SUMMARY REPORT

Terrestrial Ecological Risk Assessment for the Teck Metals Ltd. Smelter at Trail, BC.

Revised

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This document was jointly prepared and co-authored by:

Intrinsik Environmental Sciences Inc.
Swanson Environmental Strategies Ltd.
Delphinium Holdings Inc.
Teck Metals Ltd.

The Past: Cominco smelter

The Present: Teck smelter

The Columbia River valley

Paper birch-bracken fern

Urban Garden in Trail

Columbia Valley vineyard


Canada Goose Chick


Pika


American Robin


Yellow-breasted Chat


Horses near Pend d'Oreille

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INTRODUCTION

This report presents the final results of the terrestrial component of the Teck Metals Ltd. (Teck) Ecological Risk Assessment (ERA). The ERA was conducted under the British Columbia (BC) Contaminated Sites Regulation (CSR). Teck elected to conduct a landscape-scale risk assessment as the basis for a Wide Area Remediation Plan, as provided for under the CSR.


The Teck Metals Ltd. Smelter, Trail, B.C.

The ERA was conducted over a period of eight years and consisted of a series of stages and components. Consequently, there have been many reports produced as part of the documentation of the ERA. All of these reports may be found at the Interpretive Centre in Trail, the Trail and District Public Library and the Teck web site (www.teck.com).

The ultimate products of the ERA are two reports, one on the aquatic component and one on the terrestrial component. These two reports, in turn, will be used as the basis for the wide area risk management plan which will include, but will not be limited to, remediation. This report summarizes the terrestrial ERA Final report. It integrates all relevant data and analyses completed over the course of the ERA.

Background to the Risk Assessment

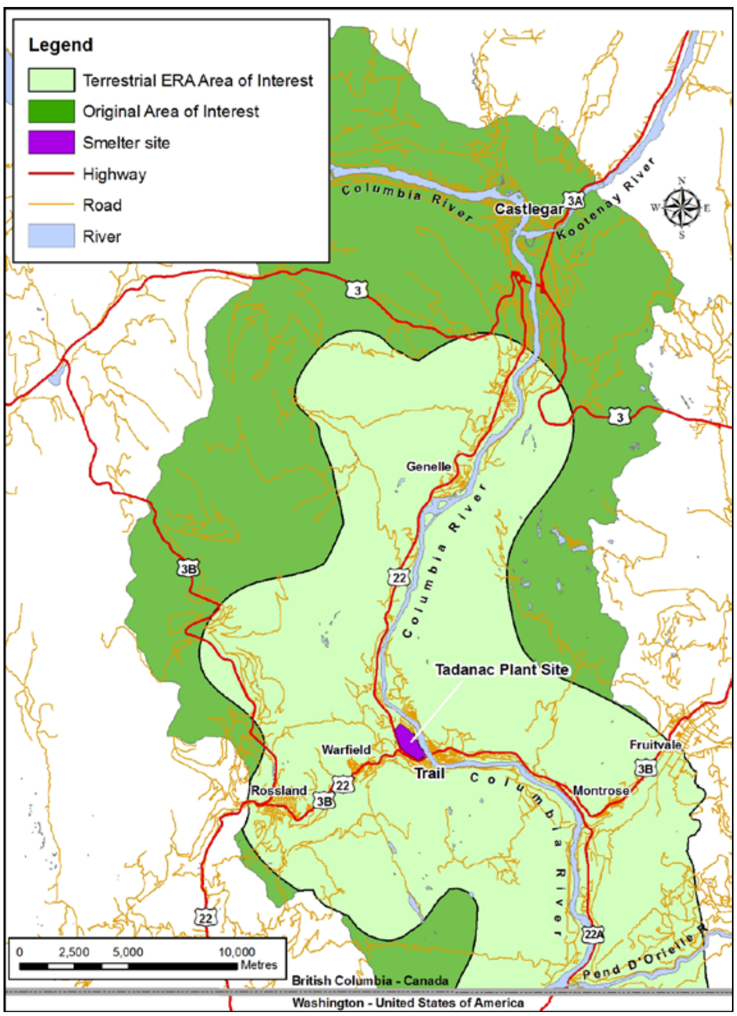

The Columbia River valley north of Genelle

Trail, British Columbia has been the site of a major lead and zinc smelting facility operated by Teck for over 100 years. In 1990, the Trail Community Lead Task Force initiated studies on human health exposure and risk, and Teck is currently concluding a human health risk assessment update. In 2000, Teck initiated an ERA.

The overall goal guiding the ERA is to have “no unacceptable residual ecological risk from past or current smelter-related emissions” (Teck Cominco Metals Ltd., 2003). Residual ecological risk is the risk remaining after natural recovery processes have taken place or after human intervention, such as remediation and re-vegetation. In order to determine if the goal has been reached, the ERA determined how past, present or future emissions from the smelter have impacted, or might potentially impact, animals (birds, fish, mammals, insects, amphibians), plants, sediment, soil and water in the area. The term “emissions” is used to include releases to the air via stack and fugitive emissions and releases to the Columbia River via discharge of treated effluent and historical discharge of slag.

Study Area Description

Figure S-1 Teck Smelter Site, Trail, British Columbia.



The Teck smelter is located in the City of Trail, which is situated in the West Kootenay region of south-eastern British Columbia. The smelter facility is in the Columbia River valley, approximately 15 km north of the boundary with Washington State (Figure S-1).

The initial terrestrial ERA Area of Interest (AOI) extended along the Columbia River valley from the International Boundary north to Castlegar, and was approximately defined by the 2,100 m contour at the west boundary, and the 1,200 m contour at the east boundary (i.e. the "height of land" on both sides of the river valley). The size of the initial AOI was very large (approximately 80,000 hectares) and contained mountainous terrain with elevations ranging from 400 to 1,800 m above sea level. The AOI was redefined by screening out areas where the concentrations of arsenic, cadmium, lead and zinc in soil did not exceed BC CSR soil standards. The AOI decreased to approximately 40,000 ha (Figure S-2). The revised AOI shown does not take into account areas where the soil standards for groundwater protection (for crop irrigation and livestock watering) may be exceeded. Groundwater monitoring results and soil leachate data are being collected to provide an indication as to the quantity of metals that are removed from soil by rain and then transported into groundwater. This information will be used to define the final area in which any of the soil standards may be exceeded.

Figure S-2 The Area of Interest (AIO) for the Terrestrial ERA. Dark green is the original AIO (80,000 ha), light green is the revised AOI based on soil data

OVERALL APPROACH USED FOR THE ERA

An ERA that covers an area the size of the AOI cannot depend upon the traditional chemical-by-chemical risk modelling methods developed for smaller sites. Therefore, the study team used a weight-of-evidence (WOE) approach that incorporated both modelling of direct toxicity and field-based measurements of exposure and effect (Figure S-3).

The direct toxicity modelling was conducted using a series of three models. Each successive model was more complex, and contained more site-specific exposure data and updated toxicity data. The use of these models allowed the ERA to focus on specific chemicals and animals within particular portions of the AOI where unacceptable risks could not be ruled out. For those animals predicted to be at risk after the third level of modelling, field-based information was evaluated.

Field data were used to assess risks to plant communities, and provide input into the WOE approach for mammalian and avian communities, and in particular American robin populations and Listed Species.

The information provided by the modeling and the field studies was combined into a new WOE approach called the Sequential Analysis of Lines of Evidence (SALE).

