



**Environment Canada Comments
SFPR Technical Review
14 August 2007**

TECHNICAL APPENDIX

ENVIRONMENTAL ASSESSMENT OF SOUTH FRASER PERIMETER ROAD

ENVIRONMENT CANADA

14 AUGUST 2007



Contents

1.0 Project Background;

2.0 Burns Bog;

2.1 Potential Impacts to Bog Hydrology

2.1.1 Characteristics of a Raised Bog

2.1.2 Proposed Route Alignment and Lagg Zone

2.1.3 Berm/Double-Ditch System (BDD)

2.2 Atmospheric Loading of mineral material into Burns Bog

2.3 Wildlife and Wildlife Habitat – Burns Bog

3.0 Comments: Draft Cumulative Effects Assessment (dated July 6, 2007)

3.1 Wildlife and Wildlife Habitat – Cumulative Effects

3.2 Air Quality – Cumulative Effects

4.0 Comments: SFPR Air Quality Update (July 6, 2007)

5.0 Comments: Draft Stormwater Management (dated June 4, 2007)

6.0 Wildlife and Wildlife Habitat

6.1 Comments on SFPR: Zones of Influence (dated April 25, 2007)

6.2 Comments: Wildlife Mitigation Crossing Plan (dated April 26, 2007)

6.3 Comments: Mitigation/Monitoring Strategy for Vegetation and Wildlife (dated April 12, 2007)

6.4 West Side of Burns Bog (Nottingham Farm) – Ecological Values and Significance



1.0 Project Background

The SFPR project consists of construction of a new 40 km long four-lane, 80 km/h route along the south side of the Fraser River. The proposed alignment extends north and east from the Highway 17/Deltaport Way intersection through Delta and Surrey along the south bank of the Fraser River. It connects highways 99, 91, 1 and 15, eventually terminating at the proposed intersection west of the Golden Ears Bridge Crossing of the Fraser River.

2.0 Burns Bog

The proposed SFPR alignment intersects the northern and southwestern margins of Burns Bog, the largest raised peat bog on the west coast of North America¹. The bog comprises a large, diverse and unique assemblage of plants and animals, including species that are federally and provincially designated as endangered, threatened, or of special concern.

Recognizing the high ecological and conservation values of Burns Bog, Environment Canada, the Province of British Columbia, the Greater Vancouver Regional District, and the Corporation of Delta, purchased the bog for \$73M in order to protect and maintain the ecological integrity of the Bog and its natural amenities. This investment is protected by a *Conservation Covenant* agreed to on March 12, 2004. The Province of British Columbia, the GVRD, the Corporation of Delta, and the Government of Canada (as represented by the Minister of Environment) are parties to this Covenant. As agreed to in the covenant, the GVRD and its partners developed a Management Plan for Burns Bog.

The management principles described in the covenant are : 1) maintain in perpetuity a large contiguous undeveloped natural area for the purpose of protecting the flora and fauna that depend on the Bog; 2) manage the Bog as a functional raised bog ecosystem as understood by the best science of the time, which includes its runoff and transition into lagg; 3) maintain the extent and integrity of the water mound and the peat that encloses it and in particular the upper porous acrotelm upon which the persistence of the bog ecosystem depends; and 4) prevent any occupation or use of the Bog that will impair or interfere with the current state of the Bog or the natural, scientific, environmental, wildlife or plant life values relating to the Bog. Section 4.1 of the *Conservation Covenant* states that the GVRD and its partners “shall not do anything, or allow anything to be done, that does or could reasonably be expected to destroy, impair, diminish, negatively affect, or alter the Bog or the Amenities”.

The *Burns Bog Ecological Conservancy Area Management Plan* was approved by the GVRD Board on May 25, 2007. According to the *Management Plan*, the following scientific guidelines are “recommended to focus discussions about the science of bog protection and restoration”:

- Return Burns Bog to an ecological condition shaped by raised bog processes, buffered from disruptive or disturbing adjacent processes on the landscape, within a timeframe of 100 years;

¹ Vitt, D.H., Halsey, L.A., and Doubt, J. (1999). Global and Regional Distinctness of Burns Bog. Department of Biological Sciences, University of Alberta.



- Achieve this ecological condition by maintaining characteristic ecological processes, structure and biota interacting over time, while recognizing the directional forces of urbanization, adjacent land uses and climate change; and,
- Measure and analyze the ecological condition using the following indicators:
 - Characteristic ecological processes: hydrological systems and water chemistry, peat accumulation, trophic interactions (exchange of energy) and connection with adjacent ecosystems and landscapes;
 - Structure and composition: the set of plant species or communities that define the bryophyte dominated shrubby structure and function of the bog habitat; and
 - Biota: the set of key, rare and/or critical acidophilic species (plants, vertebrates and invertebrates) that is collectively capable of natural or progressive evolution into other related bog ecosystem(s) with ecological integrity.

2.1 Potential Impacts to Bog Hydrology

2.1.1 Characteristics of a Raised Bog

It is crucial that environmental planning for the South Fraser Perimeter Road (SFPR) reflects a clear understanding of the abiotic and biotic characteristics of a raised bog. The ecological requirements for bogs to persist are strict and therefore impacts of the proposed construction of the SFPR cannot be adaptively managed.

The Burns Bog Scientific Advisory Panel (SAP) opinion presents eight characteristics of raised bogs. EC summarizes these eight characteristics and offers the following emphasis in order to provide the Federal RA's more context in which to consider EC's comments. We note that, in order to meet the restoration goals for the Bog, all the characteristics listed and described below must exist.

1. **Bogs must receive all their inputs of water from precipitation, and only extremely small amounts of nutrients from precipitation;** similarly bogs should only receive small amounts of nutrients from wind-blown dust or aerosols. Bog water is thus characterized as very acidic, very nutrient-poor water, with pH less than about 4.2, calcium and other minerals generally less than 3.0 ppm, and extremely low levels of the other essential elements for plant life.
2. **The water table must be maintained very near the surface and fluctuate within narrow limits within the acrotelm which extends only a short distance below the bog surface.** Ombrotrophic bogs are two layered systems, the surface acrotelm and the lower catotelm, and operate differently from most surface water/groundwater systems. Within the surface "acrotelm" the water level will vary seasonally, being fully charged with water during the winter and drying out during the summer. In the acrotelm, levels may be sufficiently high as to maintain surface pools or ponds. In the acrotelm layer, the peat close to the surface is



aerated with oxygen in the pore spaces, so that aerobic respiration occurs in the roots of higher plants and in the microfauna and microorganisms. In contrast, the peat beneath the lowest water level, the **catotelm**, is not aerated, anaerobic respiration occurs, and the biological processes are very slow and there is no movement of water. Low permeability peat thus forms and sustains a high water table.

3. **Dominance by *Sphagnum*** moss is one of the key features of bogs in the northern hemisphere. *Sphagnum* is the major contributor to peat accumulation; conditions that support *Sphagnum* are conditions that do not support the growth of trees or other vegetation.
4. **The raised bog body is elevated above the regional water table** (some decimeters to a few meters). Water slowly flows radially outwards from the raised centre towards the margins, the flow occurring almost entirely in the acrotelm. The domed structure of the bog precludes hydraulic connection to adjacent mineral-groundwater-fed wetlands.
5. An undisturbed raised bog has two main vegetation forms: 'open bog' in the centre and 'treed bog' at the margin. The water gradient steepens at the bog margin as the water moves radially outwards toward the surrounding lagg zone. The lagg zone is the transition of bog water into the surrounding mineral soil water zone. Because of the steeper water gradient at the edges, the water table drops lower beneath the surface, thus resulting in a thicker aerated zone that allows tree roots to develop. This facilitates tree growth. **Part of this water gradient exists because of the presence of vegetation that draws the water table down; this 'treed bog' or 'bog forest' zone is normally a narrow zone on the margins of raised bogs.**
6. Where the nutrient poor water of the bog meets the marginal nutrient-rich and mineral-rich surrounding wetlands or uplands, there is a mixing of the waters from the bog and mineral-soil-influenced waters. **This mixed water does not re-enter the bog, rather it leaves the lagg through streams and wetlands adjacent to the lagg.** This is a key ecological transition zone (ecotone) and changes from nutrient-poor bog forest to richer types of wetlands such as swamp forest or fen. Plant and animal species composition changes as does the type of peat being laid down. This lagg transitional zone is an essential component of a raised bog ecosystem.
7. The spatial changes from open bog through treed bog into lagg swamp forest at the bog margin are represented in vertical peat profiles taken in the centre of the bog. At the base of the profile, beneath the bog, one may encounter minerotrophic swamp, fen, or marsh communities, and sometimes aquatic sediments. Hence the spatial sequences seen at the surface are present-day representations of vertical sequences that occurred as the bog developed, over about five millennia in the case of Burns Bog.
8. A raised bog is part of a larger hydrological system, which consists of the raised bog itself, the surrounding lagg and other wetlands, and the geomorphologic setting that has created the bog. **Independently managing the parts of the system outside of the context of its hydrological setting will not maintain the integrity of the bog.**

The lagg zone, (see item 6 above) is an area of particular concern for EC. Most of the original/natural surrounding lagg features of Burns Bog have been destroyed by human activities. Currently, the waters of the Bog are primarily intercepted by perimeter ditches.



Restoration efforts are now focused on raising the water table by damming of internal ditches and canals.

The SAP opinion states, and EC concurs, that restoration and conservation of Burns Bog depends on “managing it as a complex hydromorphologic system, consisting of the Bog, plus its surrounding mire types, plus the encompassing mineral-soil terrain and its runoff.”

2.1.2 Proposed Route Alignment and Lagg Zone

The SAP opinion states, and EC concurs, that the proposed SFPR route “unambiguously passes over bog peat, enters the water mound, and passes through zones of water chemistry (Types 1 and 2) considered to be part of the Bog water system...The route also passes through ecosystems that are directly part of the bog complex and previously identified as required for the Bog’s ecological integrity²” (SAP opinion, page 5).

EC concurs with the SAP opinion that “**if the highway is built without any mitigative/protective structures between it and the Bog, there are very high risks of negative impacts on bog hydrology because all incursions into the water mound and peat mass change bog hydrology and directly jeopardize ecological integrity**”. In particular, water exiting the Bog will “pond against the highway in roadside ditches, and water running off the highway on the Bog side [and flowing into the Bog] will carry petro-chemical contaminants, heavy metals, and nutrient-rich water from the road surface and road fill material” (SAP opinion, page 5).

