STRATEGY FOR WILDLIFE ECOLOGICAL RISK ASSESSMENT AT TECK COMINCO'S KIMBERLEY OPERATIONS, BC

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ABSTRACT

The overall objective of this predictive wildlife ecological risk assessment (ERA) is to assess contaminant-related risks after implementation of Teck Cominco's closure plan for its Kimberley Operations. The first stage of the wildlife ERA, problem formulation (PF), was conducted to identify the most likely sources of potential risks for the site to help focus subsequent ERA investigations. This paper summarizes key findings of the PF and presents an overview of the main components of the wildlife ERA. A separate paper (Mann et al., 2004) addresses potential risks to the aquatic environment.

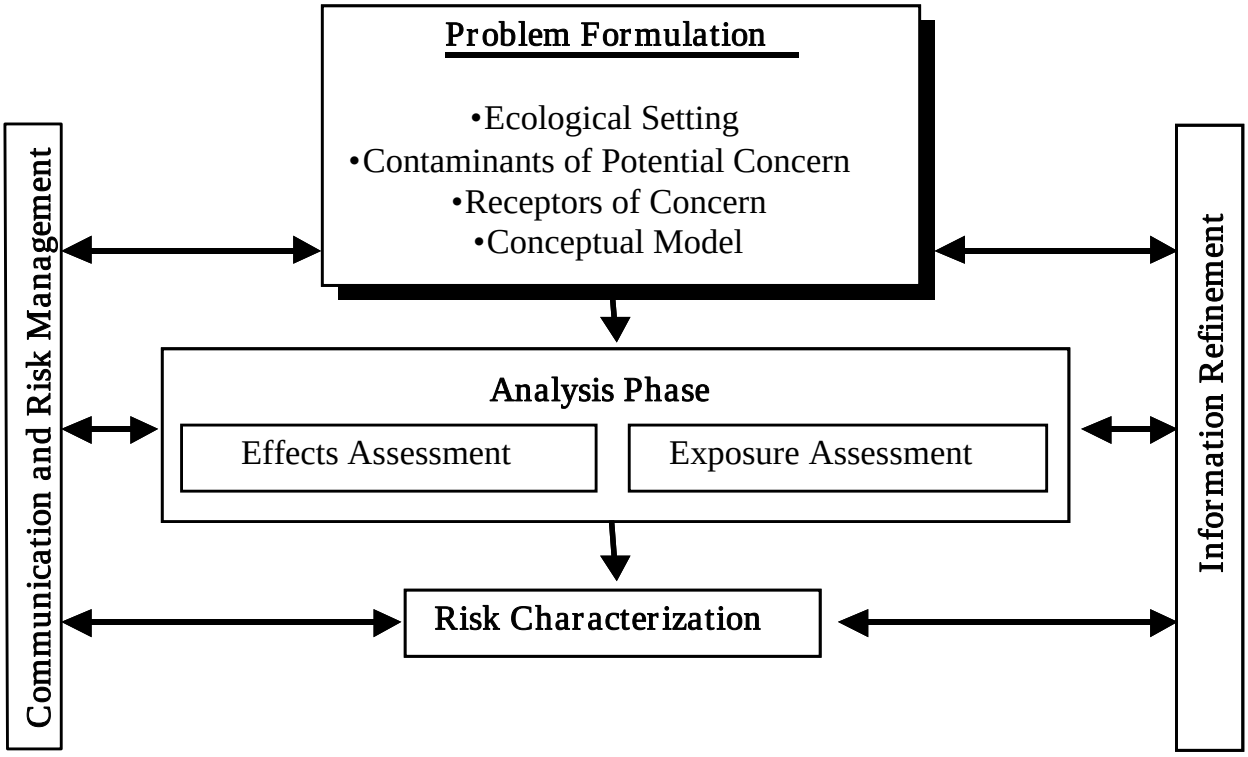
OVERVIEW

Teck Cominco Metals Ltd. (Teck Cominco) has been planning the decommissioning and closure of their Kimberley Operations for over a decade. Regulatory requirements for mine closure in British Columbia (BC) changed over this time (see Higgins et al., 2004). Consequently, the BC Ministry of Water, Land and Air Protection (BCWLAP) requested that a Human Health and Ecological Risk Assessment (HH/ERA) be conducted under the province's *Contaminated Sites Regulation* (CSR)[1] to confirm the effectiveness of Teck Cominco's Decommissioning and Closure Plan (Teck Cominco, 2000). This paper describes the problem formulation (PF) for the wildlife ERA. In addition to the typical components included in a PF (Figure 1), a screening-level analysis was conducted using available data to help focus the subsequent ERA on the contaminants, exposure pathways and receptor combinations of greatest potential risk at the Kimberley Operations site. The objectives of the PF were to:

[1] Waste Management Act, *Contaminated Sites Regulation*, BC Reg. 375/96, deposited December 16, 1996, O.C. 1480/96, effective April 1, 1997 (includes amendments BC Reg. 244/99, deposited July 19, 1999 and BC Reg. 17/2002, deposited February 4, 2002).

- Characterize the general ecological setting of the site.
- Identify contaminants of potential concern (COPCs) for the site.
- Identify key ecological receptors of concern (ROCs) for the site and document protection goals for each.
- Integrate information on COPC sources, transport/exposure pathways and ROCs into the development of a conceptual model.
- Conduct a screening-level assessment of potential risks to wildlife.
- Describe key study components used to assess risks in the ERA.

Figure 1. Problem formulation overview for wildlife ERA.



ECOLOGICAL SETTING

Based on the physical features of the site, the hydrogeological regime, and the locations of the various operational areas, the site was split up for the purposes of the ERA into:

- Site 1 – consisting of the Upper Mine and Lower Mine Yard areas, including portions of Mark Creek associated with the latter; and
- Site 2 – consisting of the Concentrator/Idle Plants areas and associated waste impoundments, including lower reaches of Mark Creek, downstream sections of the St. Mary River, Pighins Slough, and other smaller water bodies that may be used by wildlife.

Overall, the Kimberley Operations site consists of four biogeoclimatic subzones: Interior Douglas-fir dry-mild subzone (IDF-dm), Montane Spruce dry-cool subzone (MS-dk), Ponderosa Pine dry-hot subzone (PP-dh), and Engelmann Spruce-Subalpine Fir dry-cool subzone (ESSF-dk). A description of aquatic receiving environments is provided in Mann et al. (2004).

CONTAMINANTS OF POTENTIAL CONCERN

Terrestrial Wildlife

The CSR provides numerical standards for a range of contaminants and land use designations. Current plans for the Kimberley Operations site are for it to remain as dormant industrial land; the lands east of the tailing impoundments are being considered for possible use as agricultural land. The first screening exercise was to identify COPCs identified for surface soils based on industrial land use were arsenic, copper, lead and zinc. No COPCs were identified for surface soils in the eastern portion of the site based on agricultural land use.

A second screening exercise was conducted on the engineered cover systems from Sites 1 and 2 to specifically address the potential for the underlying mine wastes to mobilize into the overlying food chain (e.g., plants, soil invertebrates). COPCs for the cover systems based on industrial land use were antimony, arsenic, cadmium, chromium, copper, lead, and zinc.

Aquatic Wildlife

COPCs identified for aquatic wildlife were consistent with those presented by Mann et al. (2004). They were based on screening of water quality data collected over several years in Mark Creek against BC ambient water quality criteria. Primary COPCs (i.e., high magnitude and frequency of exceedances) were aluminum, cadmium, cobalt, and zinc, whereas secondary COPCs (i.e., low magnitude and frequency of exceedances) were copper, fluoride, manganese, and sulphate.

RECEPTORS OF CONCERN

The ROCs for this study were chosen based on a number of scientific and human value considerations. The final list included terrestrial plants and soil invertebrates, birds, mammals, reptiles, and amphibians (see Tables 1 and 2). Protection goals (i.e., definition of unacceptable effects), assessment endpoints (i.e., formal statement of what ROC characteristics will be evaluated), and measurement endpoints (i.e., measurable responses to COPCs that are linked to the assessment endpoints) were developed for each ROC. Overall, rare and endangered “listed” species were afforded a higher level of protection than common “non-listed” species.