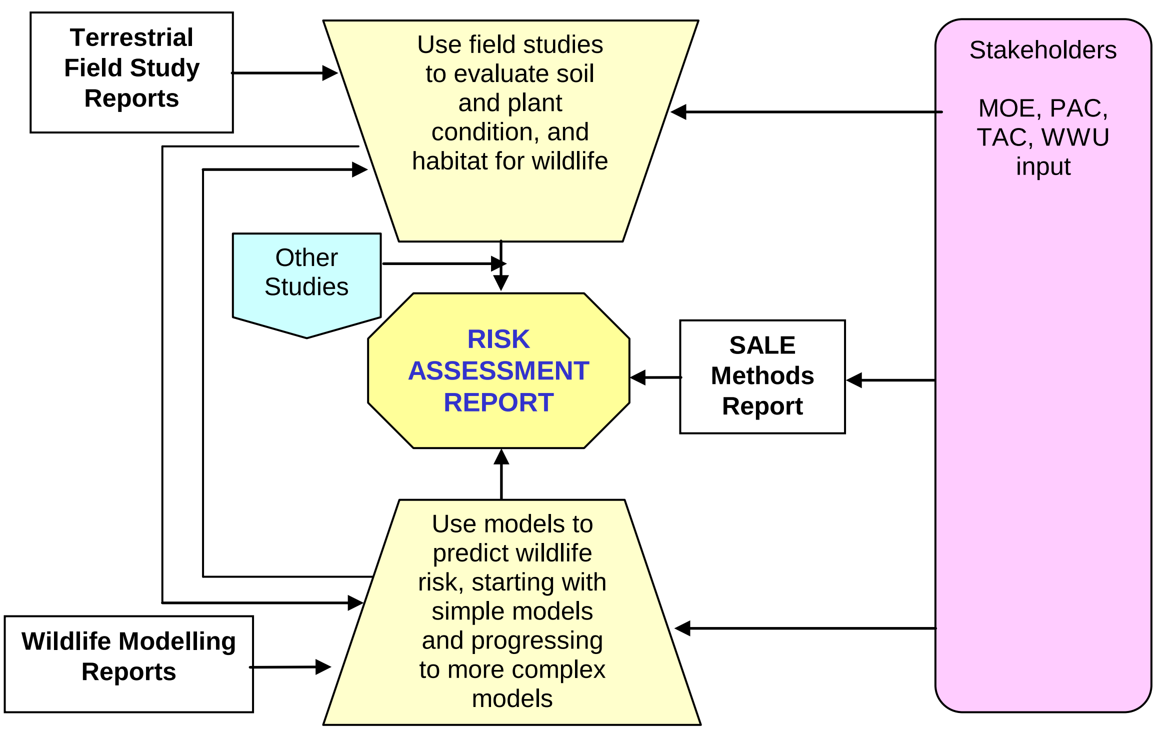
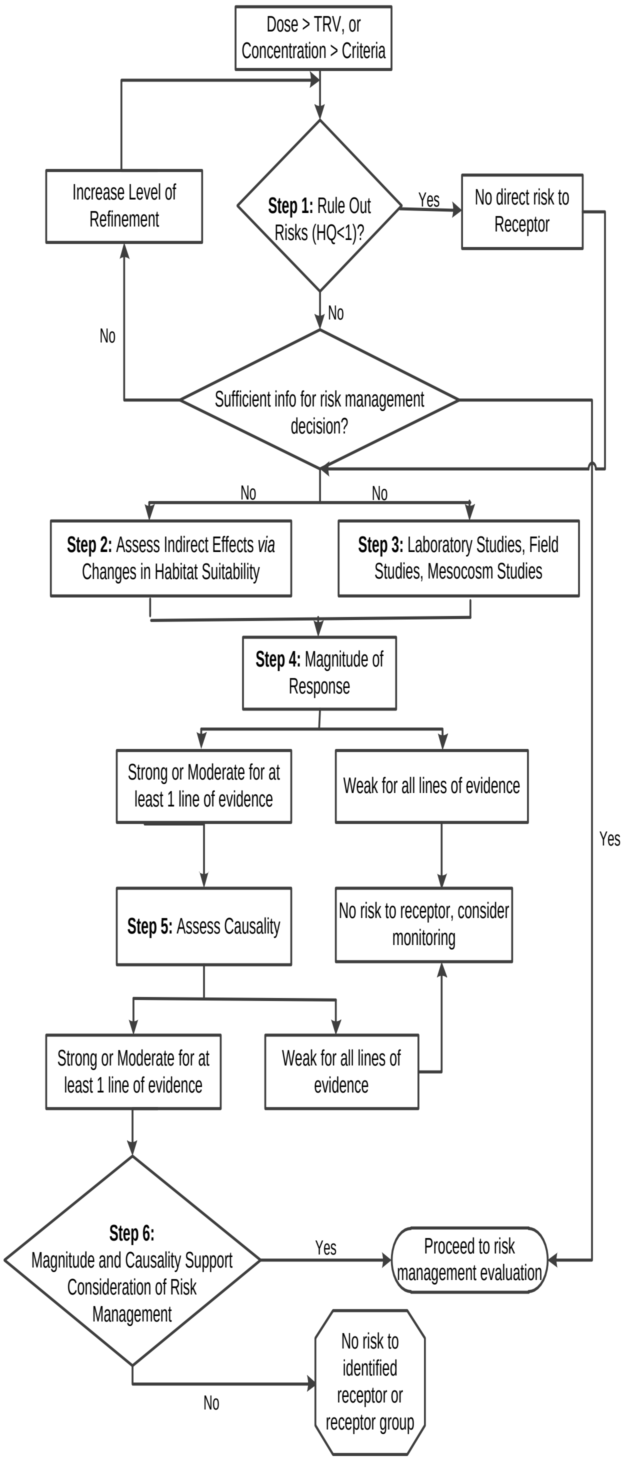


Figure S-3 Overall Approach to the Terrestrial ERA [MOE= BC Ministry of Environment, PAC = Public Advisory Committee, TAC = Technical Advisory Committee, WWU = Western Washington University, SALE = Sequential Analysis of Lines of Evidence].

Sequential Analysis of Lines of Evidence (SALE): a New Method for Assembling a Weight-of-Evidence for Risk



A new method was developed by the study team to assemble all of the lines of evidence into an overall WOE. This method is called the Sequential Swanson, 2006). The SALE approach starts with screening purposes) and then proceeds to the field-based lines of evidence (Figure S-4).

The sequential aspect of the SALE process is based upon two primary ideas. First, risks can be ruled out using comparisons of soil quality with soil standards and direct toxicity modeling using conservative assumptions. In Step 1, the SALE process recognizes that these conservative approaches are most useful in ruling out risk rather than predicting risk to plants and animals. Second, the SALE process requires that each line of evidence is assessed for three things: (1) magnitude of response; (2) the strength of the cause/effect link with the smelter; and (3) uncertainty caused by natural variability plus our lack of knowledge about ecological processes. These three criteria are evaluated together to characterize the degree of risk from smelter-related emissions (Steps 2-5). When the combination of magnitude and evidence for a link with the smelter are strong enough, risk management is considered (Step 6).

The SALE approach explicitly includes interaction between risk assessors and risk managers. It illustrates to risk managers how risk management can go beyond the simple derivation of risk-based concentrations of chemicals in soil to risk management goals based on ecological objectives (e.g. species diversity). It also can be used to stimulate discussion of the limitations of ERA, and how scientists deal with uncertainty. It can assist risk managers by allowing their decisions to be based on a flexible and transparent process that includes direct toxicity risks, indirect risks (via changes in habitat suitability and food web *interactions), and spatial and temporal factors.*

Figure S-4 The Sequential Analysis of Lines of Evidence Process.

Management Objectives

Risk management objectives were developed in accordance with the risk management goal of "no unacceptable residual ecological risk from past or current smelter-related emissions" (Teck Cominco Metals Ltd., 2003). A management objective is a specific statement about the desired condition of the environment in the Area of Interest. The management objectives translate the more general management goal into statements about what must occur in order for the goal to be achieved. The TAC and PAC were asked to provide review and input to the risk management objectives for terrestrial organisms. The eight management objectives related to the terrestrial ERA are:

The Columbia River valley

Blue Grouse

Mule deer at Tadanac

1) Minimize, now and in the future, smelter operation-related direct and indirect effects within the Area of Interest on the maintenance of dynamic self-sustaining plant communities in natural "wildland" areas.

2) Minimize, now and in the future, smelter operation-related direct and indirect effects within the Area of Interest on the maintenance of desired native and introduced plant species in "urban" areas.

3) Minimize, now and in the future, smelter operation-related direct and indirect effects within the Area of Interest on forage crops, pastureland, vegetable, and fruit production in "agricultural" areas.

4) Minimize, now and in the future, smelter operation-related direct and indirect effects within the Area of Interest on populations of wildlife in natural "wildland" areas, including resident and migratory birds, small and large mammals, valued charismatic species (e.g. raptors, bears), predators (e.g. coyotes), and hunted and harvested species (e.g. deer), and lower trophic level food resources (i.e. insects and soil-dwelling organisms).

5) Minimize, now and in the future, smelter operation-related direct and indirect effects within the Area of Interest on wildlife populations in "urban" areas, including resident and migratory birds, small and large mammals, and lower trophic level food sources (i.e. insects and soil-dwelling organisms).

Horses at pasture

6) Minimize, now and in the future, smelter operation-related direct and indirect effects within the Area of Interest on wildlife populations in "agricultural" areas, including resident and migratory birds, small and large mammals, and lower trophic level food sources (i.e. insects and soil-dwelling organisms).