Of particular concern to EC are the predicted impacts to the southwest side of Burns Bog and the adjacent Crescent Slough area (the ‘Nottingham Forest Property’), near the Highway 99 interchange. The transitional forested bog and riparian and agricultural field habitats, coupled with high wildlife values, distinguish this area as regionally significant. It is imperative that the SFPR does not encroach on this area along the southwest margin of Burns Bog because this Crescent Slough-mixed conifer forest zone is the last remaining lagg area of its type in Burns Bog, and was identified as necessary for long-term ecological integrity of Burns Bog (Hebda et al., 2000). EC concurs with the SAP opinion that lagg is essential to the hydrological and hydrochemical functions of a raised bog.

In addition to compromising the ecological integrity of Burns Bog EC is concerned that, based on the current alignment, **opportunities to determine and understand how a natural lagg functions with the specific purpose of management and restoration of the lagg around the margins of Burns Bog, and elsewhere would be lost**. This would occur because the only living example of a sharp peat-to-mineral transition zone at Burns Bog would be severely degraded or destroyed, and therefore opportunities to understand and model the hydrological and other characteristics of the bog-lagg transition would no longer be available to the scientific community.

² Hebda, R.J., Gustavson, K., Golinski, K., and Calder, A.M., (2000). Burns Bog Ecosystem Review: Synthesis Report for Burns Bog, Fraser River Delta, South-Western British Columbia, Canada. Environmental Assessment Office, Victoria.



In summary, EC believes that the value of the Bog is seriously compromised without a functioning lagg. Furthermore, there is presently no evidence that the multiple functions and attributes of a natural lagg, including its unique ecological characteristics, can be replaced by an engineered structure.

2.1.3 Berm/Double-ditch (BDD) system

As a result of development and other past activities, none of the original, natural lagg remains on the northern edge of the Bog. The existing ditches and canals in this area act in a 'pseudo-lagg' way to receive waters from the Bog. However, these act more to drain the bog rather than the desired situation, which is to maintain water within the mound or foster a lagg ecosystem.

The proponent, through consultation with the Burns Bog SAP, has proposed to construct and monitor a berm/double-ditch (BDD) system to mitigate potential impacts of the proposed SFPR to Burns Bog.

EC believes that **there is presently no evidence that the multiple functions and attributes of a natural lagg can be replaced by an engineered structure.** However, given the historical disturbance on the northern edge, an engineered structure along the northern perimeter of the Bog could be viewed as an improvement over existing conditions, though **it is unknown to what degree such a structure could contribute to maintaining or restoring bog function.**

The SAP opinion describes a theoretical berm/double ditch (BDD) system that could be placed between the road and the Bog, and provides guidance, in the form of 7 key parameters, on the successful construction of such a system. EC supports the 7 key parameters outlined on page 6 of the SAP opinion and concurs that it "could provide an effective method for both 1) protecting the Bog from highway runoff of contaminants, and 2) aiding in the process of holding the water back in the Bog".

However, it is difficult to identify what the detailed specifications for the BDD should be because there are only a few examples in the world of similar constructions, and none of them extends for as great a length or has been used in association with a bog with as complicated a disturbance history as Burns Bog.

The proposed experimental installation of a small-scale pilot study of such a BDD system by the British Columbia Ministry of Transportation is an acceptable strategy; however, **a pilot study could only provide evidence of construction feasibility, not of its hydrologic benefit or of its long term sustainability. If a pilot study is undertaken, it should be constructed along the northern alignment and not in a location that would encroach on lands covered in the Conservation Covenant, as currently proposed.**

Given the limitations of the proposed pilot study, EC strongly recommends that if a BDD system is to be incorporated into the SFPR design, it should be constructed and proven to be functional before construction of the road begins, in order to guarantee that the hydrology of the Bog is protected, and that incursions of nutrient-rich waters and pollutants are prevented during highway construction.



If a BDD system is to be incorporated into the SFPR design, **the issue of appropriate maintenance and care of the BDD system is as critical as the design, and cannot be adaptively managed.** The proposed BDD system would have to be maintained without the introduction of any mineral material into the Bog, either through direct deposition, aerosol, or atmospheric transport.

The design and maintenance of the structure remains unresolved at present; more complete engineering drawings and construction plans are integral elements to assessing the impacts and benefits of the structure with respect to bog hydrology. The structure must (1) create a physical separation between bog waters and mineral waters including all runoff from the road surface; (2) provide for non-bog waters to be drained away from the bog, and (3) provide the ability to raise and manage the water levels on the bog side of the structure. **EC also notes that if such a system is constructed and fails to function as expected, it is not clear what contingencies exist.** Given the relatively high level of uncertainty regarding the construction and function of a BDD system and the high risk to bog hydrology that the SFPR poses, EC believes that the BDD concept is an incomplete solution.

Further complicating this issue is the fact that the potential impact of aerial deposition of mineral material into the Bog may ultimately override the intended benefits of a BDD system. Any intended hydrologic benefit of a BDD system could be seriously compromised or negated if the introduction of mineral materials into Burns Bog occurs, and the subsequent promotion of a wide margin of forest leads to dewatering of the acrotelm. The promotion of the bog forest along the Highway 91 corridor since its construction in the late 1980's suggests that the conversion from bog to forest would occur rapidly. This puts into question the long-term efficacy of a BDD system given the currently proposed alignment along the margin of the Bog. EC's specific comments regarding introduction of mineral material to the Bog are presented below.

2.2 Atmospheric Loading of Mineral Material into Burns Bog

The SAP opinion reviews and summarizes the available literature on the effects of particulate drift off highways. EC has also reviewed the available literature and notes that in the Arctic studies³ effects such as changes in plant communities and soil chemistry were measurable 200-300 metres away from constructed roads. EC stresses that the **SFPR will have levels of traffic far in excess of the roadways examined in these Arctic studies.** Accordingly, EC anticipates that the impacts would likely be greater than those described in the Arctic studies.

The SAP opinion states, and EC concurs, that how far the drift extends depends on the direction of prevailing winds relative to orientation of the road, whether or not the road is gravel and dusty, and whether or not the road becomes paved. The greatest potential for dust drift will certainly occur during construction, when mineral fill is being laid.

³ Forbes, B.C. (1992), [Tundra disturbance studies. I.](#) Long-term effects of vehicles on species richness and biomass. Environmental Conservation 19:48-58.

Forbes, B.C. (1995), [Tundra disturbance studies. III.](#) Short-term effects of aeolian sand and dust, Yamal Region, Northwest Siberia, Russia. Environmental Conservation 22:335-344.



The SAP opinion also addresses the issue of aerosol spray of road materials. The SAP and EC note that the literature indicates that road spray from highways travels a significant distance from the road. Solids concentrations of spray can be high, some figures indicate as high as 420 mg/L. While spray only occurs during rainy periods 420 mg/L is a high concentration, and a larger concentration than an ombrotrophic bog (fed by precipitation only) can accommodate. The salt, sand and gravel contained in plowed snow/slush during our infrequent snowfalls would also be expected to increase aerosol spray contaminant concentrations.

Field visits and air photo assessments have indicated significant growth in the bog forest in this area. The SAP opinion concludes that introduction of mineral material through all processes has promoted this impact. Recommendations made numerous times to the proponent since November 2006 to conduct a follow-up assessment of the impact of mineralization on the bog related to existing HWY 91 have not been acted upon.

Assessment of the mineralization impacts of HWY 91 could lead to the resolution of three key issues: (1) how far the mineral material moves into the bog; (2) how much mineral material has accumulated since construction of HWY 91, and (3) how much mineral material was deposited during HWY 91 construction and during road operation. The third issue could be assessed by using lead content as a marker, as HWY 91 construction occurred just prior to lead removal from gasoline. In the absence of the requested assessment, we must conclude that the change in forest composition is a consequence of mineralization. Further information, should it substantiate this conclusion, would help calculate the momentum of forest encroachment toward the bog centre. **Ultimately, resolution of these issues may provide an indication of the minimum distance a roadway should be located away from the Bog to avoid the predicted impacts.**

Without detailed information on the rates of deposition of all nutrients for the period of construction and afterwards for similar highways, it is impossible to predict precisely the impacts of dust and emissions on the nutrient dynamics of the Bog. From the available literature, the SAP predicts that the impacts would be mainly from Ca and N. Ca and N would promote tree and shrub growth on the Bog, discourage *Sphagnum*, and thus increase evapotranspiration and promote Bog desiccation.

A modeling study of the impact of particulate matter has been recently conducted for the British Columbia Ministry of Transportation by Robert Humphries of Levelton Consultants. The study is based on estimates of particulate materials, vehicle emissions or road dust, for the proposed SFPR. Humphries concludes, '[t]he estimated increase in material deposition to Burns Bog as a result of the operation of the proposed SFPR is considered to be minimal in relation to current atmospheric deposition from other regional sources. In addition, the estimated impact of prevailing wind direction on particulate matter deposition is considered to be low' (pg. 2).

The SAP opinion indicates, and EC concurs, that this modeling study was not based on enough real data for the local effects of drift from the SFPR to be reliably determined. Further, the evidence of impact along HWY 91 indicates that local negative effects are both detectable and considerable.

EC's detailed comments specific to the Levelton modeling study are as follows:

- Additional information is required to verify the estimate of the loading of particulate matter near the roadway. In particular, references and discussion of



calculation methods are required for the assessment of 0.03 kg/ha/y for SFPR and the background loading of 1.14 kg/ha/y.

- An annual average concentration for road dust is used. This may not be appropriate given that the bulk of dustfall will occur during the dry months of the year. If specific concerns exist regarding dust loading during specific periods or seasons (rather than simply incremental loading over a long period of time) then this should be revisited.
- Road dust contains calcium and magnesium, as well as trace metals such as zinc, copper, and lead. The potential sensitivity of the bog to the specific chemicals or minerals found in road dust is not discussed, nor are the constituents of road dust PM compared to the background PM₁₀. The direct comparison of the incremental PM deposition due to SFPR to assumed deposition from background PM levels is not an adequate measure to conclude minimal environmental effects.
- Road dust emissions could potentially peak during construction of the road. EC notes that in the Local Air Quality Impact Assessment, the proponent has committed to a list of measures to minimize road dust during construction, however, these are discussed in general terms only (eg. "regularly clean roadways"). There may be additional precautions and mitigation measures possible to protect the bog from unnecessary dustfall - these should be explored and discussed in detail.
- The proponent is not planning to monitor dustfall during operation of the road. Further, in the Local Air Quality Impact Assessment, the proponent states that road dust will be managed in accordance with British Columbia Ministry of Transportation standards. Given the sensitivity of Burns Bog to road dust emissions and particulate deposition, EC recommends that a monitoring program be established should the project proceed.

