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SODIUM HYDROXIDE DERAILMENT MILE 56.6 SCREENING LEVEL ASSESSMENT OF ECOLOGICAL EFFECTS

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Cheakamus Ecosystem Restoration Technical Committee

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GLOSSARY

Community - An assemblage of populations of different species within a specified location in space and time.

Ecosystem -The biotic community and abiotic environment within a specified location in space and time.

Exposure - The contact or co-occurrence of a stressor with a receptor.

Fate - The disposition of a chemical in various media or locations as a result of transport, partitioning, uptake and degradation.

Lines of evidence - Information derived from different sources or by different techniques that can be used to describe and interpret risk estimates.

Population - An aggregate of individuals of a species within a specified location in space and time.

Receptor - The ecological entity exposed to the stressor.

Stressor - Any physical, chemical, or biological entity that can induce an adverse response.

Uncertainty - Imperfect knowledge concerning the presence or future states of the system under consideration; a component of risk resulting from imperfect knowledge of the degree of hazard or of its spatial and temporal pattern of expression.

Definitions adapted/taken from:

- U.S. EPA (U.S. Environmental Protection Agency). 1998. Guidelines for Ecological Risk Assessment. Risk Assessment Forum, Washington, DC, EPA/630/R095/002F, 1998.

- Sutter, W.G. 1993. Ecological Risk Assessment.

1.0 Introduction

Following the derailment of CN rail cars at Mile 56.6 Squamish Subdivision on August 5th, 2005, and the subsequent spill of sodium hydroxide (NaHO) into the Cheakamus River, the Ministry of Environment (MOE) indicated its desire to have a screening level assessment of ecological effects completed. The assessment should be ecosystem-based in that it should consider species interlinked and dependent upon a range of processes. In doing so, this recognizes as one species in the ecosystem is altered, others may be affected. CN has asked Triton Environmental Consultants (Triton) to undertake this assessment. This document outlines the EoRA's approach and methodology.

1.1 Approach

The assessment has adopted some of the principles for ecological risk assessment (EcoRA) recommended by the Canadian Council of Ministers for the Environment (CCME, 1996), British Columbia Ministry of Environment Lands and Parks (BC MELP, 1998) and the U.S. Environmental Protection Agency (U.S EPA, 1998). EcoRA as defined by these agencies is a process evaluating the likelihood that adverse ecological effects may occur as a result of exposure to one or more stressors. Depending on available information, this assessment of effects can be described in various ways ranging from qualitative judgments to quantitative probabilities.