7) Prevent, now and in the future, smelter operation-related direct and indirect effects on individual organisms of threatened and endangered wildlife species in the Area of Interest.

8) Prevent, now and in the future, smelter operation-related direct and indirect effects on individual agricultural animals in the Area of Interest.

Meeting the Risk Management Objectives

In order to meet the risk management objectives, risk must be minimized or prevented. The question is "how do we know when risk is minimized or prevented?" The SALE approach is designed to answer this question by evaluating three important considerations: (1) the **magnitude** of response (i.e. how large a change in abundance, diversity, or other measurements was observed?); (2) the **strength of the cause/effect link** with smelter emissions (i.e. is it likely that the observed changes were caused by the smelter?); and (3) **uncertainty** (i.e. how sure are we about the accuracy and precision of our measurements, our understanding of how smelter-related emissions would cause effects, and our ability to detect these effects?).

Is there a response and is that response large enough to be ecologically significant?

Magnitude is judged in several ways. One method for judging magnitude is to evaluate the strength of the statistical correlation between measurements (such as species diversity) and concentrations of smelter-related metals in soil. Very low correlations indicate that factors other than smelter-related metals are likely to be controlling the responses of terrestrial plants and wildlife. Moderate or high correlations indicate that smelter-related metals are likely to be influencing plants and wildlife.

Another method for judging magnitude is to use general scientific knowledge about which species are sensitive or tolerant of metals and sulphur dioxide (SO_2). In some cases, there is a relatively good scientific understanding of the response of terrestrial communities. For example, the response of plants to SO_2 has been studied for many years.

How strong is the evidence for a cause/effect link between the measured response and the smelter?

Causation is judged using formal causation criteria originally designed for use with studies of the causes of human disease. These criteria have been modified for this study and include:

- spatial correlation (the responses correspond with where metal concentrations are elevated).
- temporal correlation (the responses occurred after the release of smelter-related metals occurred).
- gradient of response (the response increased as metal concentrations increased).
- plausibility of a connection to smelter-related metals (there is a known mechanism for metal effects and the response was of the expected magnitude).
- consistency of response (there were repeated observations of metal effects in the AOI, and there is existing knowledge from other regions where similar metal concentrations have caused similar effects).
- experimental verification (metal effects were observed under controlled conditions and there was concordance of these experimental results with field data).
- specificity (the effect is specific to metals).

How sure are we about our ability to distinguish a response from natural variability?

Each line of evidence is examined against these causal criteria and an overall score is produced that reflects the strength of the evidence for a cause/effect link between smelter-related emissions and the measured responses in plants or animals. A line of evidence is not considered inadequate if it is not supported by all causal criteria. In fact, it is very rare to have a high score on all causal criteria.

How well do we understand the ecology of the area and the possible effects of the smelter on the ecosystem?

Uncertainty is evaluated by examining three things: (1) how well the field sampling captured natural variability; (2) the adequacy of information on other factors (apart from the smelter) that could also be responsible for the measured characteristics; and (3) our general level of knowledge about the ecology of the area and what level and type of effect would cause overall changes in ecosystem structure or function. Uncertainty was classified as low, moderate or high.

The combination of magnitude, causation and uncertainty scores was used to determine whether risk management should be considered.

External Review of the ERA Approach

The overall approach used for the ERA, as well as interim reports, was reviewed by a Technical Advisory Committee (TAC), a Public Advisory Committee (PAC), and other external reviewers, including Dr. Wayne Landis of Western Washington University.

PROBLEM FORMULATION

Potential Chemicals of Concern (PCOC)

The ERA focussed on potential impacts resulting from past releases of inorganic chemicals and SO_2 from the smelter. Emissions of polychlorinated dibenzo-p-dioxins and furans (PCDD/F) were addressed separately since the PCDD/F emissions from the Trail smelter were below Environment Canada's source targets for virtual elimination, and as such were not evaluated further (Cantox Environmental Inc., 2003a).

A total of 31 elements were considered to identify PCOC: aluminium, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, fluoride, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, phosphorus, potassium, selenium, silver, sodium, strontium, sulphur, thallium, tin, titanium, vanadium, zinc.

Following the completion of direct toxicity risk modelling, cadmium and lead were the only remaining PCOC with any potential to cause toxicity to wildlife (Intrinsik, 2007). However, antimony, arsenic, cadmium, copper, lead, mercury, and zinc all remained as PCOC for the assessment of risks to plants and soil invertebrates, because the modelling assessed only direct toxicity risks to wildlife species (not plants and soil invertebrates).

Representative Species and Communities

American Robin

Because it is not possible to evaluate all plants and animals in the AOI, representative species and communities were selected for evaluation in the terrestrial ERA. Species were selected to be representative of particular land uses and food webs (Cantox Environmental Inc., 2001; 2003b; Intrinsik, 2007). Receptor communities were defined to better understand the habitats and wildlife use patterns in the AOI.

Representative Wildlife Species
American crow
American robin
Belted kingfisher
Black bear
Black-capped chickadee
Columbian ground squirrel
Coyote
Deer mouse
Dusky shrew
Mallard
Osprey
Red-backed vole
Red squirrel
Red-tailed hawk
River otter
White-tailed deer

Communities
Terrestrial plant communities
Avian communities
Mammalian communities

Listed Species
Bobolink
Canyon wren
Great blue heron
Lewis's woodpecker
Townsend's big-eared bat
White-throated swift

Agricultural Species
Chicken
Cow
Horse
Crops (forage, fruit)

Plant community

Conceptual Models of Risk

Conceptual models were developed to illustrate both the direct and indirect linkages between PCOC and terrestrial plants and animals. Consideration of indirect effects allows the evaluation of how changes in habitat influence wildlife. Changes in habitat can have a much greater effect on wildlife than direct chemical toxicity, yet standard risk assessment methods do not incorporate habitat-related effects (with the exception of including the role of habitat in determining exposure to chemicals).

The wildlife conceptual model 1 (Figure S-5) illustrates the linkages between the PCOC and wildlife that could result in direct toxicity. The model shows the release of metals and metalloids from stack emissions and fugitive air emissions, and deposition of PCOC onto soil and directly onto plants (e.g. lichen, conifers). Wildlife are exposed to PCOC by ingesting soil, water, sediment, and food (e.g. plants, invertebrates, aquatic organisms).

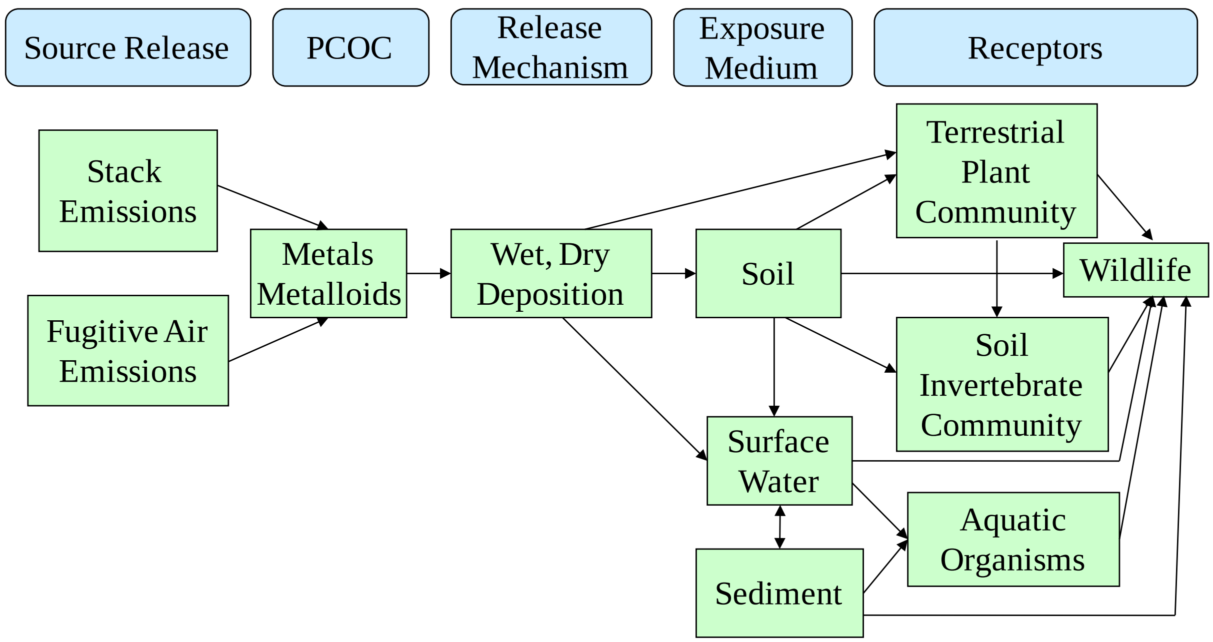


Figure S-5 Wildlife Conceptual Model 1: Direct Risks from Smelter-related Emissions.