CONCEPTUAL MODEL

Information from the preceding sections was integrated into the conceptual model, a graphic or written description of contaminant sources, COPCs, exposure pathways, and ROCs (Figure 2).

SCREENING-LEVEL RISK ASSESSMENT

Approach

The goal of the screening-level risk assessment (SLRA) was to determine which COPC/ROC combinations reflect potentially unacceptable risks and should be retained for further evaluation in the detailed risk assessment. Specific approaches used for plants and soil invertebrates, birds and mammals, and reptiles and amphibians are briefly summarized below.

As shown in Figure 2, the main exposure route for plants and soil invertebrates is via direct contact with contaminated soils. The primary assessment tools were toxicity-based soil screening benchmarks and qualitative habitat assessments.

Birds and mammals are potentially exposed to COPCs through the consumption of contaminated food items and drinking water as well as the incidental ingestion of contaminated soils or sediments (Figure 2). To determine potential risks to birds and mammals foraging in terrestrial environments, food items (e.g., grasses, leaves and berries from shrubs and trees, insects such as grasshoppers and beetles) were collected throughout Sites 1 and 2, including the cover systems. Water and soil samples were also available throughout the property. All samples were analyzed for COPC concentrations and the resulting data were incorporated into a food chain model to determine receptor-specific contaminant doses. The latter were then compared to literature-based toxicity references values (TRVs) to evaluate the magnitude of potential ecological risks.

Figure 2. Conceptual model for the wildlife ERA (see further details of the aquatic receiving environment in Mann et al., 2004).