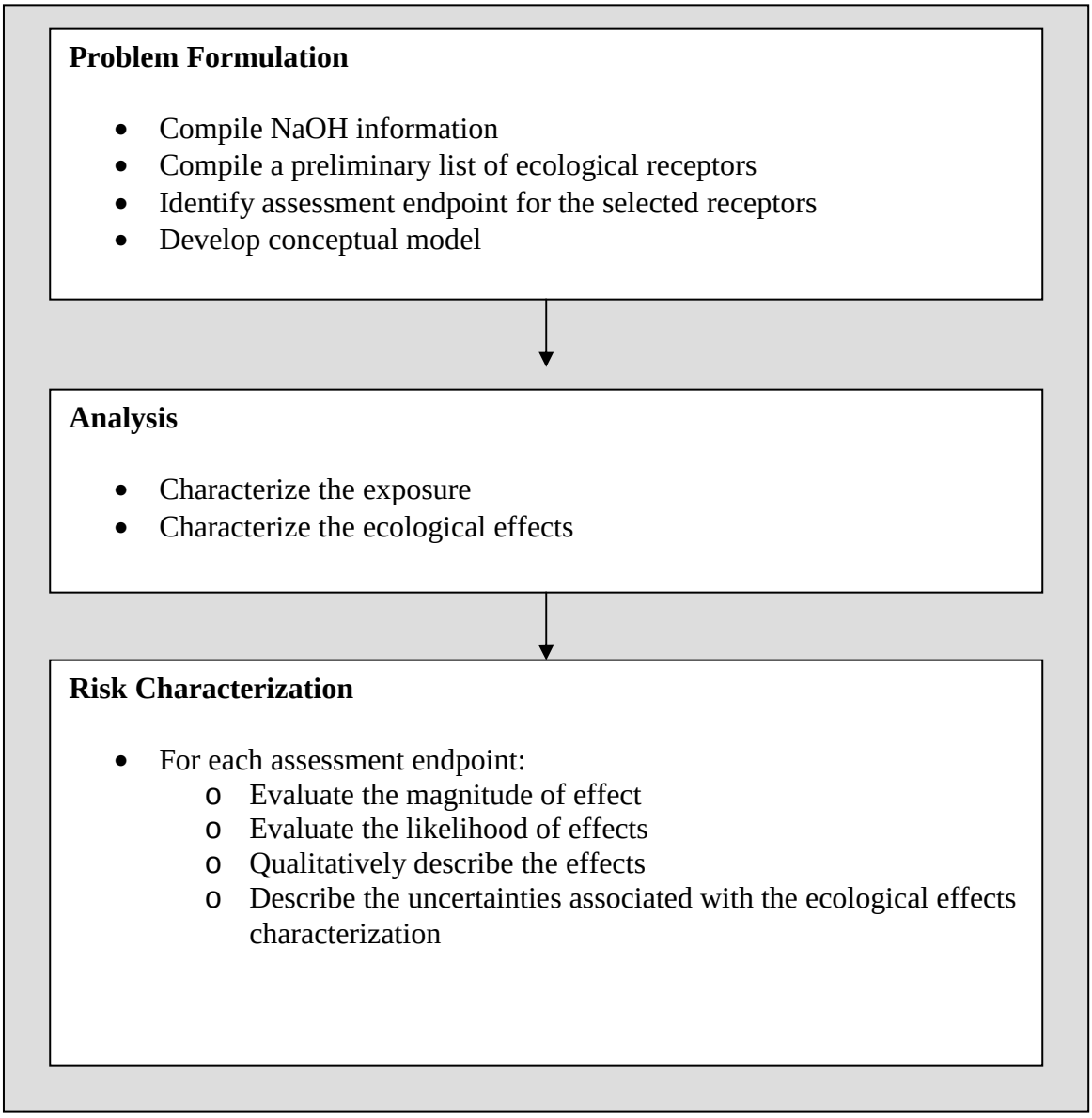
The approach selected to complete this project is a screening level qualitative assessment of ecological effects. Given the broad scope of the project and the limited amount of available data (i.e., exposure data, such as concentration of NaOH in environmental media, NaOH ecotoxicity toward specific species) it is not possible to conduct a comprehensive EcoRA for each species present in the ecosystem. The assessment will focus on the functions of populations and communities within the ecosystem. This recognizes populations are less sensitive than their most sensitive individual member and some effects may be observed at the population level without impairing the functions of the ecosystem as a whole.

Qualitative methods using subjective ecological effects ranking categories, such as high, medium and low, will be used to describe the likelihood of adverse effects rather than providing a numerical estimate of effects. The disadvantage of this qualitative approach is that it can be influenced by the perceptions of the assessors. To minimize subjective influence, the interpretation of ecological effects will contain a clear explanation of the lines of evidence leading to the conclusions, including a description of the uncertainties and assumptions used. Additionally, matrices will be used to provide a structured framework for the characterization of ecological effects (examples of qualitative matrix are presented in the effects characterization section). The assessment will consist of a "desk exercise" using existing information from baseline and monitoring reports and from the scientific literature.

2.0 Methodology

This screening level assessment of ecological effects will consist of three main steps: problem formulation, analysis and characterization of the likelihood of adverse ecological effects. The process is described in Figure 1 and discussed in more detailed in the following sections.

Figure 1. Overview of the proposed high level assessment



2.1 Problem Formulation

In the problem formulation, the three components of "risk": stressor (*i.e.*, NaOH), receptors (*i.e.*, invertebrates, fish, birds, etc.) and exposure pathways (*i.e.*, surface water, food, etc.), will be screened to define those combinations having the potential and or plausibility of causing adverse effects. The study area and its ecological setting will also be defined. Information on NaOH will

be compiled (*i.e.*, toxicity, environmental fate, etc.). A list of receptors will be developed based upon information obtained from available reports (consultants, government agencies, First Nations, non-government organizations). As there will be a large numbers of potential receptors, criteria will be developed to select the key receptors for consideration. Once the receptors have been selected, the assessment endpoints (*i.e.*, formal statement of what characteristic of the receptor will be evaluated) will be identified. The information on the receptor and NaOH will be integrated into the development of a written and visual description outlining how the derailment at mile 56.6 and NaOH spill may have affected the selected receptors.

