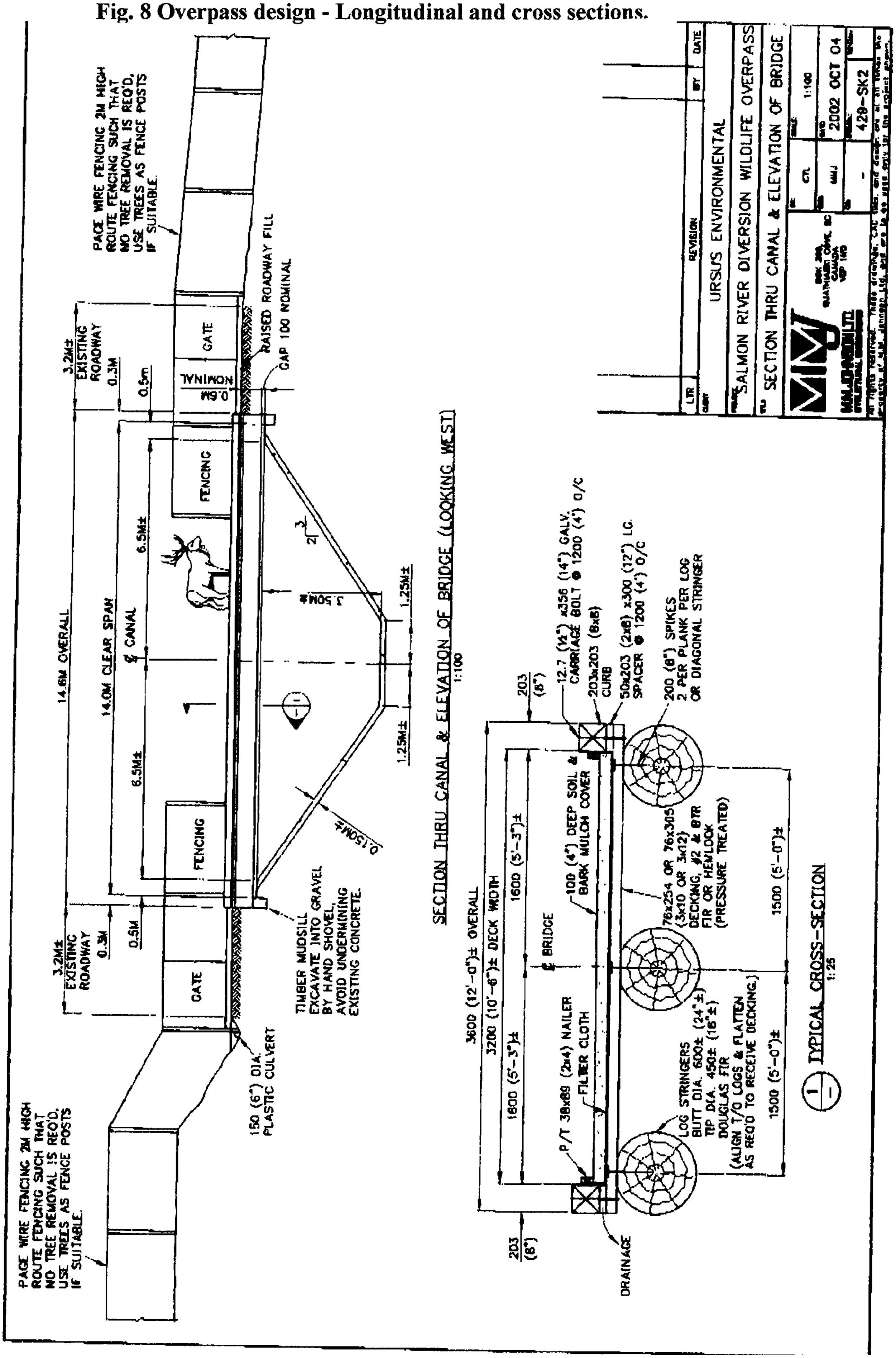


Fig. 8 Overpass design - Longitudinal and cross sections.



A layer of organic material was placed over the decking to provide traction and simulate natural forest substrates. To prevent the loss of fine material into the aquatic environment geotextile was installed between the overpass decking and the organic material.

A prominent feature of the overpass design was lead fencing running perpendicular 30 m across the two approaches to the overpass and out into the adjacent forest (Figure 9). The 8 ft. high page wire fence design was to function to direct animals traveling on either side of the diversion toward the overpass until they become familiar with the crossing location. The lead fencing was not designed to extend across the overpass to ensure that the option of traveling east-west along the SRD was not eliminated. Gates were designed into the lead fencing to permit continued vehicle use of the maintenance roads paralleling the SRD.

Design-related engineering costs for the overpass totaled approximately $ 5,300.00. A detailed listing of line-item costs is given in Appendix A

4.1.3 Overpass Construction

Overpass construction occurred in October and November of 2002, by Ashdown Construction of Campbell River. Due to limited log availability, 33" butt-diameter Douglas-fir logs were substituted in place of the proposed 24" diameter log stringers. The peeled logs (to improve longevity) were positioned onto the treated timber mudsills with two crane-mounted trucks (Figure 10). Chainsaws were used to flatten the tops where 3" x 10" x 12' deck planks would be attached (Figure 11). When the decking was completed, 8"x 8" timbers were used to form a low curb along the overpass margins and a layer of filter cloth was added over the decking (Figure 12).

In December of 2002 the 8 ft. high page wire lead fences and deck covering were installed. Treated fence posts were installed with a small Bobcat excavator (Figure 13) and set with concrete (330 lbs. used in total). To maintain drainage along an existing ditch, a 6" plastic culvert was installed under the southern part of the lead fencing. Shallow-angled aprons of fill (25 cu. yds. per side) were leveled where existing maintenance roads intersected the overpass approaches.

As indicated in Appendix A, total overpass construction costs were approximately $28,000. About 45 % of the total cost ($12,000) was attributed to construction labour and engineering inspections. The remaining 55% involved equipment and materials.

Figure 9. Lead fencing directs animals towards the overpass.