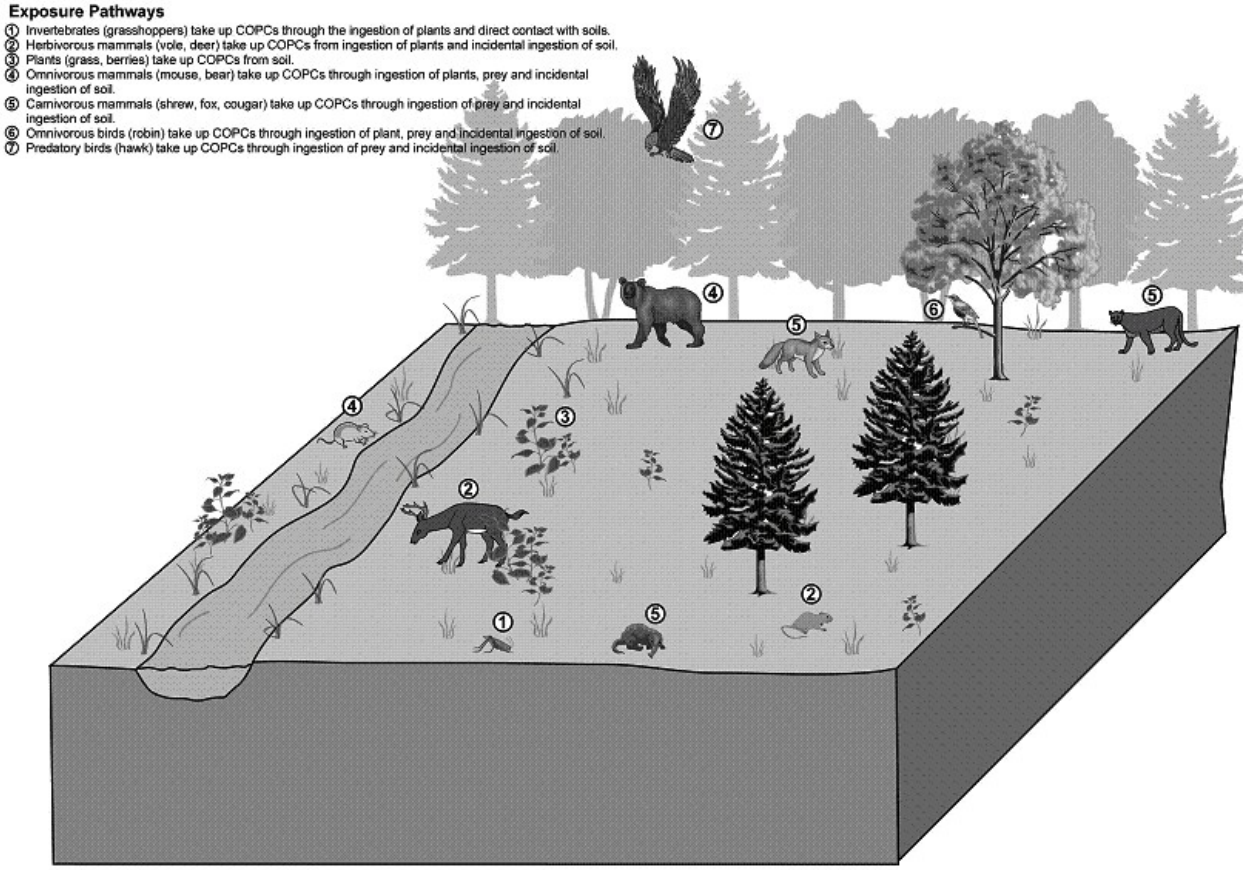


Table 1. List of terrestrial wildlife likely occurring on the Kimberley Operations site.

ROC Groups	Listed Species Potentially Using the Site[1]	Surrogates for Non-listed Species Using the Site
Small herbivorous mammals	Red-tailed chipmunk (Blue)	Meadow vole
Small omnivorous mammals	Southern red-backed vole (Blue)	Deer mouse
Small insectivorous/carnivorous mammals	Northern long-eared myotis (Blue) Townsend's big-eared bat (Blue)	Vagrant shrew Little brown bat
Medium and large herbivorous mammals	None	Whitetail deer Elk
Medium and large omnivorous mammals	None	Black bear
Medium and large carnivorous mammals	Badger (Red, endangered); Fisher (Red)	Coyote Cougar
Herbivorous birds	Sharp-tailed grouse (Blue)	Song sparrow
Omnivorous birds	None	Black-capped chickadee American crow
Insectivorous birds	Long-billed curlew (Blue) Lewis' woodpecker (Blue)	Western meadowlark
Predatory birds	Peregrine falcon (anatum) (Red, threatened) Western Screech Owl (macfarleni) (Red, endangered) Prairie falcon (Red) Short-eared owl (Blue)	Red-tailed hawk
Reptiles	Painted turtle (Blue) Western skink (Blue)	Not applicable
Amphibians	Coeur d'Alene salamander (Blue)	Not applicable

[1] Species were considered listed based on their provincial (Red or Blue) and federal (COSEWIC) status.
Note that the Dione copper butterfly was also added to the list of listed species potentially using the site.

Table 2. List of aquatic wildlife likely occurring on the Kimberley Operations site.

ROC Groups	Listed Species Potentially Using the Site[1]	Surrogates for Non-listed Species Using the Site
Piscivorous mammals	None	Mink
Insectivorous mammals	None	Little brown bat[2]
Omnivorous birds	None	Mallard
Insectivorous birds	None	American dipper
Piscivorous birds	Great blue heron (Blue)	Belted kingfisher

[1] Species were considered listed based on their provincial (Red or Blue) and federal (COSEWIC) status.
[2] Since this species may also feed on emerging aquatic insects, an aquatic exposure scenario was included in the ERA.

A similar approach was taken for birds and mammals foraging in aquatic environments. However, concentrations of COPCs in aquatic plants, invertebrates and fish were not measured at the PF stage of the risk assessment process. As a result, they needed to be estimated to support the food chain model for aquatic wildlife. This involved the derivation of literature-based bioaccumulation factors (BAFs) for each food type (i.e., plants, invertebrates and fish).

Contaminant exposure for reptiles and amphibians is likely to occur through both direct contact and indirect food chain pathways. A qualitative exposure and effects assessment was conducted for these ROCs to determine the need and, if necessary, the scope for additional investigations.