Details on the methodology for each step are presented below.

2.1.1 NaOH Information

Library databases including, but not limited to UBC Library Catalogue, Science Citation Index, Ecotox and Environment Canada publication database, will be consulted to obtain information on NaOH. Information on NaOH physicochemical properties, toxicity and environmental fate will be gathered. The goal of this information review is to gain an understanding of NaOH behaviour and effects to identify plausible exposure scenario and compile a list of preliminary receptors as oppose to obtaining detailed information on toxicity for each species.

2.1.2 Selection of Receptors

The selection of receptors of concern (i.e., fish, aquatic invertebrates, aquatic plants, terrestrial plants, soil invertebrates, birds, mammals) will consist in a multi-step process illustrated in figure 2 and discussed below.

In the first step a general species list will be compiled. This lists the regional species most representative of the assessment area's aquatic and terrestrial habitats. The type of receptors potentially present will be dependent upon biogeoclimatic zones (biological, geographical and climatic) within the assessment areas, thus these zones will be determined. To do so, the map by Meidinger and Pojar (1991) identifying the fourteen biogeoclimatic zones for the province of British Columbia will be consulted. Once the biogeclimatic zone(s) have been identified a preliminary list of native amphibians, reptiles, birds and mammals for each biogeoclimatic zone will be compiled by consulting tables provided in Meidinger and Pojar (1991) and Stevens (1995) identifying species by biogeoclimatic zones and general habitat type. Red (extirpated/endangered/threatened) and Blue (sensitive/vulnerable) listed species will also be added to the preliminary list of receptors. Information on the appropriate forest district and subdistrict will be necessary to facilitate the use of the provincial government's information regarding endangered (*i.e.*, red listed) or vulnerable (*i.e.*, blue listed) species.