The wildlife conceptual model 2 (Figure S-6) illustrates the linkages between PCOC in soil, SO_2 and wildlife that could result in indirect effects. Indirect effects include predator/prey influences, and effects on wildlife due to changes in the plant community (i.e. that serves as cover, nesting sites, foraging areas, etc.) caused by PCOC in soil and SO_2.

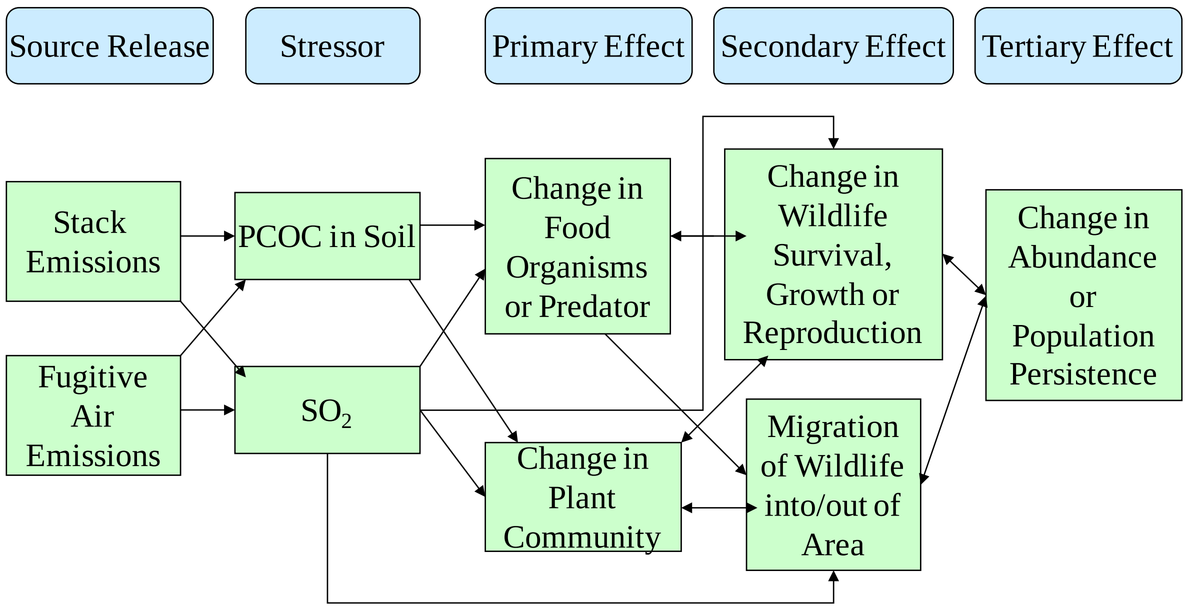


Figure S-6 Wildlife Conceptual Model 2: Indirect Risks from Smelter-related Emissions.

The conceptual model for plants (Figure S-7) illustrates both direct and indirect effects. PCOC in soil can have direct influences on plants, soil organisms and herbivores, which then influence plant communities. SO_2 also influences the plant community. In the past, SO_2 concentrations resulted in direct toxicity to plants. Current SO_2 concentrations are low enough that direct toxicity is not expected. Rather, the influence of SO_2 is considered an indirect effect because there may be current effects due to the historical influence of SO_2 on soil and the plant community.

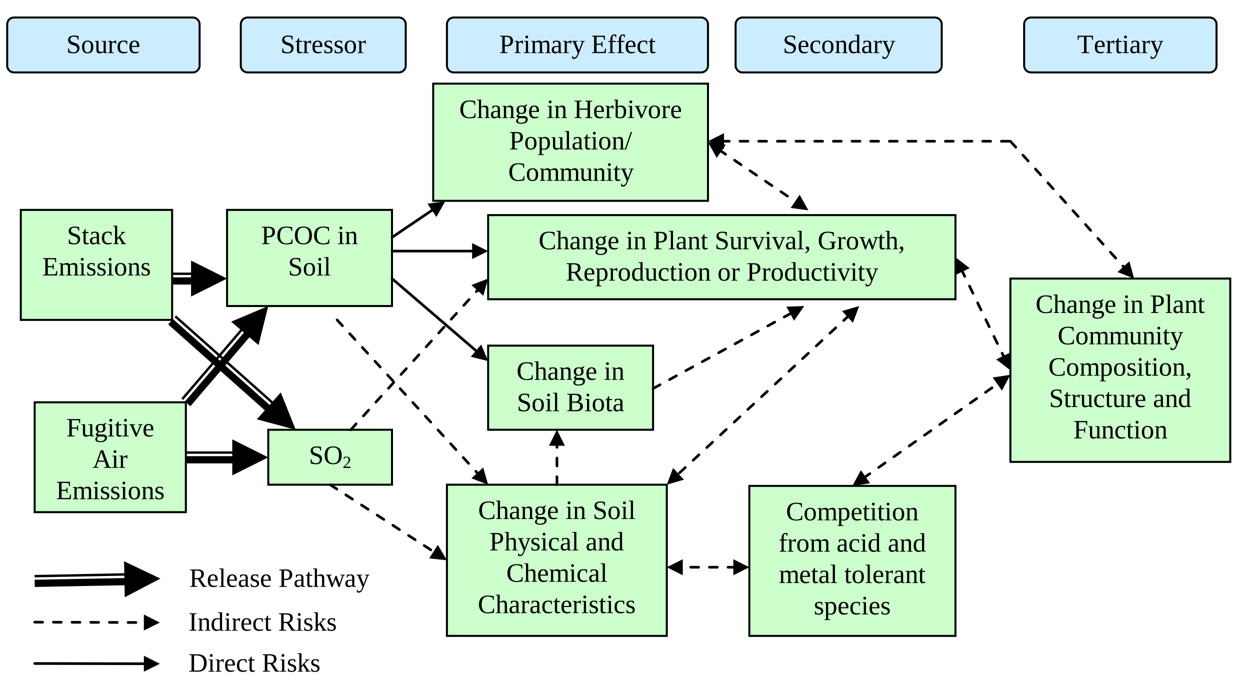


Figure S-7 Plant Community Conceptual Model: Direct and Indirect Risks from Smelter-related Emissions

Other Sources of Risk to Terrestrial Plants and Wildlife in the AOI


Logging impacts on the plant community

The Teck smelter is not the only source of risk to terrestrial plant communities and wildlife in the AOI. Fire and logging have had significant influences on plant communities in the past. Linear developments (e.g. transmission corridors, roads), and urban/commercial developments also change habitats for wildlife.

It was difficult to account for these other sources of risk in the terrestrial ERA, because the changes in the plant and animal communities are not specific to one cause. Several natural or man-made factors (e.g. fire, logging, disease, land management activities) could contribute to the observed impacts to the plant and wildlife communities. Impacts of fire and logging, in particular, are discussed further in the ERA.

ASSESSMENT OF RISK TO VEGETATION IN WILDLAND AREAS

The objective related to wildland vegetation was:

Minimize, now and in the future, smelter operation-related direct and indirect effects within the Area of Interest on the maintenance of dynamic self-sustaining plant communities in natural "wildland" areas.

Two assessment endpoints were defined to evaluate this objective:

- Forest productivity; and
- Vegetation species composition.

Several measures (lines of evidence) were used to evaluate the assessment endpoints:

- Line of Evidence #1: Forest productivity. Three measures of forest productivity were used. 1) Tree ring thickness was measured directly in western white pine (*Pinus monticola*) to determine whether there were differences in forest productivity before and after the KIVCET smelter became operational. 2) Site Index was calculated based on the diameter and height of dominant and codominant trees, in relation to known data for particular species. 3) Imagery analysis was used to assess vegetation change (tree crowns and ground vegetation cover and complexity) over a 7-year period (2000-2007) near Columbia Gardens and the Trail Airport.
- Line of Evidence #2: Plant community statistics. Associations were explored between soil parameters (soil metal concentrations, pH) and plant community parameters (plant species richness and diversity, presence of sulphur dioxide sensitive or tolerant plant species, and area occupied by trees, shrubs and herbs [as measured by percentage

cover]). A second analysis was conducted on vegetation richness and diversity related to soil metals and soil and topography characteristics (% sand, bulk density, crown closure, elevation, distance from smelter).