Figure 10. Mounting overpass stringers on mudsills, October 2002.

Figure 11. Attaching deck planks to stringers, October 2002.

Figure 12. Structural component of overpass nearing completion, November 2002.

Figure 13. Small excavator installing posts for lead fencing, December 2002.

4.2 Monitoring

The first year of monitoring focused on documenting mammal use of the overpass. Assessments of wildlife approaches compared to successful crossings of the overpass were also made. In the second year of post-construction monitoring, evidence of small wildlife use of the overpass and of wildlife use on a neighbouring BC Hydro maintenance bridge were also collected.

Wildlife use monitoring was achieved primarily with the use of Trail Master TM 1500 remote camera systems. Each system consists of three components: a transmitter, a receiver/data logger and a weatherproof 35 mm camera (Figure 14). When the infra-red beam between the transmitter and receiver is broken, the camera is triggered to take a picture and record the time/date. Beam height, receiver sensitivity, and timing between successive pictures are adjustable, and the systems could be programmed to collect data 24 hours a day. On the overpass, one remote camera system was installed mid-span, one was installed at the north-end lead fencing, and another was used to record wildlife approaches to the overpass. In January 2004 the remote camera system recording overpass approaches was moved to the neighbouring maintenance bridge, at the request of BC Hydro (E. Hill, *pers. comm.* 2004). Cameras were monitored at two to four week intervals, however 100 % coverage could not be guaranteed due to system sensitivity to cold weather, heavy rain and snow events, and film consumption by to bird or human activity in the sites. In one instance, four weeks of data was lost to vandals when film was stolen from the maintenance bridge installation. Nevertheless, it is believed the data collected were sufficient to evaluate the success of the project.

Track beds, winter track counts, pitfall arrays, live traps and track plates were also utilized during the 24 month monitoring period. Three sand track beds were assembled on the overpass deck in December 2002, one in the centre of the overpass and one on each of the north and south approach ramps. The track beds were built using 2"x 4" lumber spaced approximately 5 ft. apart (to accommodate the stride of large ungulates). Each frame was filled with a 4" depth of mortar-grade sand (Figure 15).

On the infrequent occasions when snow covered the overpass and maintenance bridge approaches winter track counts were conducted within a 15 m radius of the structures. The species, number and direction of all tracks in snow were recorded.

In the spring of 2004 pitfall traps were installed on the overpass and maintenance bridge, to document amphibian use. The pitfall traps, constructed of 2" x 4" frames partially covered by hinged 1" cedar board, spanned the width of the overpass and maintenance bridge (Figure 16). To maintain appropriate microclimates, the bottom of the pitfall traps were lined with moistened bark chips and moss. Three pitfall arrays were also installed in the adjacent forest to assess the relative amphibian abundance. Pitfall arrays consisted of covered 1 litre buckets with three 3 m lengths of plastic lead fencing (Figure 17). Pitfall buckets were also lined with moistened moss. Pitfall traps and arrays were checked on a weekly basis from mid-March through late May 2004. All the traps were removed in late May, for a total of 73 to 88 monitoring days per location.

Figure 14. Trail Master system components.

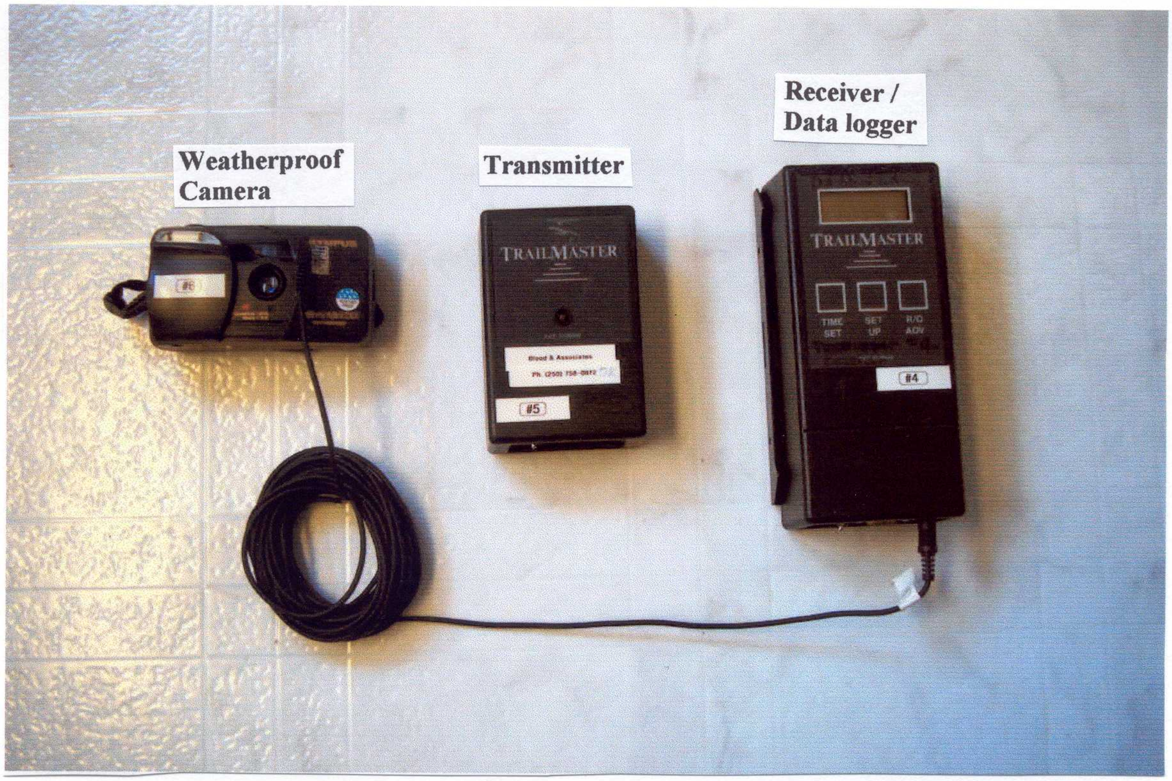


Figure 15. Track beds of sand installed on overpass approaches and mid-span.