In summary, a comprehensive monitoring and assessment of this issue should be conducted before construction, since the impacts cannot be adaptively managed. EC asserts that the proposed alignment around the bog would result in air-borne drift of particulates and aerosols onto the Bog. **The introduction of mineral materials would subsequently promote the development of a wide margin of forest, which would contribute to dewatering of the acrotelm and ultimately threaten the viability of the Bog.** Monitoring and assessment of this issue (through a study of HWY 91 impacts) will not change this eventuality, but rather would inform on the predicted rate and extent of mineral deposition and the rate of forest encroachment toward the bog centre, and provide an indication of the minimum distance a roadway should be located away from the Bog to avoid the predicted impacts.

2.3 Wildlife and Wildlife Habitat – Burns Bog

The habitat complex associated with a parcel of land on the western side of Burns Bogs is unique and supports a diverse assemblage of wildlife species. Representative habitats include: bog, transitional (lagg) and deciduous forests; upland and riparian shrublands; old-fields; agricultural fields; and, a drainage ditch system (collectively these habitats will be referred to as the 'Nottingham Forest Property'). These habitats and their associated wildlife are locally unique, and of regional value. Despite proposed mitigation, habitat loss and zones of influence



effects pose a high risk to the short- and long-term ecological functioning of this habitat complex.

The avian species listed on Schedule I of the federal *Species at Risk Act* (SARA) that are confirmed or likely to occur within the Nottingham Forest Property include: the Barn Owl; and Western Screech-Owl. Provincially listed species include: the Sandhill Crane; Band-tailed Pigeon; Barn Swallow; and, Green Heron. Several other federally (Schedule 3 of SARA) and provincially listed (red- and blue-listed) species have the potential to make use of this area.

Based on published literature, the SFPR poses a high collision (mortality/injury) risk to avian species, including the SARA-listed Barn Owl and other raptor species. The proposed alignment passes through and adjacent to high quality Barn Owl and other avian species habitats, including the Nottingham Property and areas south of Burns Bog. The planting of hedgerows that the British Columbia Ministry of Transportation has proposed may be effective in reducing collision risk to avian species in areas where this mitigation measure is applied. The effectiveness of this mitigation measure is largely unknown. It is EC's opinion that the Delta Barn Owl breeding population, and other local raptor populations, are particularly vulnerable to the additional cumulative collision risk associated with the SFPR. Increased mortality rates are anticipated and local extirpation of breeding pairs likely over the mid- to long-term. While MoT suggests that verge habitat is important for other raptor species, EC recommends that it should not be managed as an attractant to wildlife. Any habitat maintained and managed for raptor species, or avian species generally, should be kept outside of any proposed roadside edge hedgerow or vegetative barrier.

The Sandhill Crane population appears to be making a recovery in the Fraser Lowland, as evidenced by observations of increased numbers of birds staging in the agricultural fields associated with the Nottingham Forest Property over the past year. Historically, the Sandhill Crane has been abundant in the Fraser Lowlands; however, conversion of breeding and forage habitats has resulted in a much reduced breeding population. It should be noted there is uncertainty concerning which Sandhill Crane sub-populations of the Fraser Lowlands are using local habitats for breeding or staging. Presently, breeding and migrant individuals of this species travel back and forth from their roosts within Burns Bog to the Nottingham Forest Property, where they forage within agricultural and old-field habitats. The SFPR alignment would pass through and run adjacent to this forage habitat. EC does not anticipate that the alignment itself would act as an impermeable barrier to these birds accessing remaining forage habitats, though this is a concern. However, more likely is the effect of large volumes of traffic disturbing and alienating Sandhill Crane away from this area. The British Columbia Ministry of Transportation has proposed mitigation and habitat compensation measures to address these concerns, which include such things as: planting road-side hedgerows (to reduce collision risk); and, habitat protection, restoration and stewardship measures (to address habitat loss/alienation). Some of these measures require further evaluation; nonetheless, EC is presently of the view the proposed SFPR alignment would present a high risk to the long term viability of a potentially recovering Sandhill Crane population in the Fraser Lowlands.

The Trumpeter Swan population is making an impressive recovery throughout the region; however, EC is concerned that both cumulative and zones of influence effects associated with the SFPR could potentially deter this species from making use of the agricultural fields associated with the Nottingham Forest Property.



Avian species not identified as 'at risk' federally or provincially, but still of interest or concern to environmental agencies, include: the Bald Eagle; waterfowl (Mallard, American Widgeon; Green-winged Teal); Northern Saw-whet Owl; and a diverse community of songbirds. The Bald Eagle roost within the Nottingham Property may represent the second largest Bald Eagle roost site in the lower Fraser River valley. Consultation with the British Columbia Ministry of Environment is recommended in evaluating the risk to this roost as a result of the SFPR.

The proposed alignment comes within approximately 50 -100m of a very large Bald Eagle roost (refer to section 6.4). Small stands of old-growth spruce and hemlock provide excellent perch sites that overlook adjacent agricultural fields and the Vancouver landfill. Hedgerow and adjacent forested areas would dampen highway noise to some extent; however, residual noise and other disturbance effects would have the potential to deter this species from using this area. EC recommends that the British Columbia Ministry of Transportation consult with the British Columbia Ministry of Environment in regards to this matter.

Non-avian SARA-listed species found or likely to occur in and/or around the Nottingham Forest Property include: the Pacific Water Shrew; Red-legged Frog; and, to a lesser extent, the Western Toad. Provincially-listed species at risk include: the Trowbridge's Shrew; Snowshoe Hare; Southern Red-backed Vole; and, Yellow-legged Meadowhawk.

Within the Nottingham Forest Property, and along the north and north-west edges of the bog, the SFPR passes through and bisects areas that are rated as high-suitability Pacific Water Shrew habitat. A result of this would be a fragmentation of a majority of remaining high-rated habitat for this species in this area of the bog. Residual impacts to fish habitat require habitat compensation; areas identified for this purpose are intended as Pacific Water Shrew habitat compensation as well. It would be helpful if the British Columbia Ministry of Transportation could clarify which areas specifically are being proposed to serve as habitat compensation for the Pacific Water Shrew, and also clarify where wildlife crossings for this and other small mammal species are proposed in relation to areas that are high suitability habitats. Further evaluation is needed to assess the locations of wildlife crossings for small mammals. The extent to which wildlife crossings would be effective as a long-term strategy for maintaining Pacific Water Shrew viability around these areas of the bog, and in particular on the west side of the bog where the alignment bisects agricultural fields and riparian, old field and forest habitats, is uncertain. EC recommends the British Columbia Ministry of Transportation consult with the Ministry Environment on this matter.

Non-avian species of management interest include the Black Bear and Black-tailed Deer. These species have been observed in the Nottingham Forest Property. The proposed alignment would prevent them from accessing habitat outside of Burns Bog, since a wildlife crossing to accommodate their movements has not been proposed for this area. The property likely serves as an important travel corridor for a range of large and small mammal species. British Columbia Ministry of Transportation consultation with the British Columbia Ministry of Environment is strongly recommended in regards to this matter.

The recently identified new shrew species (*Sorex rohweri*) is presently known to occur in Canada only within Burns Bog. This species will be submitted to the Committee On the Status of Endangered Wildlife In Canada (COSEWIC) for assessment. If COSEWIC assesses *Sorex rohweri* as Endangered, Threatened, or as a species of Special Concern, it would then be brought forward for listing consideration under SARA. The provincial Conservation Data Centre has included this species on its 'red' (Endangered) list.



The Wildlife Mitigation Crossing Plan provides much greater detail on proposed crossing structures for facilitating wildlife movement than provided in the EA Application. However, most crossings are strongly correlated with watercourses; with very few wildlife passages proposed in terrestrial areas for terrestrial species. In particular, on the west side of Burns Bog, only two crossing structures - for amphibians, and small and medium size mammals - are proposed for a two kilometer segment of the alignment where wildlife movements, including large mammals, undoubtedly occur. Because this aforementioned area is a known travel corridor for large mammals, such as Black-tailed Deer and Black Bear, a crossing for these species is appropriate. Consultation with the British Columbia Ministry of Environment is strongly recommended on this matter.

EC predicts that the proposed alignment would, for its duration, impair the overall ecological functioning of the Nottingham Forest Property. The effects are summarized as follows:

- Long term: The project would impart permanent negative impacts that cannot be mitigated or compensated.
- Irreversible: Mitigation options to address impacts once the road is constructed are likely limited, and cannot be adaptively managed.
- High magnitude: The alignment would impact rare and unique habitats and wildlife of Burns Bog, including species that are federally listed on Schedule I of SARA and that provincially listed as threatened and endangered.
- Geographic extent: Direct, indirect and cumulative environmental effects would be local-to-regional in nature.
- Ecological context: The direct, indirect and cumulative environmental effects would impact habitats and associated wildlife of local and regional importance.

In summary, the complexity and uniqueness of the Nottingham Forest Property, at a local, regional and national level, makes suitable mitigation and/or compensation options extremely challenging, most likely impossible. Direct and indirect effects of the proposed alignment upon the habitats within this area, associated wildlife, and hydrology are such that ecosystem function would likely be severely compromised over the short and long term. It is clear that the Nottingham Forest Property is unique at a variety of spatial scales. Its long-term protection and management would undoubtedly contribute to the overall conservation efforts directed at Burns Bog, Species at Risk, as well as wildlife and wildlife habitats generally. Further, such management action would be consistent with the *Burns Bog Ecological Conservancy Area Management Plan*, the *Conservation Covenant*, and the goals of official recovery strategies and species at risk recovery teams efforts as they relate to Burns Bog.

3.0 Comments: Draft Cumulative Effects Assessment Report (dated July 6, 2007)

On reviewing the draft Cumulative Effects Assessment for the entire alignment of SFPR, a number of deficiencies have been noted by EC. On this basis, Environment Canada recommends that the Cumulative Effects Assessment be revisited. EC is willing to confer with



the British Columbia Ministry of Transportation in this regard. Key concerns include, but are not necessarily limited to, the following:

- EC disagrees with MoT's 'significance evaluation' assessment of a number of potential cumulative effects. In several cases, MoT's assigned significance ratings are much lower than ratings EC would assign. Specific details are available in section 3.1 below.
- On page 4 of the Cumulative Effects Assessment, it states that '*The SFPR impacts on approximately 250 ha of land, most of which is already developed and would be a very small component of the cumulative impact...*'. Approximately 50% of the expected footprint of the SFPR is not developed and/or has ecological values, in particular for an assemblage of species at risk. This statement therefore grossly undervalues the ecological importance of habitats along the proposed alignment.
- With respect to particulate matter deposition in Burns Bog, Environment Canada is not prepared to accept the proponent's suggestion that there are no residual impacts as a result of SFPR, and therefore no potential for cumulative effects.
- With regards to Burns Bog, the report purports (on page 19) that cumulative impacts would be low. It must be noted that the proposed alignment would directly impact remaining bog edge (lagg) habitat. EC predicts that this impact would likely be very serious. It is EC's interpretation that cumulative impacts, therefore, would also be very serious and high.