- Line of Evidence #3: Soil physical and chemical characteristics. Associations were explored between litter-fibre-humus (LFH) depth and other soil parameters (e.g. pH, organic matter, soil metal concentrations).
- Line of Evidence #4: Herbivorous avian and mammalian community composition. Direct toxicity of PCOC to herbivores could cause indirect effects on plant communities because of a change in grazing pressure or patterns. Therefore, the potential for direct toxicity to herbivorous birds and mammals was evaluated in this line of evidence.

Step 1 of the SALE Process: Screening of Metal Concentrations in Soil against CSR Standards

Metal concentrations in soil were compared to their respective BC Soil Standards for the protection of soil invertebrates and plants. The standards for the PCOC are:

- Arsenic – 50 mg/kg
- Cadmium – 70 mg/kg
- Copper – 150 mg/kg
- Lead – 1,000 mg/kg
- Mercury – 100 mg/kg
- Zinc – 450 mg/kg

No concentrations of cadmium or mercury measured in soils exceeded their respective standards. One soil sample contained copper at a concentration greater than 150 mg/kg. Arsenic, lead and zinc concentrations in soil exceeded standards at multiple locations.

A conservative method was used to estimate the area with at least a 10% probability of metal concentrations in soil exceeding the CSR standards for plants and soil invertebrates. The total area with metal concentrations in soil that exceeded these standards was approximately 6,120 ha, which represents approximately 14% of the AOI (Figure S-8).

Areas of metal concentrations that exceed CSR standards may not correspond with areas showing effects on plants and soil invertebrates. This is because total metal concentrations are not always a good indicator of the potential for effects. It is only the fraction of total metal concentration that is available for uptake into plants or invertebrates that has the potential to cause effects. Total metal concentrations can be subdivided via special chemical analysis techniques into categories that represent the amount of metal that is more or less likely to become soluble in water and thus available for uptake. If there is a small “available” fraction, then the potential for effects is also small.

Soil samples from the AOI were analyzed using a technique called sequential extraction which indicated that most of the total PCOC concentrations were in forms that were much less likely to be soluble in water and thus less likely to be “bioavailable”. Therefore, a map of areas showing total PCOC concentrations likely over-estimates the area of risk to plants and invertebrates, due to metals in soil, because most of the PCOC would not be available for uptake.

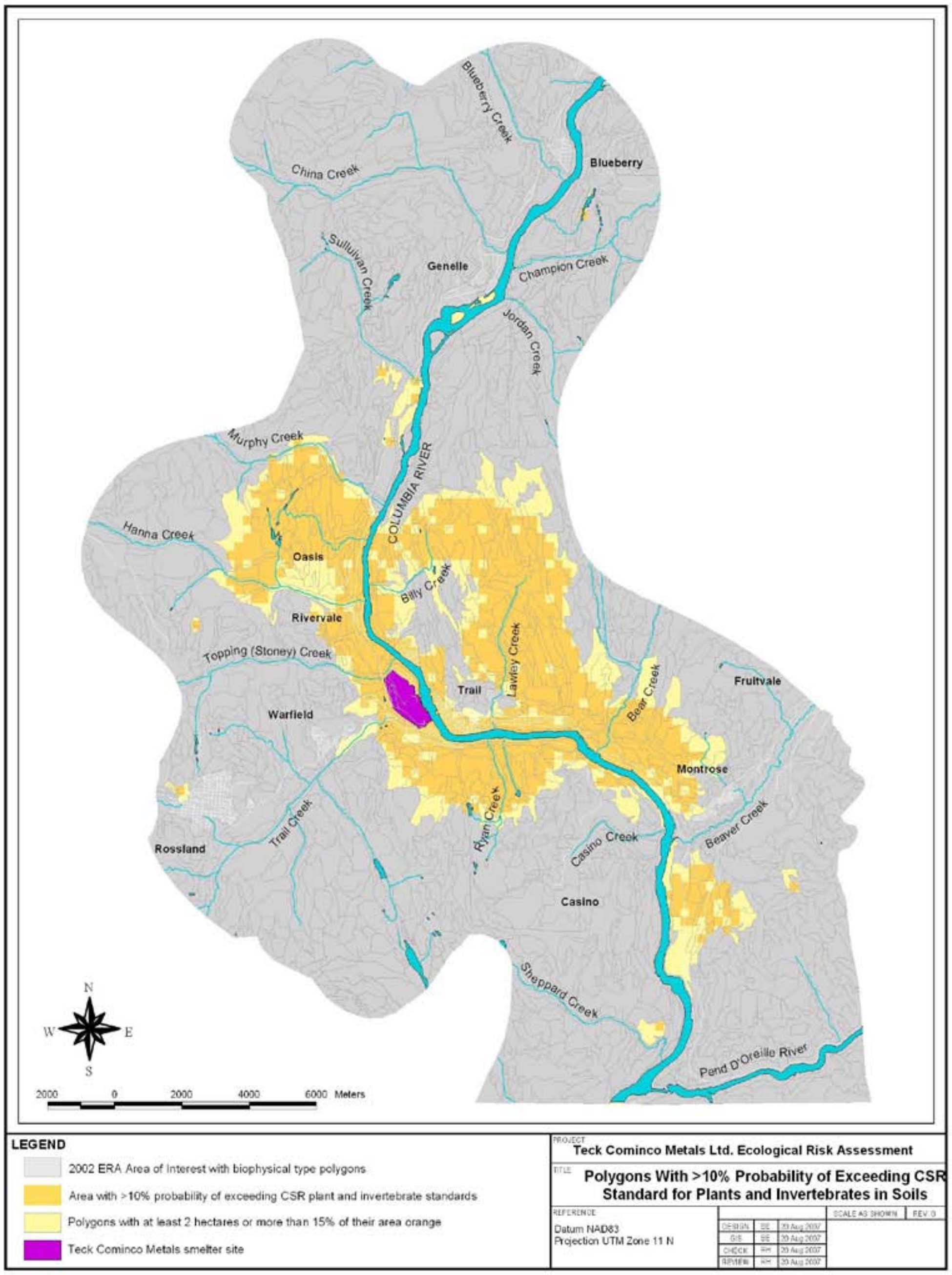
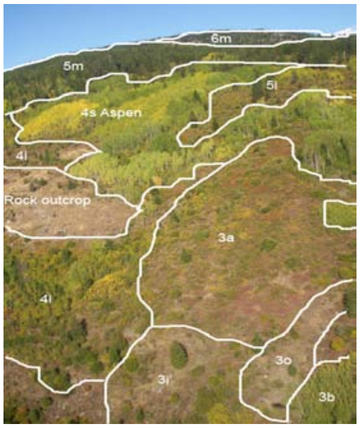


Figure S-8 Area with a >10% Probability that PCOC Concentrations in Soil Exceed CSR Standards for Plants and Soil Invertebrates.

Screening of Polygons Based on Biophysical Characteristics

Factors other than PCOC concentrations in soil, such as climate, soil texture and depth, previous air pollution injury, logging and fire have influenced the plant communities in the AOI. Therefore, the ERA was not restricted to areas of elevated metal concentrations in soil. A separate screening was completed based primarily on plant community characteristics, as documented within a biophysical habitat map. The map subdivides the AOI into numerous (1997) irregular-shaped areas (termed polygons), each being described by the soil, terrain and vegetation within it.



Various structural stages (dominant stand appearance) of the plant community; ranges from sparsely-vegetated with no trees (structural stage 1) to old forests (structural stage 7)

The screening included four steps:

- Step #1: Elimination of areas unrelated to the Objective (e.g. gravel pits, airports, etc.);
- Step #2: Elimination of areas in advancing structural stages because the presence of such stages indicates that any past impacts (if any) are not preventing the development of the plant community;
- Step #3: Elimination of areas with logging impacts IF metal concentrations in soil are less than CSR standards AND the area was not previously impacted by SO_2; and,
- Step #4: Elimination of areas in early structural stages IF metal concentrations in soil are less than CSR standards AND the area was not previously impacted by SO_2.

A total of **415 polygons** representing **8,317 ha** (20% of the AOI) remained after the 4-step screening process. These polygons are shown on Figure S-9.