Figure 16. Pitfall trap used to study small wildlife use.

Figure 17. Pitfall array installed in adjacent forest to document amphibian presence.

Small mammals were difficult to detect with remote camera systems, therefore over the autumn and winter of 2003 a brief period of live trapping was conducted. Two baited Havahart live traps were installed in the middle of the overpass and maintenance bridge, and two others were installed at each approach.

Over the summer and autumn of 2004, attempts were made to document small wildlife travel along overpass and maintenance bridge curb timbers, which were outboard of remote camera sensors. A covered 15 cm x 20 cm track plate was installed on both the east and west curb timbers of both structures. Trials involving different track plate coverings included the use of soot, photocopier toner, non-skid material and mortar sand (Figure 18).

Figure 18. Track plates installed on overpass and bridge curb timbers (Fall 2004).

5.0 RESULTS AND DISCUSSION

5.1 Predicted Wildlife Utilization

Linear developments have long been believed to have a significant potential to impact wildlife populations, however scientific investigation of both impacts and mitigation measures is still in its infancy (Clevenger 1999). In a southwestern U.S. study, one of the few to assess the impact of water diversion canals on wildlife, significant mule deer mortality was recorded (Rautenstrauch and Krausman 1989). Although no wildlife impact assessment of the Salmon River Diversion canal operation had been conducted, it was expected that the diversion canal would impose limitations to ungulate movements, particularly in fall and winter (Blood 1993).Based on both the literature review and regional traffic-related wildlife mortality information, the following species were predicted to make use of the SRD wildlife overpass:

- Roosevelt elk (*Cervus elaphus* ssp. *roosevelti*)
- Columbian Black-tailed deer (*Odocoileus hemionus* ssp.*columbianus*)
- Black bear (*Ursus americanus*)
- Cougar (*Felis concolor*)
- Wolf (*Canis lupus*)
- Marten (*Martes americana*)
- Red squirrel (*Tamiasciurus hudsonicus*)
- Deer mouse (*Peromyscus maniculatus*)

Wildlife use of the Salmon River Diversion overpass structure was expected to increase in the second monitoring season, as animals habituated to its presence.

Wide-ranging carnivores were expected to use the structure infrequently. While the presence of maintenance roads will preclude forested approaches to the overpass, some use by black bears was anticipated. This species is accustomed to crossing streams along the path of least resistance (e.g. downed trees and logging road bridges), and may discover the structure while foraging nearby. Bears will likely be attracted to herbaceous vegetation along the maintenance roads in the springtime, when few other bear foods are available. While some lead fencing appears necessary to direct wildlife to the overpass (and discourage motorized vehicles), it seems reasonable to limit the amount of lead fencing around the overpass to reduce the potential for wolves and/or cougars to trap prey against it.

Use by small wildlife appears to be contingent upon providing suitable cover objects along the approaches to the overpass and across it. A deck topping of bark nuggets may mimic the substrate of adjacent forest areas. The fact that the overpass will be open to the elements will allow ambient light and rainfall to be maintained in the crossing area, facilitating use by amphibians during moist periods.

5.2 Documented Wildlife Utilization

A total of 204 individual wildlife visits were recorded at the overpass over the course of the study. Of these, 123 were considered successful crossing events, typically of individual animals, but occasionally involving groups of 2 or 3 (among ungulates or large carnivores). The number of wildlife visits is very likely under-reported, since only one side of the overpass was monitored with a remote camera, and this for only the first 12 months of operation. In addition, rain events frequently erased any tracks made on the overpass approaches in the fall and winter. Data from the north side of the structure indicated that about 75 % of wildlife approaches led to successful crossings over the first year (Table 1). Because the north-end camera was subsequently removed, the proportion of approaches leading to crossings in the second year is unknown.

Within the first 12 months of operation, 54 successful crossing events were recorded involving 7 mammal species (44 % of all recorded crossings). By the end of the second year of operation, another 69 successful crossings were distributed among 8 mammal species. As indicated in Table 2, the greatest use of the overpass occurred in summer, accounting for about half (45 %) of all crossings. Spring and autumn saw moderate levels of use, representing 25 % and 20 % of all successful passages, respectively. Winter was the season of lowest activity, accounting for just 10 % of successful crossings.

With the exception of grey wolves (*Canis lupus*), all terrestrial mammals predicted to make use of the overpass recorded successful crossings. Species documented included:

- Roosevelt elk (*Cervus elaphus* ssp. *roosevelti*)
- Columbian Black-tailed deer (*Odocoileus hemionus* ssp.*columbianus*)
- Black bear (*Ursus americanus*)
- Columbia Black-tailed deer
- Cougar (*Felis concolor*)
- Raccoon (*Procyon lotor)*
- Eastern Cottontail (*Sylvaginus floridanus*)
- Marten (*Martes americana*)
- Red squirrel (*Tamiasciurus hudsonicus*)
- Deer mouse (*Peromyscus maniculatus*)

The number of days between the completion of overpass construction and the first recorded use of the overpass varied by species (Table 3). A black-tailed deer crossing was recorded just 6 days after construction, while the first black bear crossing was not recorded for over 290 days (roughly 190 days after emerging from the den). One needs to exercise a degree of caution in interpreting Table 3, as a certain amount of chance factors into any animal encountering the overpass. However, the salient point is that use by all nine mammal species had occurred within 17 months of construction completion. It appears that even wide-ranging mammals (excepting wolves) can be expected to approach an overpass on several occasions within that timeframe.

Table 1. Comparison of overpass approaches to successful crossings over the first 12 months of operation.