Findings

Major findings of the SLRA were as follows:

- Plants and soil invertebrates – results showed that arsenic, copper, lead, and zinc were exceeding soil toxicity benchmarks in formerly active areas of the site; limited contamination was found elsewhere. Preliminary qualitative comparisons of vegetation cover indicate that some localized effects are possible. However, the impacts of physical disturbances associated with past mining activities, logging, and reclamation appear more widespread and often confound attributing observed effects to a particular stressor type (i.e., physical or chemical). More quantitative information on the potential for COPC-related effects to plant communities on the site was targeted as part of the ERA (see Key ERA Components – Table 3).
- Terrestrial birds and mammals – only limited potential risks were identified for non-listed species whereas moderate to high potential risks were identified for listed species, which were afforded a higher level of protection. Overall, the main COPCs and exposure routes were: intake of arsenic, copper and zinc via consumption of invertebrate prey items, estimated from grasshopper tissue data; and incidental ingestion of contaminated soils. Since the assessment relied on conservative assumptions, these results did not suggest that effects were occurring, but rather that further studies were required (see Key ERA Components - Table 3).
- Aquatic birds and mammals – the use of BAFs for estimating tissue concentrations from water quality measurements in the SLRA was subject to considerable variability and thus incorporated substantial uncertainty. Specifically, there are several factors (e.g., spatial and temporal patterns in COPC concentrations in water or organisms, life history characteristics of the species of interest) that affect bioaccumulation and consequently diminish the predictive capability of BAFs. For these reasons, the use of BAFs was only considered as a preliminary tool for estimating potential risks to aquatic receptors until site-specific data on COPC concentrations in prey items were available to provide more realistic predictions (see Key ERA Components - Table 3).
- Amphibians and reptiles – in general, there is limited ecotoxicological information available for reptiles and amphibians. Consequently, most risk assessments tend to focus on rare and endangered species. Surveys of listed reptiles and amphibians at the Kimberley Operations site were incorporated as part of the ERA (see Key ERA Components - Table 3).

Table 3. Overview of key ERA components.

ROC Groups	Study Component	Tasks
Plants and soil invertebrates	Wildlife habitat assessment	• Quantify the ecological characteristics of the site (e.g., vegetation types, features of the landscape). • Examine patterns of vegetation cover and primary community structure within and among habitat units relative to patterns of soil contamination. These patterns are being established through direct field observations, interpretation of aerial photographs, and integration of habitat and contaminant data using a geographical information system (GIS).
Terrestrial birds and mammals	Wildlife habitat assessment	• Directly incorporate the ecological characteristics of the site (see above) into the food chain model (e.g., compare habitat attributes vs. foraging value for individual ROCs) to calculate realistic exposure estimates.
	Listed species survey	• Determine the presence and distribution of listed ROCs in relation to habitat features and patterns of contamination.
	Invertebrate tissue sampling	• Conduct a comprehensive sampling program targeting grasshoppers and ground insects (e.g., beetles), which were considered as the main drivers of potential risks to terrestrial wildlife.
Aquatic birds and mammals	Wildlife habitat assessment	• As per terrestrial birds and mammals.
	Listed species survey	• As per terrestrial birds and mammals.
	Plant and invertebrate tissue sampling	• Determine COPC concentrations in aquatic plants and insects in reference and exposed reaches of Mark Creek, as well as in other water bodies used by wildlife.
Reptiles and amphibians	Listed species survey	• As per terrestrial birds and mammals.

KEY ERA COMPONENTS

The SLRA identified potential risks to wildlife at the Kimberley Operations site. The main ERA study components and associated tasks, presented in Table 3, were aimed at reducing uncertainty to an acceptable level to support using the risk conclusions in making management decisions for the property.

REFERENCES

Higgins, C.A., G.S. Mann and B.B. Dawson. 2004. Human Health and Ecological Risk Assessment at Teck Cominco's Kimberley Operations, BC: Overview of Regulatory Process and Preliminary Findings of the Problem Formulation. Proceedings of the BC Reclamation Symposium, Cranbrook, BC.

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