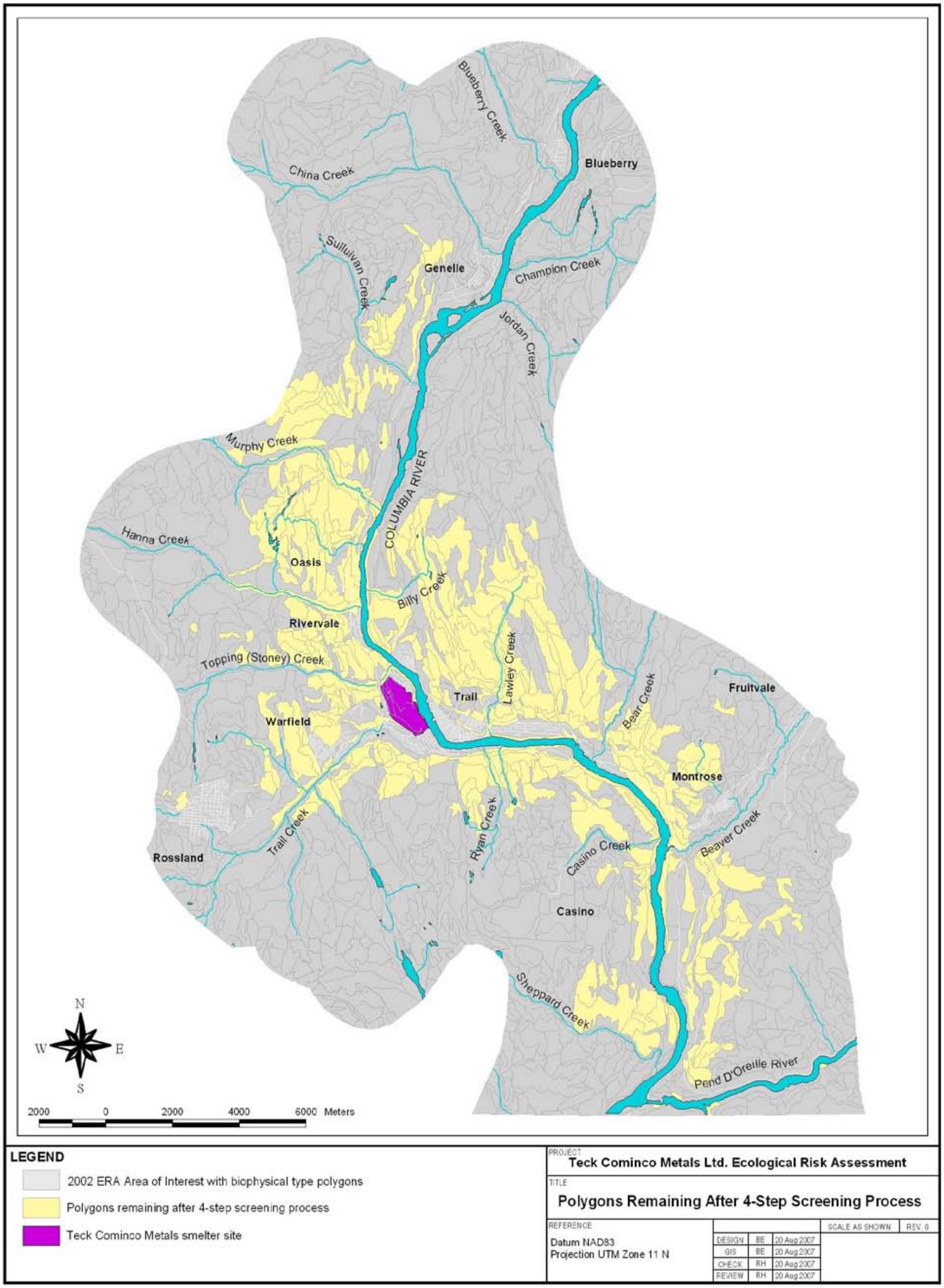


Figure S-9 Polygons Remaining After 4-Step Screening Process.

Steps 2-4 of the SALE Process: Magnitude and Uncertainty

The ERA focused on the 415 polygons remaining after the biophysical habitat screening (Figure S-9). The evaluation used four lines of evidence:

1. forest productivity;
2. plant community statistics;
3. changes in soil physical and chemical characteristics; and,
4. changes to avian and mammalian herbivore populations/ communities.

Forest Productivity:

Three measures of forest productivity were used. 1) A direct measurement of forest productivity was taken (Golder, 2007). 2) Site Index was calculated for 61 samples of multiple species at 32 locations (Enns and Enns, 2010). 3) An indirect measure of productivity was based on an imagery comparison, between 2000 and 2007, of the area near Columbia Gardens and the Trail Airport (Enns and Enns, 2010).

Productivity sampling

Tree ring analysis was conducted on western white pine (*Pinus monticola*) of between 40 and 60 years of age, in four areas. The study showed that growth was suppressed in the pre-KIVCET period (narrower rings pre-1997) and then recovered after the KIVCET smelter was installed (wider rings, sometimes even wider than in control areas). The data indicate that the current magnitude of response on tree growth is weak (adverse effects unlikely) in three of the four study areas. In one study area, a strong magnitude of response (adverse effects likely) is still evident because growth has not increased to levels similar to the control area. This may be due to continuing effects of soil metal concentrations, or effects of other factors such as lower soil nutrient levels.

Site Index was measured for 61 samples in 32 polygons using data from 2002. Both low and high Site Index values were calculated for trees at variable distances from the smelter. The data suggest the Site Index and productivity of conifers is more dependent on site variables such as soil nutrient regime than past emissions effects.

Imagery comparison was done for one area strongly affected by sulphur dioxide in the past. Comparisons of images from 2000 and 2007 showed tree crown width increasing in trees located between 400 and 600 m elevation. Ground vegetation cover also increased in polygons facing away from the smelter, and that were not in a closed canopy. This indicates that recovery of vegetation is evident, with lower elevation sites showing the most significant changes.

Uncertainty in the productivity data is considered moderate. The tree ring analysis was conducted on only one species, and in only four polygons, relative to controls from a single polygon. However, sites were standardized for topography, slope, elevation, and soil type. In addition, a sufficient number of trees (20) were sampled from each site to distinguish differences from the control site. Site index data were collected for only 32 polygons and did not account for productivity in non-tree species. The imagery analysis was available for only one area. Ground-truthing was not conducted, and changes of less than a metre could not be detected.

Vegetation Community Statistics:

Plant community

The plant community data were examined for evidence of effects of smelter-related emissions by testing for statistical relationships between plant community characteristics and soil characteristics (Golder, 2007). The plant community characteristics were species richness and diversity, presence of sulphur dioxide sensitive or tolerant plant species, and percentage of tree, shrub and herb cover. The soil characteristics were pH and soil metal concentrations.

The statistical analysis was conducted on groups of plant sample plots that represented three important factors: elevation, soil moisture and dominant tree cover type (coniferous or deciduous). Division of the data into groups based on these three factors helped account for their effects, thus allowing a clearer focus on the effects of soil pH and metal concentrations.

Group 1: Lower elevation, dry soils, coniferous
Group 2: Higher elevation, dry soils, coniferous
Group 3: Lower elevation, moist soils, coniferous
Group 4: Higher elevation, moist soils, coniferous
Group 5: Lower elevation, dry soils, deciduous
Group 6: Higher elevation, dry soils, deciduous
Group 7: Lower elevation, moist soils, deciduous
Group 8: Higher elevation, moist soils, deciduous

Douglas fir-Oregon grape (DO) plant community

Vegetation statistics were also run by separating the samples into groups according to dominant vegetation type: BF (paper birch, bracken fern); DO (Douglas fir, Oregon grape); HF (western hemlock, feather moss); and, WF (white pine, falsebox).

Results for Groups 1, 5, 7, BF and WF indicate a strong or moderate smelter-related response. Results for Groups 2, 3, 4, 6, 8, DO and HF do not indicate a smelter-related response or only a weak response.

Re-analysis of the vegetation data was completed by Enns and Enns (2010) for those plots with complete soils and vegetation data (157 plots in 147 polygons). Trends in vegetation characteristics (richness and diversity) were described relative to metals concentrations in soil, and soil and topography characteristics (e.g., % sand, bulk density, crown closure, elevation, distance from smelter). The re-analysis results were similar to the results obtained from Golder (2007).