Species	Winter 2002	Spring 2003	Summer 2003	Fall 2003	Subtotals
Black bear					
Approaches	0	0	1	1	2
Crossings	0	0	1	0	1
Cougar					
Approaches	2	1	1	0	4
Crossings	2	0	1	0	3
Roosevelt elk					
Approaches	0	0	1	0	1
Crossings	0	0	1	0	1
Black-tailed deer					
Approaches	1	3	1	6	11
Crossings	1	2	1	1	5
Marten					
Approaches	5	6	25	14	50
Crossings	3	5	23	11	42
Raccoon					
Approaches	0	1	1	0	2
Crossings	0	0	1	0	1
Eastern Cottontail					
Approaches	0	1	0	0	1
Crossings	0	1	0	0	1
No. of Species	**3**	**3**	**6**	**2**	
Total Approaches					**71**
Total Crossings					**54**
Crossings as a proportion of approaches					**76 %**

Table 2. Summary of Salmon River Diversion wildlife overpass use (Dec. 02 to Nov. 04).

Species	2003 Successful Crossing Events					2004 Successful Crossing Events					Study Totals (Proportion)
	Winter	Spring	Summer	Fall	Year 1 Subtotal	Winter	Spring	Summer	Fall	Year 2 Subtotal	
Black bear	0	0	1	0	**1**	0	3	0	0	**3**	**4 (3%)**
Cougar	2	0	1	0	**3**	0	1	1	2	**4**	**7 (6 %)**
Roosevelt elk	0	0	1	0	**1**	0	2	0	0	**2**	**3 (3 %)**
Black-tailed deer	1	2	1	1	**5**	1	8	6	1	**16**	**21 (17 %)**
Marten	3	5	23	11	**42**	4	5	12	4	**25**	**67 (53 %)**
Raccoon	0	0	1	0	**1**	0	0	0	0	**0**	**1 (1 %)**
Eastern cottontail	0	1	0	0	**1**	0	2	0	0	**2**	**3 (3 %)**
Red squirrel	0	0	0	0	**0**	0	2	4	6	**12**	**12 (10 %)**
Deer mouse	0	0	0	0	**0**	1	0	4	0	**5**	**5 (4 %)**
	6	8	28	12	**54**	6	23	27	13	**69**	**123 (100 %)**
By Season											
Winter	12 crossings		10 %								
Spring	31crossings		25 %								
Summer	55 crossings		45 %								
Fall	25 crossings		20 %								

Table 3. Number of days to first recorded use of overpass for individual species.

Species	Date of First Recorded Use	Days after completion of construction
Black-tailed Deer	Dec. 6, 2002	6
Cougar	Jan. 17, 2003	48
Marten	Mar. 6, 2003	96
Eastern Cottontail	Apr. 4, 2003	125
Roosevelt Elk	Jun. 21, 2003	203
Raccoon	Aug. 10, 2003	253
Black Bear	Sept. 18, 2003	291
Deer Mouse	Dec. 12, 2003	353
Red Squirrel	May 17, 2004	502

Wildlife use was also recorded at the maintenance bridge 350 m downstream of the wildlife overpass. Unfortunately, significant data gaps resulted from vandalism and equipment breakdowns at this location over July and August of 2004. A total of 52 individual wildlife visits were recorded at the maintenance bridge between November 2003 and November 2004 (Table 4). The majority of these (44 visits, or 85 %) were successful crossings. It should be noted, however, that in the absence of track beds opportunities to record approaches without crossings were limited to occasions when snow or frost was covering the ground. Successful crossings at the maintenance bridge involved seven of the nine mammal species recorded on the overpass. Interestingly, Roosevelt elk and Eastern cottontail approached the maintenance bridge, but were not documented as making successful crossings. Based on the limited dataset, which lacks information from the busy summer period, marten appear to be the most frequent users of the maintenance bridge, followed closely by bears.

Table 4. Summary of recorded maintenance bridge use, November 2003-04.

Species	No. of Recorded Crossings	% of All Recorded Crossings
Marten	16	36
Black bear	14	32
Deer mouse	6	14
Black-tailed deer	3	7
Raccoon	3	7
Cougar	1	2
Red Squirrel	1	2
Total	**44 Crossings**	**100 %**

As indicated in Table 5, no small mammals were caught in the wildlife overpass or maintenance bridge pitfall traps. Based on the recorded capture rates, Dusky or Vagrant Shrews (*Sorex* spp.) appear to be moderately abundant in forests adjacent to the two structures at this time of the year, while Deer Mouse density appears to be very low. The latter is to be expected, as mouse populations generally peak in late summer and decline until late spring as a result of winterkill and predation. The dearth of suitable habitats for Townsend's Vole is probably responsible for this species' absence from the trapping data. The inability to trap rare Vancouver Island Water Shrews during the study was not surprising, given that they are thinly distributed even in apparently suitable habitats.

Despite the use of bark nuggets on the deck to retain moisture, no evidence of spring use by amphibians was found at the wildlife overpass. Nor was any sign of amphibian use found at the old maintenance bridge. The very low rate of amphibian captures in adjacent forests (only 3 captures over a total of 234 trap-nights) suggests the dry spring weather and young stand age combined to provide very poor habitat conditions for amphibians near the Salmon River Diversion. Though not supported by the trapping results, it is possible that amphibians avoid the old maintenance bridge because of its creosote-impregnated timbers.

Table 5. Summary of pitfall trap results, Spring 2004.

Trap Location	Number of Trap-Nights	Small Mammal Captures	Amphibian Captures
Wildlife Overpass	88	no captures	no captures
Wildlife Overpass - Adjacent Upland Forest	83	7 Dusky/Vagrant Shrews 1 Deer Mouse	1 Red-legged Frog (juvenile)
Maintenance Bridge	88	no captures	no captures
Maintenance Bridge - Adjacent Upland Forest	78	19 Dusky/Vagrant Shrews 1 Deer mouse	1 Red-legged Frog (adult) 1 Western Red-backed Salamander
Old Maintenance Bridge Adjacent Riparian Forest	73	10 Dusky/Vagrant Shrews	no captures

Evidence of overpass use by native reptiles was difficult to obtain, as they move too closely to the ground to be picked up by remote cameras, and could easily escape from the mid-span pitfall trap. A single garter snake slither track was recorded on the northern approach track bed in the spring of 2004, but similar tracks could not be found on the mid-span track bed. Given that garter snakes are excellent swimmers, the diversion probably does not represent much of an obstacle to their travel. The track probably resulted from a snake selecting the track bed as a basking location.