3.1 Wildlife and Wildlife Habitat – Cumulative Effects

Page 4, Table 10.3-2: Why are wildlife issues (e.g. road-related mortality) not included as issues? Most if not all of the projects listed in this table have and continue to impart negative impacts to wildlife, including habitat loss, collision and injury, and zones of influence (ZOI, noise and visual) effects. EC recalls that habitat impacts associated with the Golden Ears Bridge were not considered 'minor', and required concerted mitigation and/or compensation efforts along specific segments of the alignment, specifically in and around Unnamed Creek and Katzie Slough, to address residual impacts.

Page 4, 2nd last paragraph: The report states that '*The SFPR impacts on approximately 250 ha of land, most of which is already developed and would be a very small component of the cumulative impact...*'. Approximately 50% of the expected SFPR footprint is currently not developed and/or has associated and important ecological values, including for species-at-risk. This statement grossly undervalues the ecological importance of habitats along the proposed alignment.

Page 6, Deltaport Third Berth Project: The Vancouver Port Authority has committed to undertaking a suite of mitigation measures with respect to its DP3 project to address collision risk to the Barn Owl. Nevertheless, there remains a risk that DP3 could act cumulatively with SFPR and other existing and proposed projects to impact the regional Barn Owl population, in particular if proposed mitigation proves not to be entirely effective.

Page 6, BCTC Transmission Line Upgrade: There is uncertainty as to whether bird collision rates will increase or decrease as a result of this project. For that reason, bird carcass surveys



will be undertaken once the project is in operation to assess bird collision rates in high collision risk areas.

Page 7, Terminal 2 (T2) Project: While the specifics of this project may be unknown, assessing potential cumulative effects for aspects of this Vancouver Port Authority project can be reasonably done based on what is known today. For example, the movement of goods (TEUs) under existing conditions, i.e., rail and truck traffic, from Deltaport is presently known. An increase in TEUs arising from DP3, and T2 should it occur, is expected. It should be straightforward to estimate the increased traffic rate and, on that basis using the existing literature (for example, WARS?, Andrusiak (1994), Preston & Powers (2006)) approximate the resulting increased mortality/injury rate for species of concern (Barn Owl, for example). This in turn would inform – within limits – the nature and extent of potential cumulative environmental effects for species susceptible to vehicle collisions.

Page 11, Change in Noise Levels: None of the mitigation measures described in this section applies to the most sensitive ecosystem component along the proposed corridor, namely the Nottingham Forest Property.

Page 14, Table 10.3-3: This table is incomplete. For example, T2, should it occur, could interact with SFPR to cumulatively impact Wildlife Pattern Changes and Wildlife Mortality. Similarly, railway growth could interact cumulatively with SFPR to impact Wildlife Mortality, while transportation infrastructure and SFPR could act cumulatively to impact Cultivated Fields, wetlands, Wildlife Pattern Changes and Wildlife Mortality.

Page 15, Upland Forests: The cumulative impacts of the SFPR upon this ecotype have been assessed as 'low'. What is the numerical equivalent of this rating? In other words, since the total amount of this ecotype can be quantified for the region (Delta/Surrey), as well as historical losses and direct losses from the SFPR, it should be possible then to quantify the cumulative losses that would arise from the SFPR.

Page 15, Section 10.3.4.1, 1st paragraph: Indirect impacts have been assessed qualitatively. As discussed in this review to date, it is important to quantify zones of influence impacts for the purposes of mitigation and habitat/wildlife compensation.

Page 16, 1st paragraph: The report suggests the spatial extent of impacts to riparian forest as a result of Highway 91 is unknown. Aerial photos are available prior to the mid 1980s, from which it should be possible to evaluate historical impacts. Further, while aerial photographs may not be available to evaluate railway development impacts to the Fraser (north of Alex Fraser Bridge), professional opinion is available.

Page 16, 1st paragraph: Habitat compensation would not address the overall net loss of listed plant communities. For other projects, a compensation ratio of 1:1 has been used to protect equivalent amounts of habitat. A 1:1 compensation ratio for the SFPR would result in an overall net loss of habitat, as it has for other projects that have applied this approach.

Page 16, 2nd paragraph: Given historical and on-going rates of loss of upland forest, the SFPR's cumulative effects contribution rating of 'low' requires further discussion.

Page 17, 4th paragraph: The report states that impacts to cultivated fields 'were not predicted to affect habitat used by threatened Sandhill Crane species'. The Zone of Influence report



suggests a 300 m (82 ha) impact to Sandhill Crane. Proposed vegetative buffering (and possibly construction timing) would possibly reduce impacts during construction and operation. Overall, however, it is EC's position that net negative impacts have been substantially underestimated.

Page 17, 4th paragraph, last sentence: Much of the surplus agricultural land purchased for the project may not be suitable for mitigation/compensation because of, among other things, proximity (Zones of Influence) effects. Assessment of the various properties as wildlife habitat compensation will need to be the subject of further discussion between the British Columbia Ministry of Transportation, Ministry of Environment, and EC.

Page 18, 2nd paragraph: An assessment of the historical impacts of Highway 91 is recommended, as the discussion in this paragraph does not meaningfully contribute to an evaluation of the potential cumulative effects of SFPR.

Page 19: With regard to Burns Bog, the report purports that cumulative impacts will be low (see paragraph 4). It must be noted that the proposed alignment would directly impact remaining bog edge (lagg) habitat. Based on concerns raised to date by the SAP and EC on the direct effects of the alignment on Burns Bog, EC does not accept that the SFPR's cumulative contribution would be low. Rather, EC rates the SFPR's cumulative effects contribution as high.

Page 19, 6th paragraph: EC does not accept the position that existing zones of influence impacts (Highway 99, Highway 17, railway lines and agricultural activity) are so large that any impacts from the SFPR would be effectively masked. This conclusion should not be accepted when there exists the possibility to address the question scientifically. EC is prepared to confer with the British Columbia Ministry of Transportation in revisiting this evaluation.

Page 20, 3rd paragraph, last sentence: Attributing impacts due to indirect effects of the SFPR is not too speculative. It is important to identify the source of each impact where it is feasible to do so. There would undoubtedly be cumulative negative environmental effects related to indirect habitat loss attributable to SFPR. The question that needs to be answered is: How much would the SFPR 4-lane 80km/hr highway likely contribute to negative impacts above and beyond existing and likely future impacts? Further, what can be discerned from that information about likely effects upon wildlife making use of impacted upland forest habitats.

Page 20, Section 10.3.4.2, 2nd paragraph: Explain how cumulative environmental impacts from the SFPR would be of minor consequence relative to existing conditions. Direct (habitat loss) and indirect effects (mortality/injury, noise, visual, edge effects) would emanate from SFPR, and act in a cumulative fashion with past, present and likely future impacts. EC asserts that the SFPR would pose a major consequence relative to present conditions.

Page 21, Section 10.3.4.3, 3rd paragraph: Large mammal species would likely be adversely impacted. Increasing numbers of highway and secondary roads in an increasingly urbanized environment undoubtedly inhibit the movements of a range of species, particularly mammal species. EC disagrees with the British Columbia Ministry of Transportation, which concludes that no cumulative effects would arise from the SFPR.



Page 21, Section 10.3.4.4, 1st paragraph: A single crossing for deer is proposed. The statement contained therein should be singular; currently it suggests more than one crossing is planned.

Page 22, Section 10.3.4.4, 1st paragraph: EC rates the risk to Barn Owl (and possibly other raptor/migratory bird species) as a result of SFPR in combination with existing and future highway infrastructure projects in Delta as high, not medium. EC takes into consideration, among other things, the uncertainty in proposed mitigation effectiveness.

Page 29, Section 10.3.6, Conclusion, 2nd paragraph: Based on the above, a ‘nil’ or ‘low’ rating for cumulative effects on habitat fragmentation, riparian/upland forest, and wildlife movements is deemed incorrect. It is anticipated that most of the cumulative effects anticipated would be moderate to high.

Page 30, Table 10.3-5: EC disagrees with the significance evaluation given to several potential cumulative environmental effects, and recommends the following changes in Table 10.3-5 as follows:

Excerpt from Table 10.3-5:

Potential cumulative effect	SFPR contribution	Significance (level)
Habitat Loss Bog Habitat	MOT rating = Low EC opinion = Mod	MOT rating = Low EC opinion = High
Habitat Loss Cultivated fields	MOT rating = Low EC opinion = Mod	Mot rating = Low EC opinion = High
Habitat Loss Upland Forest	MOT rating = Mod EC opinion = Mod	MOT rating = Low EC opinion = Mod
Fragmentation Upland forest	MOT rating = Low EC opinion = Mod	MOT rating = Nil EC opinion = Mod
Changes in wildlife movements	MOT rating = Low EC opinion = Mod	MOT rating = Nil EC opinion = Mod
Wildlife mortality (collisions)	MOT rating = Low EC opinion = Mod	MOT rating = Low - Mod EC opinion = High

3.2 Air Quality – Cumulative Effects

Page 23, last paragraph: It states: ‘The basis for future air quality predictions is the GVRD growth management strategy, which uses population and land use changes predicted and planned for in municipal OCPs’. It is not stated whether the Gateway Program is incorporated into the OCP; and if not, whether the Gateway Program would affect the predicted land use and population growth south of the Fraser River – and therefore affect future predicted transportation-related emissions.

Page 25, Table 10.3-4: Federal Responsible Authorities have not made a determination on the likelihood of significant adverse effects of all of the individual projects or the cumulative impacts of the projects listed in Table 10.3-4. Projects on this list that have yet to receive an



environmental assessment certificate may be required to mitigate air quality impacts by reducing emissions to levels below those in the emissions projections in this table.

Page 26, last paragraph: EC notes that the Proponent is including the Gateway Program under a suite of initiatives to reduce vehicle emissions and improve air quality. This statement is difficult to understand because the Gateway program is projected to increase, rather than decrease, emissions of both GHGs and CACs over the 2021 projects without the Gateway scenario.

Page 27, 1st paragraph: Environment Canada is not prepared to accept the proponent's suggestion that there are no residual impacts as a result of SFPR, and therefore no potential for cumulative effects.

4.0 Comments: SFPR Air Quality Update (dated July 6, 2007)

It is stated that the Air Quality Update takes into account congestion reduction measures for the Port Mann Highway 1 project, including tolling and HOV lanes. EC notes there is no description of:

- The method used to estimate the effectiveness of these measures;
- The possible uncertainty or variability of the effectiveness of these measures;
- The assumptions that were made to arrive at these estimates;
- How the effectiveness of these measures will be monitored; and
- Whether the measures will be altered if the desired congestion mitigation effectiveness is not reached.