Figure 2. Receptors selection framework

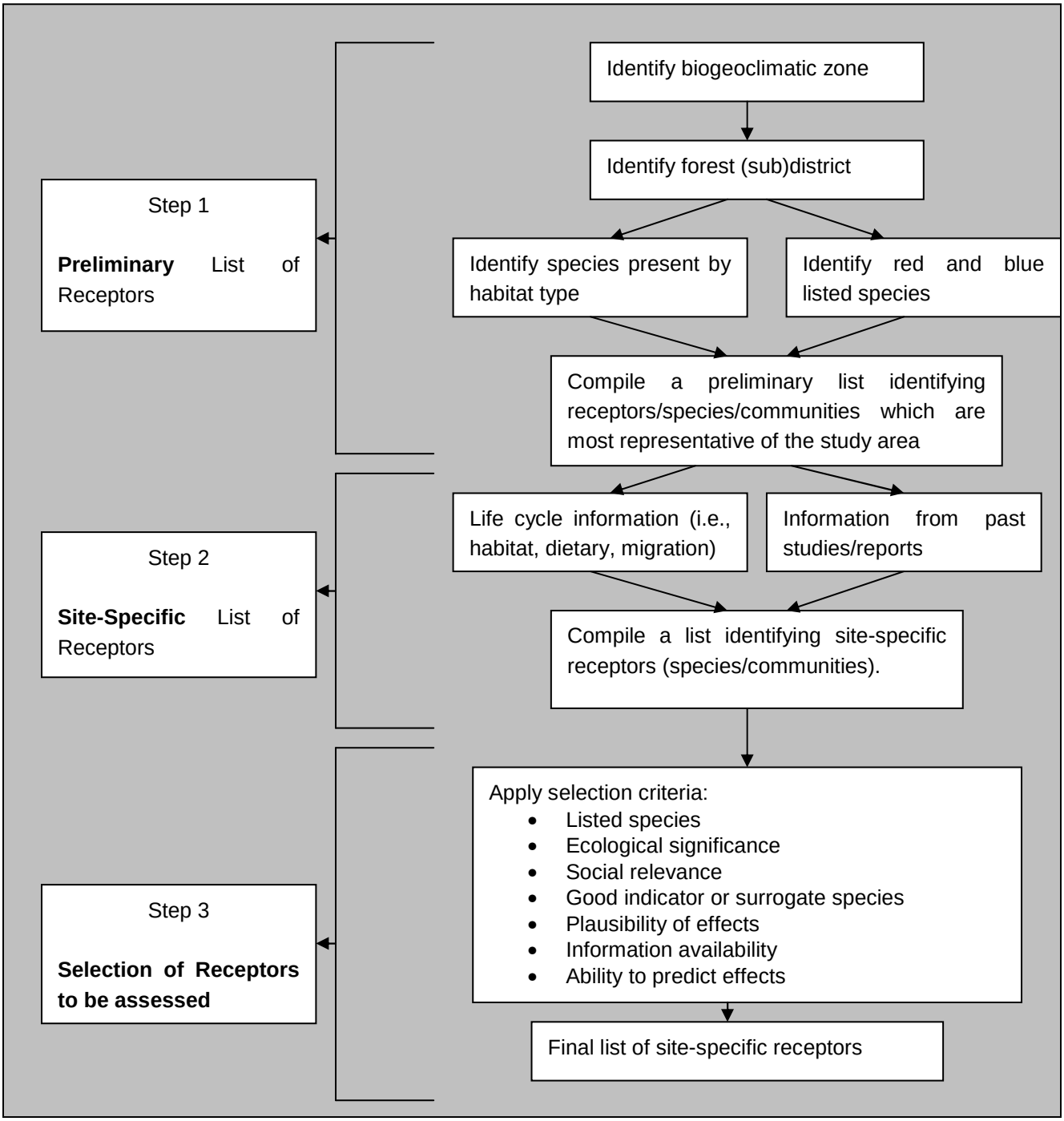


Table 1 presents the format of the preliminary list of receptors. Note Table 1 is incomplete as it is only indented to illustrate the proposed table format.

Table 1. Preliminary list of receptors (incomplete for example only).

Animal class	Animal community	Species
Birds	Herbivorous/insectivorous	American dipper
Birds	Piscivorous	Great Blue Heron
Birds	Carnivorous	Bald eagle

Note: Scientific names of all species will be included.

In the second step, the preliminary species list will be refined to be site-specific. That is an evaluation of which species are likely to use the site and have the potential of being affected directly or indirectly by NaOH will be made. In doing so life cycle information will be compiled, and will include but will not be limited to:

- Species distribution;
- Migration pattern (*e.g.*, short distance migrants, permanent resident species, etc.);
- Habitat and seasonal range; and,
- Diet composition.

This information will be gathered from available report (consultants, government agencies, First Nations, non-government organizations), and field and reference guidebooks.

In the third and final step, the receptors of concern for the high level assessment will be selected from the site-specific species list. Since not all receptors can be assessed in detail, receptors of concern are the actual ecological resources which will be addressed in the assessment. To do so, selection criteria will be applied to the receptors listed in the site-specific list. The proposed selection criteria are presented below.

Table 2. Proposed selection criteria for final receptor selection

Criteria	Description
Listed species	Is classified as a threatened or endangered species (e.g., Red and Blue listed species).
Ecological significance	The species/communities help sustain the natural structure, function, and biodiversity of an ecosystem or its components; may contribute to the food base (e.g., primary production), provide habitat (e.g., for food or reproduction); the loss or reduction of the receptor may results in a potential cascade of adverse effects; the receptor use the assessment area for an important ecological function (e.g., spawning area, feeding area).
Social significance	The receptor has cultural, recreational or commercial importance.