A discussion of overpass and maintenance bridge use by mammals is presented below.

Roosevelt Elk (*Cervus elaphus* ssp. *roosevelti*)

The diversion canal bisects the southern portion of the resident "Swamp" elk herd range (Blood 1993). Given the infrequent traffic on the diversion canal maintenance road, it is unlikely that elk have abandoned adjacent habitats. It is interesting that most studies report deer and elk appear to be more sensitive to the openness of passage structures than their width. With the possible exception of overhead cover for tracking beds, it should be possible to design a very open crossing structure to facilitate use by these species.

Because elk are the heaviest mammals occurring in the area and sometimes move in groups, overpass design loading focused on this species. However, high levels of use by Roosevelt elk were not anticipated. This is because the project area is on the margins of the resident "Swamp" herd's range and the migratory "Grilse" herd's winter range. The lone elk crossing in 2003 took place in late June and involved a pair of elk, presumably same-aged bulls. It is likely the same pair of mature bulls that were observed two weeks later in the Salmon River Diversion (Figure 4). Only two other elk crossings and two approaches were recorded at the overpass. Significantly, one of these crossings involved a group of three cows (Figure 19). Elk activity at the overpass occurred mainly in the spring, although some summer activity was also noted. Although elk used the overpass infrequently, it was demonstrated that both bulls and cows found the structure acceptable.

There was only one documented occurrence of elk near the maintenance bridge, an approach in the spring. As the maintenance bridge offers a shorter span and greater rigidity, it could be expected that elk prefer it over the overpass structure. However, it is possible that lead fencing, which was only present at the overpass, is important in encouraging elk crossings.

Columbian Black-Tailed Deer (*Odocoileus hemionus* ssp. *columbianus*)

Black-tailed deer are typically abundant in the central part of Vancouver Island (Shackleton 1999). However, current population levels are reported to be near a 20 year low on many parts of the Island (K. Brunt, *pers. comm.* 2004). Over the course of the study, 21 successful crossings were recorded, including bucks, does and fawns (Figure 20). Considerably more deer crossings occurred over the second year of monitoring (16 vs. 5), suggesting resident deer habituated to the structure after approximately 16 months. Deer showed little hesitation in accessing the structure, using it even before all work on the deck was completed. According to data gathered in 2003, about half of all deer approaches resulted in successful crossings (5 of 11). Although crossings were recorded in all seasons, a large majority of those occurred in spring and summer (80 %). The low overall number of fall and winter crossings (4 over 2003-04) and relatively large number of approaches without

Figure 19. Group of Roosevelt elk cows using the overpass in April of 2004.

Figure 20. One of five recorded overpass crossings by deer in 2003.

crossings (8) may indicate that deer are reluctant to cross on the overpass when the deck is frosty. In the unseasonably cool fall of 2003, for instance, six deer approaches were recorded, yet only one successful crossing was made. The interval between successful deer crossings ranged from 2 to 190 days. Over the spring and summer, when most deer activity was recorded, crossings occurred at 2 to 35 day intervals. Approximately 65 % of deer crossings occurred during daylight, the majority of these in the morning hours. About 20 % of the crossings occurred at dawn and 15 % of crossings occurred in darkness.

Due to the previously mentioned difficulties, only three deer crossings were recorded on the neighbouring maintenance bridge. One of these was in winter and other two were in spring.

Black Bear (*Ursus americanus*)

On Vancouver Island, black bears possess relatively small home ranges and occur at higher densities than cougars (up to 1 bear/km^2). Black bear activity was not expected during their normal hibernation period (Dec. to late Mar.) and none was recorded at the overpass before the first week of April. In total, only four successful crossings were recorded out of six documented approaches. The first bear activity recorded at the overpass about 5.5 months after emergence, or 9.5 months after construction was completed (Figure 21). The interval between black bear visits during the active season ranged from 24 to 48 days.

The dearth of bear activity was initially puzzling, considering the site's proximity to typical bear habitats such as wetlands and riparian areas. Remote camera data from the existing maintenance bridge helped to explain the observed low levels of bear activity at the overpass. The maintenance bridge, which has been in place for decades and is adjacent to Patterson Creek, recorded no less than 14 bear crossings between April and October of 2004. This is a considerable amount of activity, especially given that this remote camera was out of service over July and August. In one instance three bear crossings were recorded on one day. It seems that the existing maintenance bridge is either well-placed to facilitate bear movements, or that bears are thoroughly habituated to its presence. Nevertheless, because bears tend to avoid conspecifics, the overpass may provide an alternate means of accessing preferred habitats when several bears are active in the vicinity.

Cougar (*Felis concolor*)

As wide-ranging carnivores, cougars were expected to use the overpass very infrequently. However, this species was recorded at the overpass more frequently than bears, which are essentially resident in the area. In total, seven successful crossing events were recorded for cougars at the overpass, and three other approaches were documented that did not result in a crossing. Active year-round, cougars were found to use the overpass in all seasons. The interval between cougar visits ranged from 20 to 97 days (average 38.1 days). Three of the crossings occurred in daylight and four occurred during darkness. Cougars showed little hesitation in using the new structure, with two successful crossings just three months after construction. Females with cubs were recorded crossing in January and February of 2003, while all other records were of individual cats (Figure 22). No evidence

Figure 21. An adult cougar heading south across wildlife overpass in February of 2003.

Figure 22. Lone use of the overpass by bears in 2003 occurred in September.

was found that cougars ran ungulates into the lead fencing, a concern expressed during the BCRP Technical Review.

In contrast to the relatively high levels of use at the overpass, only one successful crossing was recorded at the maintenance bridge. This was a daylight crossing of a lone adult in mid-winter. It is possible that other crossings occurred over the summer while the remote camera was damaged or inoperable.

Wolf (*Canis lupus*)

The inability to detect wide-ranging wolves at the overpass when prey species were present in the vicinity might be explained by the site's proximity to a heavily used logging road. However, for other carnivores (e.g. cougars and bears) a shift to a more nocturnal pattern of activity is often seen under such circumstances. It may be the case that wolves have temporarily abandoned the area due to low deer densities (reported to be at a 20-year low on Vancouver Island). However, a healthy elk herd persists nearby in the Salmon River Valley.