Further, it is unclear if these congestion reduction measures are the main reason for the change in emissions and ambient air quality estimates, as opposed to some of the other updates such as changes in vehicle classes within the EMME2 model. This information would be helpful to agencies reviewing the updated emissions estimates.

It is stated that Diesel PM_{2.5} concentrations are well within ambient guidelines. There are no actual ambient standards specifically for Diesel PM_{2.5}, so we suggest that references and comparison to ambient standards be removed from the tables and text.

5.0 Comments: Draft Stormwater Management Strategy (dated June 4, 2007)

Construction phase (Erosion and Sediment Control)

It is recommended that construction phase erosion and sediment control practices be designed and planned in advance in order to identify space and access limitations that could inhibit the use of suggested BMPs. If such cases exist, alternative methods should be developed that would alleviate sediment issues during construction (i.e. portable settling tanks, areas that could be used



for dispersion). The following suggestion is made for inclusion in Tables 1 and 2 of the subject memo (summaries of preliminary performance targets and recommended BMPs):

Any space and access limitations that could inhibit the use of suggested BMPs will be identified in advance of construction and if such cases exist, alternative BMPs will be developed that would alleviate erosion and sediment control issues during construction.

Operation phase (Water Quality)

Given that the Best Management Practices (BMPs) identified for use are largely landscape BMPs, they can be expected to demonstrate variable performance over time. Therefore, a maintenance plan should be developed to ensure that the BMPs are functioning properly. Maintenance plans will vary, although inspection for sedimentation and flow problems, as well as targeted monitoring may be necessary. A maintenance plan should be developed and carried out for this project, and duties assigned to a responsible party. The proposed project should also be designed so that stormwater BMPs are reasonably accessible to enable the required maintenance. The following suggestions are made for inclusion in Tables 1 and 2 of the subject memo (summaries of preliminary performance targets and recommended BMPs):

A maintenance plan for stormwater BMPs will be developed and carried out, and duties will be assigned to a responsible party, to ensure that BMPs perform effectively over time.

6.0 Wildlife and Wildlife Habitat

Wildlife and wildlife habitat comments pertaining to the entire proposed alignment are provided immediately below. EC also includes the report *West Side of Burns Bog (Nottingham Forest Property) – Ecological Values and Significance* (updated August 2007), in section 6.4 which has been developed during the course of the SFPR environmental assessment review

Outstanding wildlife and wildlife habitat issues for the proposed alignment include such issues as:

- The scale and nature of zones of influence impacts;
- The character and duration of monitoring – mitigation programs;
- The number, location and design of wildlife crossings; and,
- The character and scale of cumulative effects.

Resolution on the above will provide the basis to complete the draft Habitat Compensation Plan, an integral component of a conclusion to this review.

While the Zones of Influence Report (ZOI), dated April 25, 2007, does describe and assign impacts for various wildlife Valued Ecosystem Components (VECs), its findings do not effectively translate to the zones of influence information likely to arise from the SFPR (e.g., quantifying zones of influence along the alignment). A quantification of SFPR zones of influence is needed to complete the draft Habitat Compensation Plan.

EC recommends the ZOI describe the 'critical habitats' captured within a total zones of influence impact for each VEC. For example, a noise zone of influence impact may extend as a far as



200 m for songbirds. Within that total area, priority habitats should be identified for consideration and inclusion in the Habitat Compensation Plan. EC is prepared to confer with the British Columbia Ministry of Transportation on this matter.

The Vegetation and Wildlife Mitigation Monitoring Strategy has merit. However, additional work is needed on areas such as:

- Model assumptions and hypotheses;
- Appropriate periods of pre- and post construction monitoring;
- Assigning appropriate 'action' thresholds;
- Committing to a suite of explicitly recognized mitigation measures where monitoring indicates a problem; and,
- Ensuring consultation with the appropriate agencies (British Columbia Ministry of Environment, SAP, EC, etc).

A number of wildlife species – amphibians, small mammals, migratory birds, and raptors - are SARA-listed and/or provincially-listed due, in part or in whole, to habitat loss, fragmentation and mortality arising from project developments such as SFPR. Long-term maintenance and viability of at-risk populations within increasingly urbanized environments such as the Fraser Lowlands depends in large part on the maintenance and protection of the functioning ecosystems that support them.

6.1 Comments on SFPR: Zones of Influence Report (dated April 25, 2007)

Page 1, 2nd paragraph, 1st sentence: From our review of the document, it does not appear that the areal extent of the zones of influence has been consistently estimated for all Valued Ecosystem Components (VEC's) and all applicable areas.

Page 3, 2nd paragraph: The Barn Owl is listed as a species of Special Concern under the federal *Species at Risk Act* (SARA), and is included as a VEC under the SFPR environmental assessment (EA) review. Given the known mortality risk highways pose to this and other raptor species, their inclusion in the ZOI report is appropriate.

Page 4, 1st paragraph, 4th bullet: The residual impacts related to zones of influence will be an important consideration when EC assesses the nature and significance of impacts related to the SFPR for the purposes of habitat compensation.

Page 9: EC is generally in agreement that zones of influence impacts upon amphibians would be partly mitigated by: a) wetlands proposed around Burns Bog for the purpose of creating and maintaining lagg; b) fisheries compensation wetlands; and c) crossing structures in the Delta ravines and the Fraser Heights area. Monitoring the use of crossing structures over a period of 5-10 years, to determine mitigation efficacy, is recommended, in consultation with the British Columbia Ministry of Environment.

Page 12, 3rd paragraph: The suggested zone of influence related to passerines in cultivated fields appears reasonable (i.e., 200 m). However, it is not clear how this zone has been applied



to the alignment between Highway 17 and Highway 99. An existing zone of influence relating to 72nd street and the railway (in the order of 100 m) and to Highway 17 and 99 (zones of influence in the order of 200 m) suggest the SFPR would have the potential to interact in a cumulative fashion and intensify the zones of influence effects.

Page 12, 3rd paragraph: It is unclear why zones of influence were not considered north of Highway 99 where not all agricultural areas are buffered by forest. Please explain.

Page 13, 1st paragraph: The suggested zone of influence of 600 m relating to passerines in forests may be too large. Zones of influence in the order of 100-200 m may be more applicable along the SFPR.

Page 13, 2nd paragraph: Zones of influence along the north edge of Burns Bog cannot be discounted. Interior forest species are likely to be present such that zones of influence apply to them.

Page 13, 3rd paragraph: Zones of influence in the Delta Ravines cannot be discounted. Sensitive interior species are likely to be present despite urbanization in the area.

Page 14, 4th paragraph: Zones of influence in the Fraser Heights area cannot be discounted. The report is unclear about the predicted existing zones of influence from residential areas including roads. The addition of SFPR to existing zones of influence – railway line, roads, and residential developments – suggests a strong likelihood for cumulative adverse effects.

Page 14: 'Quiet pavement' or 'sound walls' are not proposed for north of Highway 99. As such, the British Columbia Ministry of Transportation is not proposing to reduce the potential zone of influence in the area of the Nottingham Forest Property. Such noise-reducing measures are proposed for Fraser Heights, to address local community concerns respecting potential noise impacts. In any event, what does the scientific literature say about whether such measures would be effective in mitigating noise and consequently zones of influence impacts to wildlife?

Page 16, 1st paragraph: The suggested zone of influence related to Sandhill Crane appears reasonable (i.e., 300 m).

Page 16, 1st paragraph: The suggested zone of influence related to Trumpeter Swans appears reasonable (i.e., 200 m) and should encompass other waterfowl species found in this area.

Page 17: Please describe the nature and extent of the commitment to a vegetative buffering as a mitigation measure.

Page 17: A summary of indirect effects of the SFPR on waterfowl and Sandhill Cranes related to zones of influence should be provided here.



6.2 Comments: Wildlife Mitigation Crossing Plan (dated April 26, 2007)

Page 2, 1st paragraph: We note that over 25% of the proposed 80 locations are fisheries crossings with no modifications for wildlife passage. How would these structures serve as movement corridors for wildlife?

Page 2, 3rd paragraph: Of the 80 wildlife crossings proposed, only four (4) sites include areas where watercourses do not currently exist. This reflects a large under-representation of crossings in terrestrial areas along the SFPR alignment, particularly in key wildlife areas such as the west side of Burns Bog.

Page 3, 1st paragraph: The inclusion of a large culvert to link the wildlife habitat compensation corridor at the north end of Burns Bog to the Fraser River may be of benefit to larger mammals. However, it is unclear how this feature would be incorporated into the pond complexes proposed in this area for lagg management. What evidence is there that large mammals currently make use of the area where this travel corridor is proposed? Additional information, and consultation with the British Columbia Ministry of Environment is needed with regards to this matter.

Page 3, 1st paragraph: The creation of an ecological barrier to medium and large mammals, and the risk of mortality the alignment would pose to these species, needs to be discussed with the British Columbia Ministry of Environment.

Page 4: Given the length of the SFPR alignment and the pockets of remaining habitat for larger species such as deer and possibly bear, identification of only one large mammal wildlife corridor along the alignment needs to be discussed with the British Columbia Ministry of Environment.

Page 5, Pacific Water Shrew: A 1.5 m diameter culvert appears to be reasonable, although smaller culverts are proposed where a 1.5 m diameter culvert is not practical or technically feasible. What does the literature say about the Pacific Water Shrew use of smaller culverts? Would use of smaller culverts be consistent with British Columbia Ministry of Environment best management guidelines?

Page 5, Red-backed Vole: A larger culvert size would likely be more effective in facilitating passage by red-backed voles.

Wildlife Crossing Spreadsheet:

- Why have fisheries crossings that have no specific design modifications for wildlife been included for wildlife?
- Why are so few terrestrial (dry) crossings recommended along the alignment?
- Recommendations regarding 1.5 m diameter culverts for Pacific Water Shrew are commendable; commitments to their inclusion in final design need to be developed in consultation with the British Columbia Ministry of Environment.
- How will natural substrates and coarse woody debris be placed in 1 m high culverts?
- Additional crossing structures for small mammals in areas south of Highway 99 are recommended. Townsend's Vole populations in this area are critical to many species of wintering raptors, and dispersal between populations is important.



- Why are so few crossing structures recommended in critical habitat areas west of Burns Bog?
- How will the large crossing structure proposed at the north end of the bog be compatible with proposed pond complexes in this area? A 30 m – two 15m corridors actually – may likely not be effective to function as a travel corridor for large mammal species.

6.3 Comments: Vegetation and Wildlife Mitigation Monitoring Plan (VWMMP) (dated April 12, 2007)

Page 14, 2nd paragraph, Planning: Please describe the ecological assumptions made and the models applied.