Overall uncertainty was low because data were obtained for several variables at 440 locations within 350 polygons, and represented a broad range of metal concentrations in soil. The consistency between the results from Golder (2007) and Enns and Enns (2010) provides confidence in the overall results of the vegetation community statistical analysis.

Soil Physical and Chemical Characteristics:

Associations were explored between litter-fibre-humus (LFH) depth and soil parameters (e.g. pH, organic matter, metal concentrations). Metals in soils may inhibit the formation of the LFH layer. This may be due to direct toxicity to the soil bacteria, fungi and invertebrates that play an important role in the break-down of litter. It may also be due to the effects of soil metals on the plant community, where metal-tolerant plant species may not produce the mixture of decomposable material typical of unaffected areas (e.g. bracken fern-dominated communities).

The magnitude of response is weak because there were no significant correlations between LFH depth and any soil parameter (i.e. pH, organic matter content, PCOC concentration (arsenic, cadmium, copper, lead, selenium, zinc), or pH-adjusted total PCOC concentration).

Uncertainty is moderate. Data were obtained for few variables related to LFH development, but from a large number of sample locations across the PCOC concentration gradient. Several important natural variables were not accounted for in the analysis (e.g. type of plant community contributing to the LFH layer).

Herbivore Community Changes:

White-tailed Deer

The indirect effects on plants due to grazing pressure from herbivores was assessed by considering the direct effects of PCOC on herbivorous avian and mammalian populations and communities.

No unacceptable direct toxicity risks were predicted to avian or mammalian herbivore populations (Intrinsik, 2007), and the avian and mammalian communities are representative of the habitats present.

The uncertainty related to herbivores is moderate. There is greater confidence in the avian community data than the mammalian community data. Insufficient data were collected to address the potential cascade of indirect effects between plant communities and wildlife.

Summary of Evidence for Effects of Smelter Emissions on Plant Communities:

There is evidence to support the conceptual model that metals and previous air pollution injury may continue to influence plant communities in portions of the AOI, based on the biophysical habitat screening, the productivity measurements, and the vegetation statistical analyses. The evidence is stronger for some areas (polygons) within the AOI. These areas are all at lower elevation, and are often in the paper birch, bracken fern or white pine, falsebox biophysical areas. The influence of soil metals cannot be separated from the past influence of SO_2. There is little support for the influence of PCOC on LFH development, or related to indirect effects of avian and mammalian herbivores on plant communities. It appears that plant community impacts are due to a combination of direct effects (e.g.

PCOC toxicity to plants) and indirect effects (e.g. competition from acid- and metal-tolerant plants).

Step 5 of the SALE Process: Assessment of Causality

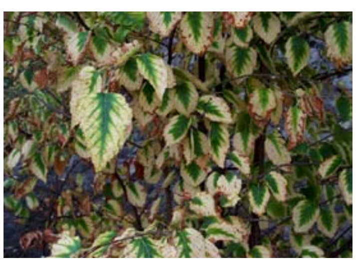
There is moderate evidence of a cause/ effect link between plant communities and the smelter.

Plant communities in the AOI have obviously been adversely affected by smelter emissions in the past. However, there is only moderate evidence of an ongoing link between plant community responses and smelter emissions as per the Conceptual Model. Therefore, the overall evidence for a cause/effect link between plant community measures and the smelter is moderate, for the following reasons:

There is a strong spatial correlation between vegetation characteristics and smelter- related parameters (e.g. PCOC in soil, soil pH) in lower-elevation areas closer to the smelter. The higher the elevation, the less evidence of smelter-related effects, either via soil metal concentrations or air pollution injury from sulphur dioxide emissions.

Effects on the plant community show a definite trend with time. Significant historical impacts to plants from the 1930s to the 1990s have been documented. However, as smelter emissions decreased, because of changes in smelter operations and improvements in emissions control technology, the plant communities have responded.

The vegetation statistical analysis shows a gradient in response, especially at low elevation sites and in BF units. There are more early structural stage plant communities with canopy openings or bare mineral soil closer to the smelter, at lower elevation, and facing the smelter. These areas contain higher metal concentrations in soil and experienced previous air pollution injury to a greater extent than areas further from the smelter, at higher elevation, and not facing the smelter.



Historical metal injury symptoms in birch

There are plausible mechanisms for the effects of PCOC in soil and previous air pollution injury on plant communities in the AOI, primarily at lower elevation and close to the smelter. Injury of plants from emissions of SO_2 is well documented around sources such as smelters. Signs of previous air pollution injury can still be seen in the aerial photographs.

Healthy birch leaf

It is plausible that previous air pollution injury could be responsible for observed impacts in the plant community, as shown by the biophysical habitat mapping and vegetation statistical analyses. The plant communities are continuing to change (e.g. increased productivity, increased cover) since KIVCET was installed and emissions of metals and SO_2 were reduced. Current emissions are not at a level of concern for plants, and plant cover is observed to be increasing.

There was consistency in the evidence among sites within the AOI related to correlations between vegetation statistics (except LFH) and smelter-related indices, and biophysical habitat screening results and one or both of PCOC concentrations in soil and previous air pollution injury. There are many sites where vegetation community parameters did not correlate with PCOC concentrations in soil. Factors such as soil features, climate, logging and fire history also may influence plant communities in the AOI.

None of the responses could be considered to be specific to the effects of PCOC in soil. Several potential confounding natural and man-made factors (e.g. fire, logging, disease, land management activities) could contribute to the observed impacts to the plant community.

Step 6 of the SALE Process: Risk Characterization; Should We Proceed to Consideration of Risk Management?

There is support for the Conceptual Model, which predicts direct or indirect effects on plant communities due to smelter emissions, for portions of the AOI.

The AOI has been subdivided into 1,997 polygons. The biophysical habitat screening eliminated 1,582 polygons from further consideration. Therefore, 415 polygons remained. The productivity data, results of the vegetation community statistical analyses, results of the analysis of soil characteristics, and consideration of herbivore communities support the removal of 16 of the 415 polygons. These polygons were at high elevation or within Douglas fir, Oregon grape or western hemlock, feather moss plant communities. Therefore, 399 polygons remain to be considered in the risk management planning process. This represents approximately 7,900 ha or 18.4% of the AOI (Figure S-10).

The plant communities within the AOI have continued to develop since the time period used to develop the biophysical habitat map (aerial photograph taken in 1999) and the field data that were collected for statistical analysis of plant community characteristics (2001). Therefore, consideration of risk management options should be based on an updated assessment of plant community structure.