Table 2 (Cont.). Proposed selection criteria for final receptor selection

Good indicator or surrogate species	As all species cannot be assessed in details, the chosen receptor will represent other species (e.g., benthic invertebrate community instead of a specific species of aquatic invertebrate or a robin may represent insectivorous songbirds or the Dusky shrew may represents insectivorous small mammals.
Plausibility of effect	The receptor is sensitive to direct or indirect effects from NaOH and can potentially be exposed to these effects.
Information availability	There is enough information to characterize the receptor and identify potential effect.
Ability to predict effects	Where no information exists, can the characterization depend on judgment and inference as to what the potential effects may have been?
Ability to measure the effects	Once the effects have been identified and the risk has been characterized, it will be possible and practical to measure/assess the effects.

The final table of receptors will have the following headings:

Site specific receptor	Listed species	indicator /surrogate species	Ecological significance	Social significance	Plausibility of effect	Information availability	Ability to predict effects	Ability to measure the effects	Considered in the risk assessment
									Yes
									No

2.1.3 Assessment Endpoints

Once the receptors have been selected, the assessment endpoints will be identified. The assessment endpoint should be expressed in terms of a function or quality which is to be maintained. For example, if the receptor is "benthic community", the assessment endpoint(s) could be "the maintenance of benthic invertebrate communities within the range of natural variability".

Information gathered during the receptors selection process (i.e., life cycle information) will be used to define what is important for the receptor in question and for the ecosystem overall function in order to define the assessment endpoint. The selection of assessment endpoints will also be based on guidance provided by CCME (1996) and the U.S. EPA (2003) and on professional judgment.

2.1.4 Conceptual Model

The information on NaOH and on the receptor will be integrated into the development of a written and visual description outlining how NaOH could have affected the selected receptors. To do so, as many as possible exposure pathway between NaOH and the receptors will be identified, for example:

- Direct exposure in surface water for aquatic invertebrate;
- Direct exposure in surface water for fish;
- Direct exposure to contaminant in surface water to wildlife (*i.e.*, aquatic birds and mammals);
- Exposure via ingestion of food with elevated contaminant concentration for fish; and,
- Exposure via ingestion of food with elevated contaminant concentration for wildlife (aquatic birds and mammals).

Only relevant exposure pathways would be evaluated during the subsequent analysis phase of the assessment. The conceptual model will include a rational explaining why a pathway was select or omitted for assessment.

2.2 Analysis

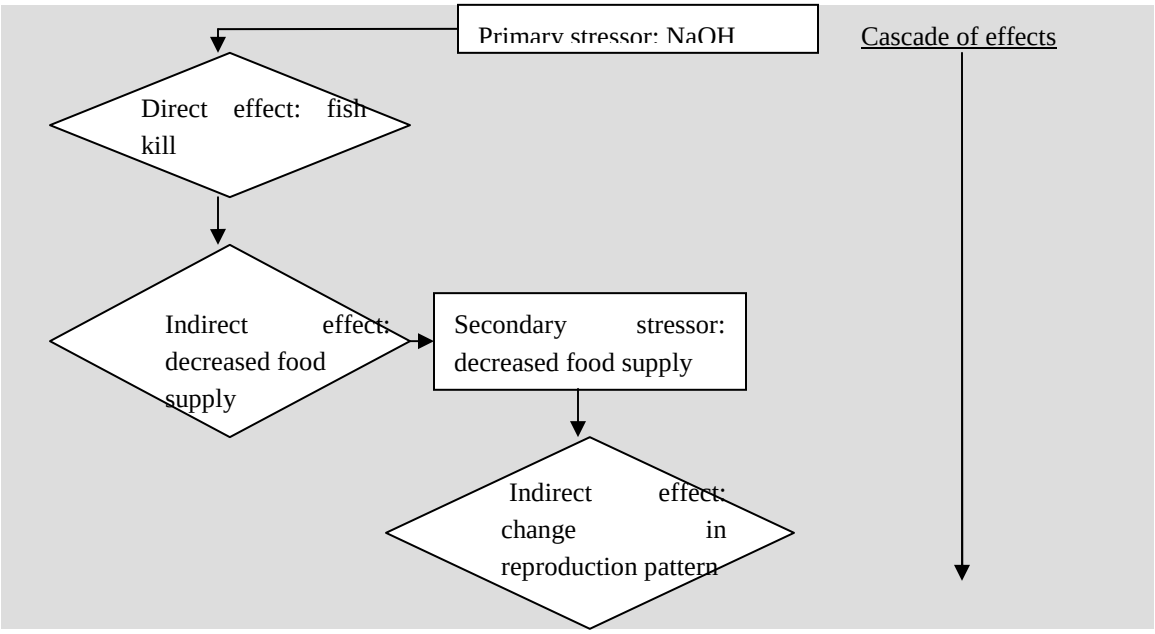
The exposure and ecological effects of the NaOH spill in the Cheakamus River, identified during the problem formulation, will be characterized. The tasks completed during this phase will include the analysis of:

- Exposure by examining the distribution of NaOH;
- Exposure by examining the receptors (*i.e.*, life cycle, dietary need, spatial distribution, habitat use);
- Exposure by examining contact between NaOH and receptors (intensity and spatial and temporal extent of contact); and,
- Effects (direct and indirect).

The consideration of indirect effects will also include the analysis of secondary stressor and cascading effects. Primary, or direct, effects occur when a stressor acts directly on a receptor and causes an adverse response. Secondary, or indirect, effects occur when the entity's response becomes a stressor to another entity. For example, while one direct effect of NaOH exposure was fish kill, the consequence of fish kill could be reduced food availability. In this case, reduce food availability become the secondary stressor potentially affecting species distribution and reproduction pattern. This example is illustrated in Figure 3. In the same way, indirect effects such as potential changes in the reestablishment of communities and populations will be considered in the analysis.

The analyses of ecological effects will consider the plausibility the effects occur as a result of the derailment. It is important to realize there will be some receptors for which no information exists and the characterization will depend on judgment and inference as to what the potential effects may have been. For the same reasons, characterization of effects will not be possible for all identified receptors.

Figure 3. Example of consideration of direct and indirect effects - primary and secondary stressor.



2.3 Ecological Effects Characterization

The information obtained during the analysis phase of the assessment will be used to characterize the ecological effects on the assessment endpoints. The concept of "risk" will be adopted to characterize the ecological effect in using the general concept that the resulting effects will depend on the multiplication of two factors: likelihood of adverse effect and consequence. Likelihood in this case would be the chance the derailment caused the effects characterized in the analysis phase. Consequence would include considerations of the intensity, spatial and temporal scales, and reversibility of the effects. Qualitative matrices will be developed and used to characterize the effects. Examples of qualitative matrices are presented below. Narrative explanations of effect will be provided for each ranking.

Qualitative measure of likelihood:

Levels	Descriptor
High	Certain
Medium	Possible
Low	Unlikely
Any	Any

Qualitative rankings used to describe consequence:

Intensity of effect

Levels	Descriptor
High	Changes in the assessment endpoints exceeding natural variability
Medium	
Low	
Any	No effect

Extent of effect

Levels	Descriptor
High	Entire range of species territory
Medium	X% of species territory
Low	Local

Frequency of effect

Levels	Descriptor
Continous	
Periodic	
Isolated	

Duration of effect

Levels	Descriptor
Long term	
Short term	

Reversibility of effect

Levels	Descriptor
Irreversible	
Reversible	

Consequence assessment:

Intensity	Spatial scale	Temporal scale – frequency	Temporal scale-duration	Reversibility	**Consequence**
					High
					Medium
					Low

The final ecological effects will be characterized using a matrix incorporating the likelihood and consequence:

Assessment Endpoints	Description of effect	Likelihood levels	Consequence Levels	**Risk levels**
				High
				Medium
				Low
				No risk

3.0 References

BC MELP (British Columbia Ministry of Environment, Lands and Parks). 1998. Recommended Guidance and Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia. January, 1998.

CCME (Canadian Council of Ministers for the Environment). 1996. A framework for ecological risk assessment: General guidance.

Meidinger, D and J. Pojar (editors). 1991. Ecosystems of British Columbia, B.C. Ministry of Forests, Victoria, BC. Special Report No. 6. 330 pp.

Stevens, V. 1995. Wildlife diversity in British Columbia: distribution and habitat use of amphibians, reptiles, birds, and mammals in biogeoclimatic zones. Research Branch, BC Ministry of Forests, Wildlife Branch, BC Ministry of Environment Lands and parks, Victoria, BC, Working Paper 04/1995.

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