Page 15, 2nd paragraph, Monitoring: Please explain 'Validation Monitoring' and the underlying ecological assumptions and models.

Page 16, 2nd paragraph, 2nd sentence: Omit the statement 'undisturbed habitats in the project vicinity are rare' from the text, as it is misleading and incorrect.

Page 17, 3rd paragraph, Burns Bog Plants and Communities: EC disagrees that impacts to plant associations as a result of road construction and operation would be low. The SAP and EC need to be consulted in regards to this component of the VWMMP.

Page 18, 1st paragraph: The duration of post-construction effectiveness monitoring needs to be discussed with the British Columbia Ministry of Environment, SAP, and EC. One year of post-construction monitoring to assess impacts of invasive species is insufficient to address this long-term issue.

Page 19 under Monitoring Strategy, Aquatic Insects and Butterflies: Monitoring is proposed for two years following construction of the SFPR . This is too short a period of time to address long-term impacts to these species. As well, if construction is initiated in 2007, there will be no baseline information on insects by which to compare post-construction results. EC recommends that the British Columbia Ministry of Transportation consults with the British Columbia Ministry of Environment, SAP, and EC since this matter relates to habitat associated with Burns Bog.

Page 20, 3rd paragraph, Aquatic Insects and Butterflies: One year of baseline data (pre-construction) will not be enough to adequately determine whether a 20% change in insect abundance has occurred. Will insect diversity also be measured? EC recommends that the British Columbia Ministry of Transportation consults with the British Columbia Ministry of Environment, SAP, and EC since this matter relates to habitats associated with Burns Bog.

Page 21 under Monitoring Strategy, Water Associated Birds: Surveys for Sandhill Cranes should be conducted until late-October (as noted in Section 3.2.2.4 of the VWMMP), and be initiated in 2007. How many years of monitoring are proposed? What are the adaptive



management plans if a >20% decline – or threshold agreed to between the British Columbia Ministry of Transportation and EC - is observed?

Page 22 under Monitoring Strategy, Raptors: What data will be used to assess a 20% increase in road kill statistics? What road statistics would be used? Are there statistics from other roads that can be applied? Road kill statistics have not been provided in the environmental assessment to date to shed light on this issue.

Page 23, 1st paragraph, Passerines, Woodpeckers and Other Birds: Burns Bog is identified as having the greatest species diversity along the proposed alignment. Does proposed mitigation, as described in the 3rd paragraph under 'Mitigation Strategy', apply to the alignment in the area of Burns Bog, and in particular, the Nottingham Forest Property area?

Page 23 under Mitigation Monitoring, Passerines, Woodpeckers and Other Birds: Variable radius point counts are unlikely to be sufficiently robust to determine major changes in cavity-nesting bird abundance over short periods of time. In statistical terms, it is unlikely that enough pre-construction data will be available for comparative purposes. With construction proposed for later in 2007, how is it possible to collect pre-construction data? If statistically significant declines are noted, what options would be available for adaptive management?

Page 24, 1st paragraph, Mammals: When will the genetics of the southern red-backed vole be confirmed? Are there studies currently under way?

Page 25, 1st paragraph, Mammals: Proposed culvert crossing designs need to be compatible with those outlined in the Wildlife Crossing Plan.

Page 29, 1st paragraph, Amphibians: Two years of 'effectiveness monitoring' would not be sufficient to determine the effectiveness of mitigation. As for other projects, sampling periodically over a period of 8-10 years would be more appropriate to determine the effectiveness of culverts and associated mitigation for this taxon.

Page 32 under Mitigation Monitoring, Raptors: Peregrine Falcon is unlikely to be a major issue in the Crescent Slough area and should not be included.

Page 36, Aquatic Insects: Focusing on one or two areas for insect monitoring over a longer period of time would likely be more effective than doing so over a larger geographic area over a shorter period of time.



6.4 Regional Significance Paper

West Side of Burns Bog (Nottingham Farm) - Ecological Values and Significance

Prepared For:

Environment Canada - Canadian Wildlife Service (PYR)

Prepared By:

Martin Gebauer
Gebauer & Associates Ltd.
6387 Larch Street
Vancouver, B.C. V6M 4E8

Edited by:

Andrew Robinson
Canadian Wildlife Service (PYR)

Updated August 14, 2007

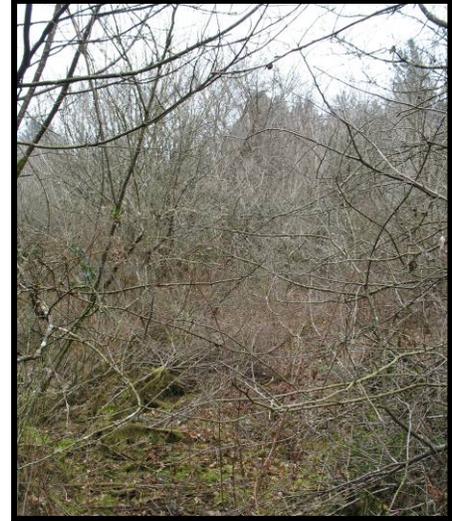
1.0 Introduction and Background

A portion of the proposed SFPR alignment is situated along the western side of Burns Bog in the transition area between lagg-type forests and agricultural fields. The area is often referred to as the Nottingham Farm and treed areas as Sherwood Forest. The west side of Burns Bog (hereafter referred to as the 'Nottingham Forest Property'), including the agricultural fields, forests and riparian shrublands, have been identified as being of regional significance for a number of wildlife species, some of which are likely to be impacted by a road in the area. The purpose of this memo is to describe the ecological values of the area in support of statements made by regulatory agencies during meetings and in correspondence with the Ministry of Transport, proponent for the SFPR.



2.0 General Habitat Description

The west side of Burns Bog has a high diversity of habitats supporting a wide assemblage of plant and animal species. Habitat types include Lodgepole Pine (*Pinus contorta*)-dominated bog forest, Sitka Spruce (*Picea sitchensis*) and Western Hemlock (*Tsuga heterophylla*)-dominated transitional (lagg) forests, Paper Birch (*Betula papyrifera*)-dominated deciduous forest, extensive riparian shrublands (see photo), wet marshes, old-field areas, agricultural fields and ditches. The juxtaposition of these habitats (see adjacent photo) supports a wide diversity of wildlife species, several of which are included on Schedule I of the federal *Species at Risk Act* (SARA). When the diversity of habitats and species is taken into account, the area is considered by Environment Canada to be regionally unique.



3.0 General Wildlife Description

The shrub and forest-



dominated areas between Crescent Slough and the 72nd Street right-of-way were visited by Martin Gebauer and other observers on at least seven occasions in the last two years: 21 February 2006, 22 and 24 February 2007, 05 and 13 March 2007, and 23 and 26 April 2007. The numerous bird and mammal species recorded in these habitats are summarized in Appendix 1. Robertson (2006) confirms the high wildlife biodiversity in the area.

Fifty-eight (58) bird species and eleven (11) mammal species were observed on seven winter and spring visits to the Nottingham Farm area. Common species observed during this period included waterfowl such as Mallard (*Anas platyrhynchos*), American Wigeon (*Anas americana*) and Trumpeter Swan (*Cygnus buccinator*), songbirds including Dark-eyed Junco (*Junco hyemalis*), Song Sparrow (*Melospiza melodia*) and Black-capped



Chickadee (*Poecile atricapillus*), and Bald Eagle (*Haliaeetus leucocephalus*). The focus of this technical memo is to provide information on rare and endangered species or species of management concern for which the west side of Burns Bog provides critical habitat (see below).

4.0 Rare and Endangered Species and Other Species of Concern

4.1 Bald Eagle

The forested areas between the landfill and Sherwood Forest provide roosting areas for numerous Bald Eagles, which are likely attracted to the large flocks of Glaucous-winged Gulls (*Larus glaucescens*) that frequent the landfill. Thirty (30) to forty (40) eagles were typically seen on field visits reported in Appendix 1 (see photo of eagle in spruce grove and photo with 18 eagles in four large cottonwoods along Crescent Slough), but as many as 335 eagles (January 16, 2005) have been reported at Burns Bog landfill and in the vicinity (Jordison and Elliott 2005). The site may represent the largest Bald Eagle roost site in the lower Fraser River valley, and the second largest Canadian roost site after the Brackendale site, Squamish, B.C.



An active Bald Eagle nest is present on the proposed alignment in a large Black Cottonwood. The nest is active as an adult and a chick were observed in the nest on an April 26 visit to the area (see photo below with adult in nest). The nest protected under the *BC Wildlife Act*.



4.2 Barn Owl (*Tyto alba*)

Barn Owls are blue-listed provincially and listed as Special Concern on Schedule 1 of the federal SARA. Barn Owls appear to be particularly common in western portions of Burns Bog, due in part to the abundance of prey items such as Townsend's Vole (*Microtus townsendii*), and the proximity of suitable roosting areas (Summers and Gebauer 1999). These roosting areas are often small microsites within the forest consisting of dense young hemlock stands with a greatly reduced if not absent shrub and herb understorey (see adjacent photo). Barn Owls are also known to nest in suitable



barns and other structures in the Crescent Slough area (Sofia Nesis, M.Sc. Student, pers. comm., 2007). On an April 2007 visit, a Barn Owl was observed flying from a nest box in a large shed by the blueberry fields and may be nesting here. Sofia Nesis has observed significant Barn Owl feeding activity in the old field habitats between Crescent Slough and Sherwood Forest.



Barn Owls are known to be particularly susceptible to road-related mortality. Preston and Powers (2006) documented finding 542 Barn Owls (of 952 owls) along roadways in the lower Fraser River valley.

4.3 Western Screech-Owl (*Otus Kennicottii* ssp. *kennicottii*)

Western Screech-Owl is blue-listed provincially and listed as of Special Concern on Schedule 1 of the SARA. Spruce-dominated forests and mixed woodlands at the west end of the bog are particularly suitable for this species. Although surveys by the proponent did not record any screech-owls in this area, they are expected given the availability of high suitability habitat. Materi and Blood (1999) reported Western Screech-Owl from the northwest area of the bog and Biggs (1976) considered them to be common in eastern areas of the bog. Preston and Powers (2006) reported that 17 of 952 owls collected along lower Fraser River valley roadways were Western screech-Owl.