Raccoon (*Procyon lotor*)

On Vancouver Island, high densities of raccoons may occur in rural and urbanized areas, and near productive marine shorelines. However, they are considerably less common inland. Only two approaches and one successful overpass crossing by raccoons was recorded over the course of the monitoring program. The approaches took place in late spring and in mid-August of 2003, and both involved single individuals (Figure 23).

Three raccoon crossings of the maintenance bridge were recorded within a brief period in late October / early November of 2004. Given the spacing of 1 to 2 days between visits, these likely represent the same individual. Since the maintenance bridge is adjacent to quality foraging habitats along Patterson Creek, higher levels of use would be predicted at the maintenance bridge than at the overpass. However, this was not supported by the limited dataset produced at the site.

Marten (*Martes americana*)

Over the two-year monitoring period, marten accounted for over half of all successful crossings of the overpass (54 %). Marten used the overpass in all seasons, but most frequently in summer, which included 52 % of all marten crossings. A large majority of recorded crossings occurred in darkness (58%). Daylight and dusk/dawn crossings accounted for 18 % and 13 % of recorded crossings, respectively. The interval between successful crossing events for marten ranged from < 1 day to 48 days. Crossing intervals of less than 2 weeks were recorded 84 % of the time. It was very unusual to go more than 2 weeks without recording a successful marten crossing.

Figure 23. A single raccoon crossing was recorded in mid-August of 2003.

Figure 24. Marten crossings were recorded in all seasons, with the highest levels of use occurring during the summer.

Martens were quick to find the wildlife overpass, but slow to start using it. Marten scats on the northern approaches were first noted in December of 2002. However, more than two months passed before the first marten was recorded by the remote camera (Figure 24). It is believed mid-span bait stations and the installation of hardware cloth along lead fencing hastened use by this species, which seldom strays from overhead cover. After a lull in April, martens became the most frequent user of the overpass in 2003, accounting for over three-quarters of all successful crossings that year (42 of 54 crossings). The absence of marten crossings in April of both years coincided with the marten birth period (Powell *et al.* 2003). Conversely, the high frequency of crossings in July and August of both years may have been related to females entering estrus. Marten crossings were slightly lower in 2004, but they were still the most common type of use (25 of 69 crossings). It is noteworthy that no pictures of marten kits were recorded at the overpass, although they are apparently able to secure their own food at just two to three months of age (Powell *et al.* 2003). Several marten crossings involved walking along overpass curb timbers, beyond the detection zone of the remote camera system.

A total of 12 successful marten crossings were recorded at the neighbouring maintenance bridge in 2004. Of the crossings for which time of day could be determined 90 % occurred during darkness and 10 % occurred at dawn.

Eastern Cottontail (*Sylvaginus floridanus*)

The recording of eastern cottontails at the overpass was also unexpected, although the range of this rabbit is reported to be expanding at rate of about 7 km per year since it was released from the Victoria area in the mid-1960's (Merilees *et al.* 1992). Cottontails commonly occur in shrubby habitats throughout the Comox Valley, where forage and hiding cover are abundant. However, it is sparsely distributed within the heavily forested areas around Campbell River and areas to the north.

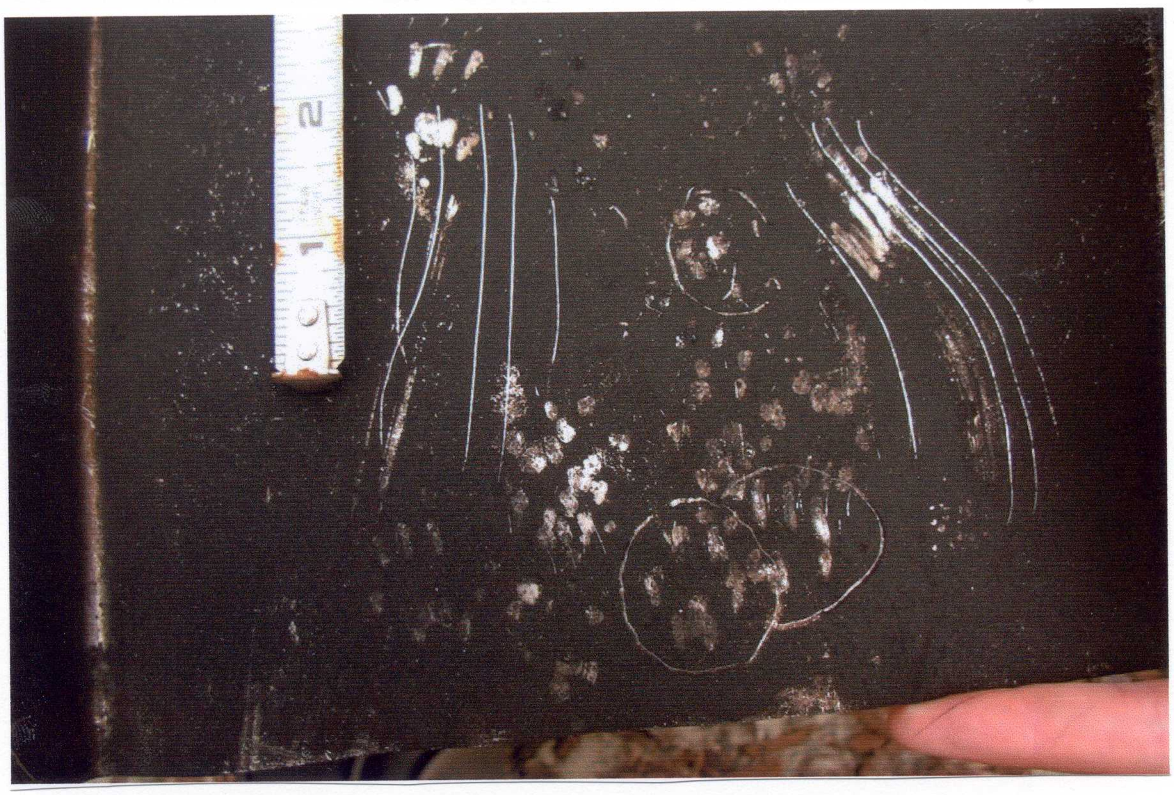
Cottontails only approached the overpass on four occasions in two years of monitoring, including three times in the spring and once in mid-summer (Figure 25). All crossings took place in the springtime under cover of darkness, typically their period of highest activity. There was a single cottontail track observed in the snow at the maintenance bridge in mid-January of 2004. This particular approach did not happen to result in a crossing, but there is no evidence to suggest cottontails see the maintenance bridge as an obstacle to travel.