4.4 Other Raptors

The diversity of habitats attracts many other raptor species including Great Horned Owl (*Bubo virginianus*), Barred Owl (*Strix varia*), Northern Saw-whet Owl (*Aegolius acadicus*), Long-eared Owl (*Asio otus*), Short-eared Owl (*Asio flammeus*), Northern Pygmy-Owl (*Glaucidium gnoma*), Northern Harrier (*Circus cyaneus*), Red-tailed Hawk (*Buteo jamaicensis*), Rough-legged Hawk (*Buteo lagopus*), Sharp-shinned Hawk (*Accipiter striatus*), Cooper's Hawk (*Accipiter cooperii*), Northern Goshawk (*Accipiter gentilis*), Peregrine Falcon (*Falco peregrinus*), American Kestrel (*Falco sparverius*), and Merlin (*Falco columbarius*) (Biggs 1976; Materi and Blood 1999; Summers and Gebauer 1999; McDade 2000; Robertson 2006). Of the diurnal raptors, not including Bald Eagle, Arffman (1987) and TERA Planning Ltd. (1991) found Northern Harrier and Red-tailed Hawk to be the most common species. Materi and Blood (1999) found Northern Saw-whet Owls to be the most common breeding owl in Burns Bog. As well, there is good evidence that Northern Saw-whet Owls winter in the lower Fraser river valley in significant numbers. Preston and Powers (2006) found that saw-whet owls are also very susceptible to road-related mortality: 278 individuals were found along roadways in the lower Fraser River valley.



4.5 Sandhill Crane (*Grus canadensis*)

The fields around Crescent Slough and west of Burns Bog have been identified as a critical fall staging area for Sandhill Cranes (Gebauer 1995; Gebauer 1999a). Burns (1997) found that the average number of cranes foraging in open fields in the Crescent Slough over the previous 20-year period to be 21, with a high count of 33 in one flock in 1991. In 1993 and 1994, the maximum number of cranes seen foraging in fields near Crescent Slough was 25 and 28, respectively (Gebauer 1995), while in 1999, the maximum number was 21 (Gebauer 1999a). Surveys by Robertson (2006) in fall 2006 documented a (surprising) maximum number of 56 cranes in early October. These birds are unlikely to all be originating solely from the lower Fraser River valley breeding population as was surmised by Gebauer (1995 and 1999a). As well, Gebauer (1995) documented that birds utilizing Crescent Slough fields during the day, roosted in central areas of the bog at night. No other large aggregations of Sandhill Cranes are known to occur in the lower Fraser River valley.

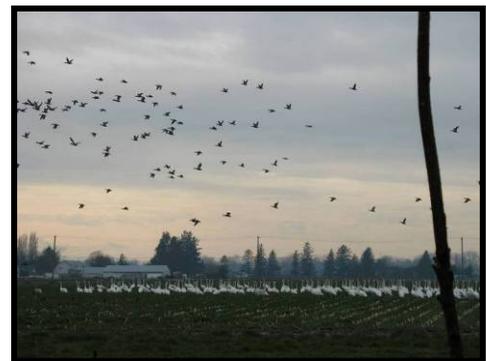
Burns Bog is known as one of the last remaining breeding areas for Sandhill Cranes in the lower Fraser River valley. In 1999, Enviro-Pacific Consulting (1999) and Gebauer (1999) estimated a breeding population of three to four pairs in the bog with a total summer resident population of approximately 10 birds. These densities were similar to those identified in 1994 (Gebauer 1995).

4.6 Great Blue Heron (*Ardea herodias*)

Great Blue Herons are blue-listed provincially and listed as of Special Concern on Schedule 3 of SARA. Forested habitats provide roosting opportunities, while agricultural areas, particularly old-field habitats, and ditches provide excellent foraging opportunities.

4.7 Waterfowl

Numerous waterfowl utilize fields in the Crescent Slough area. Large flocks of Mallard, American Wigeon and Green-winged Teal (*Anas crecca*) were observed during most field visits. Surveys by McDade (2000) indicate the number of dabbling ducks using Burns Bog in winter could exceed 10,000. Many of these birds would forage in agricultural fields such as Crescent Slough during the day.



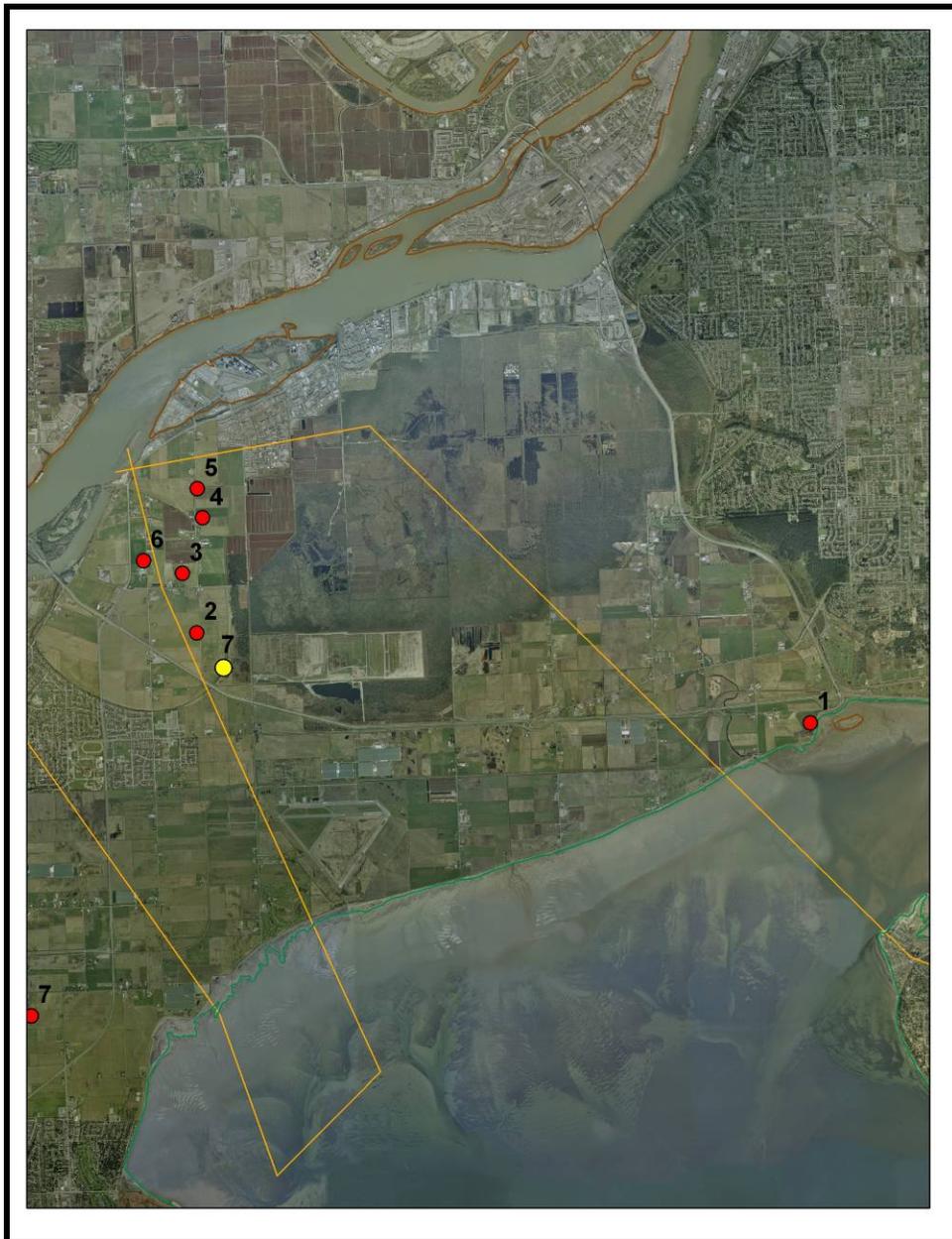


As well, large flocks of Trumpeter Swan utilize the Crescent Slough fields (Robertson 2006), and appear to prefer the area relative to other fields in the immediate vicinity (see map of Canadian Wildlife Service surveys below). Numbers 1 through 5 on the map represent 160 Trumpeter Swans (2002 survey) while numbers 6 and 7 represent 117 individuals (2006 survey). Up to 400 Trumpeter Swans have been observed feeding in the winter cover crop fields in the area (Markus Merkens, Delta Farmland and Wildlife Trust, pers. comm., 2007).



4.8 Songbirds and Other Birds

The high diversity of habitats in the area provides living areas for a wide variety of bird species. Robertson (2006) observed the greatest species richness of breeding passerine and woodpecker species in Burns Bog (Segments 216-224). Similarly, the western end of the bog, east of Crescent Slough, had 'considerable richness' of wintering birds. The area not only provides excellent breeding habitat for a number of species but wintering habitat for songbirds, particularly sparrows, and movement corridors for migrants. Field observations summarized in Appendix 1 indicate that 58 species have been documented in a few short visits to the area. Gebauer (1999b) listed 175 bird species that had been observed within or adjacent to Burns Bog, again highlighting the importance of these habitats to many bird species.



4.9 Black-tailed Deer (*Odocoileus hemionus* ssp. *columbianus*)

The forested habitats at the west end of Burns Bog provide security and foraging habitat for an apparently healthy deer population. The juxtaposition of forested habitats to excellent foraging habitats in agricultural areas is of particular value. Deer are regularly observed moving between these habitats in





the area where the SFPR is proposed. Robertson (2006) concurs, concluding that '...deer regularly move between Burns Bog and the adjacent fields at a series of locations north of the 60th Avenue right-of-way through to the west end of the Bog'.

In 1982, the Black-tailed Deer population of Burns Bog was estimated to be about 50 animals (Beak 1982), while Burns (1997) estimated the population at about 100 animals. The current estimate is around 50 animals with fewer than six animals likely being harvested annually (Jack Evans, Ministry of Environment, pers. comm., 2007).

4.10 Black Bear (*Ursus americanus*)

In 1982, Beak (1982) estimated a population of 12 Black Bears in the bog. McIntosh and Robertson (1999) estimated that Burns Bog could support up to five bears based on current habitat conditions and home range size. Since the mid-1990s, the number of bears appears to have declined dramatically. McIntosh and Robertson (1999) hypothesized that a large bear shot in the bog in 1997 may have been the last male bear in the area. The Nottingham's, local farmers in the area, do not recall seeing bears in the last two to three years (pers. comm., 2007). Nevertheless, bears may still occasionally inhabit the bog (see photo of possible scat taken in 2006) and have the potential to rebuild populations if the other bears disperse into the area.



4.11 Pacific Water Shrew (*Sorex bendirii*)

The Pacific Water Shrew is red-listed provincially, was recently determined to be Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC - April 2006), and is officially proposed to be uplisted from Threatened to Endangered under the SARA by the Minister of Environment.

Pacific Water Shrew was confirmed as occurring in the bog during the ecosystem review (Fraker et al. 1999; McDade 2000). Suitable living habitat is available along the west side of Burns Bog including Crescent Slough with habitats of highest value including riparian areas or mature lagg-type forests in proximity to permanent waterways. Suitability mapping by Robertson (2006) indicates that high quality habitat exists in the subject area.





4.12 Southern Red-backed Vole (*Clethrionomys gapperi* ssp. *occidentalis*)

The *occidentalis* subspecies of the Southern Red-backed Vole is known to inhabit the bog including the square parcel of red-listed and high suitability habitat at the northwest end of the bog just west of the 72nd Street right-of-way (Fraker et al. 1999; Robertson 2006). Burns Bog is the only known viable population of this subspecies in Canada. There is uncertainty as to whether *occidentalis* is in fact a subspecies. McDade (2000) in his report on the Burns Bog Ecosystem Review states, 'the presence of the Southern Red-backed Vole in Burns Bog is highly significant, as this is the only known occurrence in the province.' Until there is resolution on this matter, a pre-cautionary approach to the management of this species in Burns Bog is recommended. The proposed alignment intersects red-listed habitat this is also high suitability habitat for this species.

4.13 Snowshoe Hare (*Lepus americanus* ssp. *washingtonii*)

The *washingtonii* subspecies of Snowshoe Hare was thought to be extirpated in the Delta and Surrey areas, but has recently been rediscovered in several areas. Butler and Footit (1974), as cited in Biggs (1976), reported a carcass of a Snowshoe Hare found in the bog. Given that surveys for this species have not been conducted in Burns Bog in recent years, there is a possibility that this species occurs, including on the west side of Burns Bog.

4.14 New Shrew Species (*Sorex rohweri*)

A new species of shrew (*Sorex rohweri*) has recently been described for western Washington and southwestern British Columbia ranging between the Columbia and Fraser rivers (Rausch et al. 2007). Burns Bog is the only location in Canada that the species has been identified. A recent reassessment of shrew specimens captured during the 1999 Ecosystem Review of Burns Bog has confirmed that some of these specimens also match the characteristics of the new species. The provincial Conservation Data Centre red-listed this species in June 2007.

4.15 Red-legged Frog (*Rana aurora*) and Western Toad (*Bufo boreas*)

The Red-legged Frog is blue-listed provincially, and of Special Concern federally and on Schedule 1 of the SARA. This species has been confirmed in the bog (Knopp and



Larkin 1999; McDade 2000) and has a high probability of occurring in and around wetland and forest habitats on the west side of Burns Bog. Western Toad, a species of Special Concern federally and on Schedule 1 of SARA, was not confirmed as occurring in the bog during the 1999 ecosystem review; however, it has been recorded in two locations by Rithaler (2003). One toad was found in an industrial area south of Tilbury Island and another in the bog just south of the proposed 80th Street interchange.

5.0 Summary

The data collected thus far points to high biodiversity values along the west side of Burns Bog. The nature and extent of the likely effects of the SFPR upon specific habitat features and associated wildlife can in some instances be readily measured. The direct (footprint) and quantifiable loss of habitat along the alignment, for example, is readily assessed. Indirect effects, including noise and light pollution, collision rates, hydrological impacts, the introduction of invasive species and air-borne road contaminants, can also be identified but are far more challenging to quantify. The most difficult impact to assess is upon overall ecosystem functioning. In other words, posed as a series of questions: How well will the habitats of the west side of Burns Bog continue to function holistically to supply the necessary life-cycle requisites of wildlife so as to sustain the mix of species populations at their present levels? If mitigation is required, is there a high likelihood it will be successful? If not, can the principles of adaptive management be applied to situations where mitigation fails? If mitigation and adaptive management is deemed too risky, can habitat elsewhere be protected to supply and support, in the long term, these same wildlife populations? How would any such compensation measures align with, in the case of species at risk, recovery efforts targeted at these species?

Based on research in Banff National Park, Parks Canada offers the following analogous considerations with regards to road ecology (for more information refer to http://www.pc.gc.ca/pn-np/ab/banff/docs/routes/chap2/routes2_E.asp):

1. There is a larger ecological footprint associated with the physical footprint of roads - planners and managers need to consider the broad landscape rather than the one-dimensional road corridor.
2. The effects of road mortality can be felt in 1-2 generations, while barrier effects take several generations to manifest.
3. Animals need to move through the landscape, disperse freely, and re-colonize areas to be part of viable populations.
4. How much connectivity is necessary for wildlife, and what imposes a barrier to connectivity are difficult questions, especially for rare, elusive species.
5. Mitigation means to reduce the impact - not restore to pristine conditions.
6. There is a need for more systematic monitoring of measures in order to devise functional wildlife crossing structure systems and implement transportation plans based on well-founded science.
7. Mitigating highways is most economical during upgrades rather than going back to retrofit.



Environment Canada Comments
SFPR Technical Review
14 August 2007

8. Bridge reconstructions are excellent cost-effective opportunities to mitigate roads for wildlife and fisheries concerns.
9. There's no one-size-fits-all solution for crossing structures, but certain habitat elements (e.g., cover) can be designed into passages to meet passage requirement needs.
10. Wildlife crossing structures are built to last. Therefore, managing human activity and development is critically important for sustained effectiveness over the long term. Long-term land use plans adjacent to crossing structures need to be compatible with wildlife conservation plans and corridor requirements.

The complexity and uniqueness of habitats in this area renders suitable mitigation and/or compensation options challenging. Direct and indirect effects upon habitat, wildlife, and hydrology (as we are informed by the Burns Bog Scientific Advisory Committee and Environment Canada specialists) point to reduced ecosystem effectiveness over the short and long term. The Nottingham Forest Property, based on this review as well as a previous study of the larger bog, supports a diverse assemblage of wildlife, including some that are rare and endangered. This area is deserving of long-term protection in the context of management of Burns Bog, Species at Risk, and species of management concern.



6.0 References

- Arfmann, C.M. 1987. A ten year study of wintering raptor populations in the lower Fraser Valley region of British Columbia. Student report, Simon Fraser University. 94 pp plus appendices.
- Beak Consultants Ltd. 1982. Annacis Highway environmental assessment> Prepared for Ministry of Transportation and Highways, N.D. Lea and Associates Ltd., June 1982.
- Biggs, W.G. 1976. An ecological and land-use study of Burns Bog, Delta, British Columbia.
- Burns, B. 1997. Discover Burns Bog. Hurricane Press, Vancouver, B.C.
- Butler, R.W. and M.J. Footit. 1974. Preliminary survey of Burns Bog. B.C. Fish and Wildlife Service, Unpublished Report.
- Clevenger, A.P., Chruszcz, B., Gunson, K., & Wierzchowski, J. 2002. Roads and wildlife in the Canadian Rocky Mountain Parks - Movements, mortality and mitigation. Final Report (October 2002). Report prepared for Parks Canada, Banff, Alta.
- Enviro-Pacific Consulting. 1999. Status of the Greater Sandhill Crane (*Grus canadensis tabida*) in Burns Bog, delta – 1999. Unpublished report prepared for ENKON Environmental Ltd.
- Fraker, M., C. Bianchini and I. Robertson. 1999. Ecosystem Review Burns Bog. Prepared by Robertson Environmental Services Ltd. for Enkon Environmental Limited on behalf of Delta Fraser Properties and Environmental Assessment Office.
- Gebauer, M.B. 1995. Status, reproductive success and habitat requirements of Greater Sandhill Cranes (*Grus canadensis tabida*) in the Lower Fraser River Delta in 1993 and 1994. Unpublished report, prepared for B.C. Ministry of Environment, Lands and Parks, Surrey.
- Gebauer, M.B. 1999a. Burns Bog Greater Sandhill Crane (*Grus canadensis tabida*) study: late summer/ early fall 1999 survey results and review of existing information. Prepared for Delta Fraser Properties Partnership and the



- Environmental Assessment Office in support of the Burns Bog Ecosystem Review.
- Gebauer, M.B. 1999b. Status of Wildlife in Burns Bog, Delta – 1999: late summer/ early fall 1999 survey results and review of existing information. Prepared for Delta Fraser Properties Partnership and the Environmental Assessment Office in support of the Burns Bog Ecosystem Review.
- Hebda, R.J., K. Gustavson, K. Golinski and A.M. Calder. 2000. Burns Bog Ecosystem Review Synthesis Report for Burns Bog, Fraser River Delta, Southwestern British Columbia. Environmental Assessment Office, Victoria, B.C.
- Jordison, L. and K. Elliott. 2005. The Wandering Tattler 28(7). Vancouver Natural History Society.
- Knopp, D.H. and L.K. Larkin. 1999. Burns Bog and adjacent areas – amphibian and reptile study. Prepared for Delta Fraser Properties Partnership and the Environmental Assessment Office in support of the Burns Bog Ecosystem Review. B.C.'s Wild Heritage Consultants, Sardis, BC, Canada.
- Materi, J.J. and D.A. Blood. 1999. Burns Bog Spring Raptor Study. Unpublished report prepared by D.A. Blood & Associates Ltd. for ENKON Environmental Ltd.
- McIntosh, A. and I. Robertson. 1999. Ecosystem Review Burns Bog – Status of Black Bears. Unpublished report prepared by Robertson Environmental Services Ltd. for Enkon Environmental Ltd. on behalf of Delta Fraser Properties and Environmental Assessment Office.
- Preston, M.I. and Powers, G.A. 2006. High Incidence of Vehicle-Induced Owl Mortality in the Lower Mainland and Central Fraser Valley, British Columbia. *Wildlife Afield* 3: 1:15-23 Supplemental.
- Rithaler, R.C. 2003. Amphibians in Delta, British Columbia – status & species distribution by watershed (distribution map). Environmental Services, Corporation of Delta.
- Robertson Environmental Services Ltd. 2006. South Fraser Perimeter Road Vegetation and Wildlife Impact Assessment, Technical Volume 12 of the Environmental Assessment Application. Prepared for the Ministry of Transportation.



- McDade, G. J. 2000. Burns Bog Ecosystem Review. Report of the Special Advisor to the Minister of the Environment. March 31, 2000.
- Rausch, R.L., J.E. Feagin and V.R. Rausch. 2007. *Sorex rohweri* sp. nov. (Mammalia, Soricidae) from northwestern North America. *Mammalian Biology* 72(2): 93-105.
- Summers, K.R. and M.B. Gebauer. 1999. Burns Bog Raptor Study: late summer/early fall 1999 survey results and review of existing information. Prepared for Delta Fraser Properties Partnership and the Environmental Assessment Office in support of the Burns Bog Ecosystem Review.
- TERA Planning Ltd. 1991. Waterfowl, shorebirds and raptors within the property owned by Western Delta Lands Inc., Burns Bog, 1989-1990. Prepared for Western Delta Lands Inc. 35 pp.