Red Squirrel (*Tamiasciurus hudsonicus*)

Red squirrels were the last species to be documented using the overpass, despite the widespread occurrence of their feeding sign in the adjacent forest. No evidence of squirrel crossings was obtained using the remote camera in two years of monitoring. The first evidence (Figure 26) of their interest in the overpass was found in the southern track bed in the first week of May 2004, nearly 18 months after overpass construction was completed. By

Figure 25. Overpass use by an eastern cottontail, a species uncommon north of the Comox Valley, was recorded in April of 2003.

Figure 26 . Red squirrel crossing documented on overpass cub timber track plate.



the third week of May, squirrel tracks in all track beds indicated successful crossings had occurred. In late May, a squirrel was observed crossing the overpass along the western curb timber, beyond the detection zone of the remote cameras. Installation of track plates on the curb timbers resulted in the documentation of 10 additional crossings over summer and fall, for a total of 12 recorded crossings.

No squirrels were detected with the remote camera at the maintenance bridge over 2004. However, tracks in snow were observed one of the bridge curb timbers, indicating a successful winter crossing. Track plates on curb timbers failed to detect another crossing in 2004.

Deer Mouse (*Peromyscus maniculatus*)

The deer mouse is active year-round and has a small (<3 acres) but well-defined home range (Forsyth 1985). Mice normally reach their highest densities in late summer, as early litters reach sexual maturity and bear offspring. The first evidence of overpass use by mice was recorded 12 months after construction. Owing to the small size, they appeared only once in remote camera photos. Live traps and curb timber track plates documented four of the five overpass crossing events in 2004. They were documented crossing the maintenance bridge on three occasions over the winter of 2004.

6.0 EVALUATION & RECOMMENDATIONS

6.1 Summary of Conclusions

The Salmon River Diversion Wildlife Overpass Pilot Project was successful in demonstrating that a relatively narrow overpass (< 4 m width) was used by a variety of wildlife, that most mammals accepted the structure within 17 months of construction, predators did not utilize lead fencing to entrap prey. Specific conclusions of the study are as follows:

1. Overpass design elements important in attracting wildlife use include structural rigidity and lead fencing to direct animals to crossing areas. Insufficient data was collected to assess the importance of woody debris on small mammal use and the importance of deck treatment on ungulate or amphibian use.

2. Over 120 wildlife crossing events were recorded at the overpass. A large majority of these were single animals, but occasionally small groups of deer, elk and cougars were recorded.

3. Overall, summer was the season of highest overpass use (45 % of crossings), followed by spring (25%), fall (20 %) and winter (10 %).

4. First year data indicates that approximately 75% of wildlife approaches to the overpass lead to a successful crossing.

5. Seven of the eight mammal species predicted to benefit from the overpass made successful crossings. No evidence of the eight, the grey wolf, was found. The unexpected use by the eastern cottontail and raccoon, relatively uncommon in the region, increased the total number of mammal species using the overpass to nine.

6. Evidence of use by all nine species occurred within 17 months of construction completion. The time lag between construction completion and first use of the overpass ranged from 6 days (black-tailed deer) to 502 days (red squirrel).

7. Marten presented the highest frequency of use (53%) followed by deer (17 %) and squirrels (10 %). Remaining species accounted for 1 to 6 % of recorded crossings.

8. Marten habituated to the overpass within 6 months of overpass completion. Deer and squirrels took approximately 16 months and 18 months, respectively. Although the intervals were widely spaced, cougars made regular overpass crossings, suggesting habituation within 15 to 18 months.

9. Seven of the nine species that used the wildlife overpass also made successful crossings of the BC Hydro maintenance bridge 350 m downstream. Roosevelt elk and eastern cottontails are the only two species which failed to be detected at the maintenance bridge. This may have been attributed to interruptions of remote camera

service. Black bear use of the well established maintenance bridge was notably higher than the new wildlife overpass.

6.2 Summary of Recommendations

The wood-framed overpass supported considerable wildlife use; however its service life is only estimated to be approximately 10 years. Replacement of this temporary structure with a permanent, low maintenance one is recommended. However, more data is required to determine the optimal location for a new permanent structure. While rebuilding on the current overpass site is one option, competing sites may exist between any of the other existing bridges across the Salmon River Diversion. These other structures include two bridges for maintenance vehicles on either side of Patterson Creek (350 m to 450 m east of the overpass), and a recently completed logging bridge near the outlet of the diversion (2,100 m east of the overpass). To facilitate permanent overpass site-selection, a monitoring study employing consistent techniques, at all potential crossing areas and through all seasons, should be conducted.

7.0 ACKNOWLEDGEMENTS

Our thanks are extended to the Bridge Coastal Fish & Wildlife Restoration Program for funding this project. Janice Doane, BCRP Program Coordinator, provided timely advice on numerous administrative details concerning this project. Special thanks to field assistant Guy Monty for his efforts in monitoring the overpass in all seasons and weather conditions.

8.0 LITERATURE CITED

BC Hydro. 2000. *Bridge-Coastal Fish and Wildlife Restoration Program Strategic Plan: Volume 2 - Campbell River Watershed.* BCRP Program, Vancouver. 47 pp.

Blood, D.A. 1993. *Wildlife Restoration Plan, Upper Campbell River.* Prepared for B.C. Hydro, Environmental Resources. 60 pp.

Brunt, K. Wildlife Biologist, Ministry of Water, Land and Air Protection, Region 1. *Personal communication*, May 2001.

Brunt, K. Wildlife Biologist, Ministry of Water, Land and Air Protection, Region 1. *Personal communication*, March 2004.

Clevenger, A. P. 1999. *Ecological Effects of Roads in the Bow River Valley, Alberta.* In..Banff National Park Research Updates, Vol. 2 Issue 2. 7 pp.

Clevenger, A.P. 1998. *Permeability of the Trans-Canada Highway to Wildlife in Banff National Park: Importance of Crossing Structures and Factors Influencing Their Effectiveness.In.* Proceedings of the International Conference on Wildlife Ecology and Transportation, Fort Myers, Florida, February 1998.

Cole, E.K., M.D. Pope, and R.G. Anthony 1997. *Effects of Road Management on Movement and Survival of Roosevelt Elk (Cervus elaphus roosevelti).* Journal of Wildlife Management 61 (4): 1115 – 1126.

Forman, R.T.T. and A.M. Hersperger. 1996. *Road Ecology and Road Density in Different Landscapes, with International Planning and Mitigation Solutions. In.* Proceedings of the Transportation Related Wildlife Mortality Seminar, Tallahassee, Florida, June 1996.

Forsyth A. 1985. *Mammals of the Canadian Wild*.Camden House Publishing Ltd., Camden East, Ontario. 351 pp.

Foster, M.L. and S.R. Humphrey. 1993. *Use of Highway Underpasses for Panthers.* Florida Museum of Natural History, University of Florida, Gainesville, FL. 13 pp. + Figures.

Hill, E. Senior Wildlife Biologist, BC Hydro. *Personal communication*, January 2004.

Jackson, S.D. and C.R. Griffin. 1998. *Toward a Practical Strategy for Mitigating Highway Impacts on Wildlife.* In. Proceedings of the International Conference on Wildlife Ecology and Transportation, Fort Myers, Florida, February 1998.

Land, D. and M. Lotz. 1996. *Wildlife Crossing Designs and Use by Florida Panthers and Other Wildlife in Southwest Florida..* In. Proceedings of the Transportation Related Wildlife Mortality Seminar, Tallahassee, Florida, June 1996.

Lenert, M.E., L.A. Romin and J.A. Bissonnette. 1996. *Mule Deer Highway Mortality in Northeastern Utah: Causes, Patterns, and a New Mitigative Technique.* In. Proceedings of the Transportation Related Wildlife Mortality Seminar, Tallahassee, Florida, June 1996.

Merilees, B., K. Langelier and K. Machin. 1992. *The Arrival of the Eastern Cottontail in Nanaimo.* Nanaimo Field Naturalists, Thrush: Series 2, Volume 4, p. 9-11.

Nyberg, J.B. and D.W. Janz (Editors). 1990. *Deer and Elk Habitats in Coastal Forests of Southern British Columbia.* B.C. Ministry of Forests, Special Report Series No. 5.

Powell, R.A., S.W.Buskirk and W.J. Zielinski. 2003. *Fisher and Marten* (Martes pennanti and Martes americana). In. Wild Mammals of North America: Biology, Management, and Conservation. (G.Felhamer, B. Thompson and J. Chapman *eds.*). Johns Hopkins University Press, Baltimore, Maryland. 1216 pp.

Pursello, B. Environmental Coordinator, B.C. Ministry of Transportation and Highways, Kamloops Region. *Personal communication*, July 2001.

Rautenstrauch, K.R, and P.R. Krausman, 1989. *Preventing Mule Deer Drownings in the Mohawk Canal, Arizona.* Wildlife Society Bulletin 17 (3): 280-286.

Roof, J. and J. Wooding. 1996. *Evaluation of the S.R. 46 Wildlife Crossing in Lake County, Florida.* In. Proceedings of the Transportation Related Wildlife Mortality Seminar, Tallahassee, Florida, June 1996.

Ruediger, B. 1996 . *The Relationship Between Rare Carnivores and Highways.* In. Proceedings of the Transportation Related Wildlife Mortality Seminar, Tallahassee, Florida, June 1996.

Shackleton, D. 1999. *Hoofed Mammals of British Columbia.* Royal B.C. Museum Handook. University of B.C. Press. Vancouver. 268 pp.

Simpson, K. and L. Gyug. 1991. *Effects of the Okanagan Connector Freeway on Wildlife and Effectiveness of Mitigation Techniques.* Keystone Wildlife Research, Whiterock. Prepared for Ministry of Highways, Victoria. 41 pp.

Woods, J.G. 1988. *Effectiveness of Fences and Underpasses on the Trans Canada Highway and their Impact on Ungulate Populations – Second Progress Report.* Canadian Parks Service, Western Region, Revelstoke. 97 pp.

Appendix A. Project budget summary (all amounts less GST).

Budget Item	Approved Budget Amount	Budget Expended to Nov. 30/04	Budget Surplus
Labour			
Project Mgr.	**26,350.00**	25,800.00	150.00
Technician	**6,800.00**	6,800.00	0.00
Construction	**10,250.00**	10,250.00	0.00
GPS Contractor	**551.05**	515.00	36.05
Engineering	**7,229.22**	7,229.22	0.00
Total Labour	**51,180.27**	**50,994.22**	**186.05**
Expenses			
Occupancy Permit	**1,100.00**	750.00	350.00
Mileage	**6,883.95**	6,632.99	250.96
Lumber & Equipment	**14,879.23**	12,844.19	2,035.04
Remote Camera Rental	**2,400.00**	2,400.00	0.00
Gates & Fencing	**3,141.55**	3,141.55	0.00
Motels & Meals	**350.00**	58.32	291.68
Total Expenses	**28,754.73**	**25,827.05**	**2,927.68**
Administration			
Admin. Fees	**6,550.00**	6,415.00	135.00
Rept. Production / Film Processing	**1,700.00**	847.30	852.70
Supplies	**3,100.00**	1,633.56	1,466.44
Total Admin	**11,350.00**	**8,895.86**	**2,454.14**
Totals	**$ 91,285.00**	**$ 85,717.13**	**$ 5,567.87**