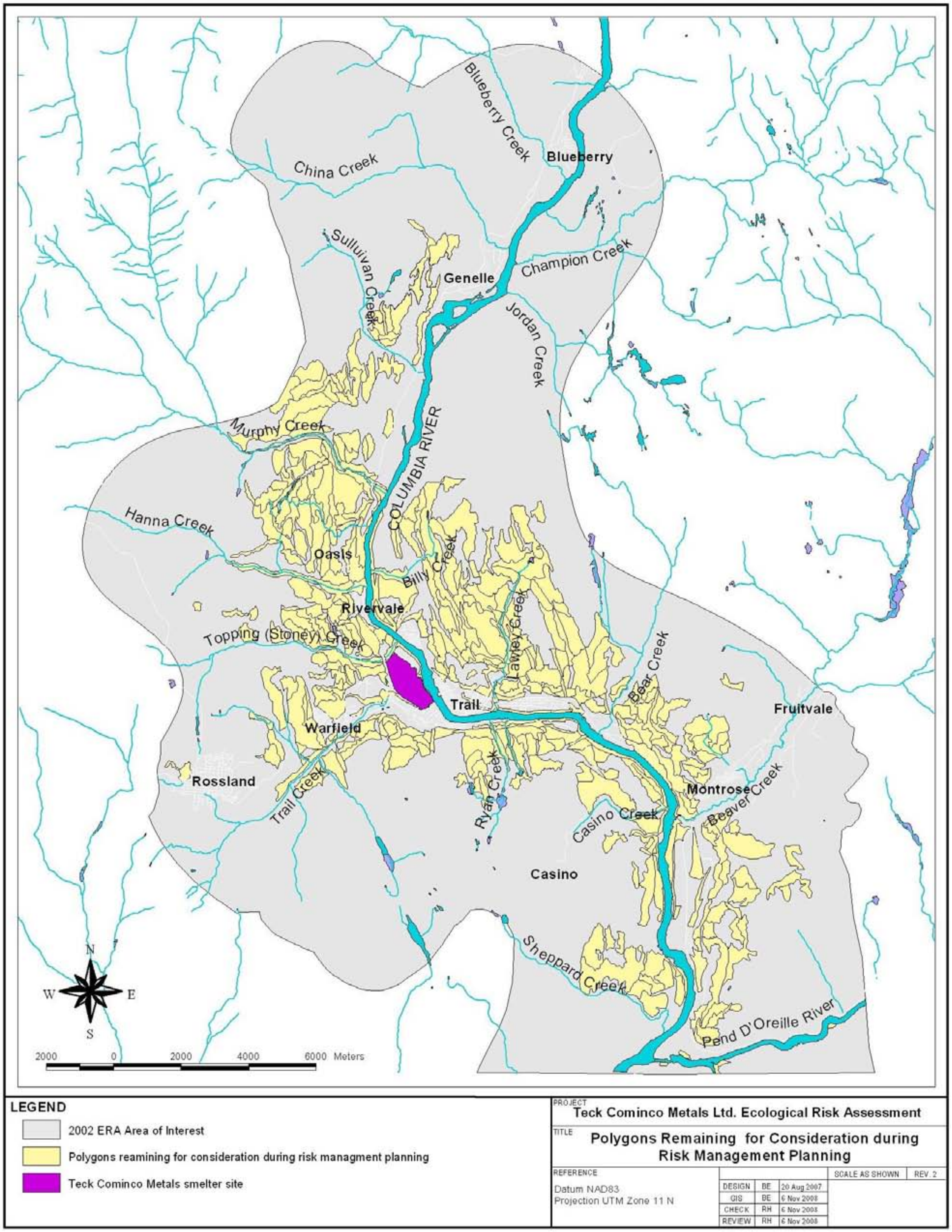


Figure S-10 Polygons Remaining for Consideration during Risk Management Planning.

ASSESSMENT OF RISKS TO VEGETATION IN URBAN AREAS

The objective related to urban vegetation was:

An urban garden in Trail

Minimize, now and in the future, smelter operation-related direct and indirect effects within the Area of Interest on the maintenance of desired native and introduced plant species in "urban" areas.

Two assessment endpoints were defined to evaluate this objective:

1) Plant productivity; and,
2) Native and introduced vegetation species presence and condition.

It is difficult to evaluate directly the influence of smelter emissions on plants in the urban environment because people can alter the system by using irrigation, adding soil and nutrients, and adding or removing plants. Therefore, several groups involved in growth and maintenance of plants in the urban areas around Trail were asked about plant growth and condition (Golder, 2007).

Identification of Urban Areas Considered in the Evaluation

There are 81 polygons (totalling 1,900 ha) containing at least 10% urban/suburban, urban park or rural areas. Only 27 of these polygons (totalling 610 ha) contain soil metal concentrations exceeding CSR standards for plants and soil invertebrates. These polygons generally are located near the smelter.

Summary of Information

There are no quantitative estimates of the magnitude of response for this objective. The assessment of urban plants was not considered a full risk assessment but rather a problem formulation because the only information was anecdotal.

Observations from representatives of the Trail Parks Department, the Horticultural Society and Communities in Bloom included:

- Organic matter and fertilizer have been added to city gardens;
- No reports of problems with flower or vegetable gardens in the area;


An urban garden in Trail

- No changes in productivity of the gardens;
- Improvements in the growing conditions in the City of Trail flower beds (Trail was the 2006 Communities in Bloom National Award winner for cities with a population between 5,001 and 10,000 people; Trail received the highest score of 5 blooms for landscaped areas);
- An increase in growth of species such as juniper trees and black locust in the downtown area; and,
- A belief that smelter emissions were not responsible for any persisting plant health concerns; near the smelter, there are areas with very sandy soil and low soil moisture and nutrients.


An urban garden in Trail

In summary, no concerns were raised by local city workers or residents, and landscaped areas of Trail received the highest award from the Communities in Bloom program.

There are significant uncertainties in this analysis. Data are qualitative, and from only a few people. There could be impacts at individual properties which may not be identified via the interview process. However, the people interviewed have broad experience over many years in the area, the Communities in Bloom judges were from outside Trail and BC and therefore are impartial, and responses were consistent among the people interviewed.

Conclusion; Should We Proceed to Consideration of Risk Management?

There is no support for the plant Conceptual Model for urban areas.

The available evidence indicates that the risk management objective for urban plants is being met; however, there are significant uncertainties. There are no quantitative or published data documenting urban plant growth, presence or condition. Qualitative anecdotal information suggests native and introduced plants in urban areas (including gardens, landscaped areas) are growing well.

At this time, consideration of risk management is not indicated by the results of this problem formulation. However, if property-specific issues arise in future, site-specific data on PCOC concentrations in soil may be required to assess individual properties to ensure that the risk management objective is met.

ASSESSMENT OF RISKS TO CROPS


Pasture

The objective related to agricultural crops was:

Minimize, now and in the future, smelter operation-related direct and indirect effects within the Area of Interest on forage crops, pastureland, and vegetable and fruit production in "agricultural" areas

Two assessment endpoints were used to evaluate this objective:

1) Yield of forage crops or pasture and yield of fruits; and,
2) Quality of forage crops, pastureland and fruits.

Area farmers (Columbia Gardens Vineyard and Winery, a greenhouse operator, and a dairy farmer) were contacted and asked several questions related to yields over time; cultivation practices, including soil amendments and irrigation; and, concerns about smelter emissions related to their agricultural operation (Golder, 2007).

The focus was on areas containing cultivated field and pasture.

Identification of Agricultural Areas Considered in the Evaluation

There are 34 polygons (totalling 460 ha) with at least 10% cultivated field or pasture in the polygon. Only six of these polygons (totalling 93 ha) contain soil metal concentrations exceeding CSR standards for plants and soil invertebrates. These six polygons are in the Columbia Gardens area. The other 28 polygons were eliminated from further consideration for various reasons (e.g. the four screening steps used for wildland plants under Objective 1.

Summary of Information

There are no quantitative estimates of the magnitude of response for this objective. The assessment of cultivated fields and pastures was not considered a full risk assessment but rather a problem formulation because the only information was anecdotal. Information was obtained from both the vineyard and a farmer in the Columbia Gardens area. These individuals made up the entire agricultural component of this sparsely populated area, at the time the data were collected.

Observations from the local vineyard in Columbia Gardens, which has been in operation since 2001, included:

- There have been no health issues with the grapevines at the vineyard that could be attributed to smelter emissions;
- The soil is nutrient-rich and therefore fertilizers are not used; and,


Columbia Gardens Vineyard

- The vineyard is drip-irrigated using water from a nearby groundwater spring.

Cultivated Field

Observations from the local dairy farmer in Columbia Gardens, who maintains 50 acres of hay and corn fields, included:

- Soil acidity had been problematic in the past, but has been addressed with lime treatments;
- Crops are amended with fertilizer and manure annually, and with lime every eight years;
- Crops are irrigated with groundwater; and,
- His crops grow very well.

In summary, no concerns were raised by farmers growing fruit or forage crops in Columbia Gardens, the area with the potential for PCOC in soil to exceed CSR standards for plants and soil invertebrates.

There are significant uncertainties in this analysis. Data are qualitative and from only two people from unique farms, the vineyard has been operating only since 2001, and there could be impacts at individual properties which may not be identified via the interview process. However, responses were consistent between the people interviewed and people were interviewed in the area suspected to be most at risk due to PCOC concentrations in soil.

Conclusion; Should We Proceed to Consideration of Risk Management?

There is no support for the plant Conceptual Model for agricultural areas.

The available evidence indicates that the risk management objective for agricultural plants is being met; however, there are significant uncertainties. There are no quantitative or published data documenting agricultural plant growth, presence or condition. Qualitative anecdotal information suggests fruit and forage crops in agricultural areas (in particular, Columbia Gardens) are growing well.

At this time, consideration of risk management is not indicated by the results of this problem formulation. However, if property-specific issues arise in future, site-specific data on PCOC concentrations in soil may be required to assess individual properties to ensure that the risk management objective is met.

ASSESSMENT OF RISKS TO WILDLIFE

White-crowned Sparrow

The three objectives relating to wildlife in the AOI are:

Minimize, now and in the future, smelter operation-related direct and indirect effects within the Area of Interest on populations of wildlife in natural "wildland" areas;

Minimize, now and in the future, smelter operation-related direct and indirect effects within the Area of Interest on wildlife populations in "urban" areas; and,

Minimize, now and in the future, smelter operation-related direct and indirect effects within the Area of Interest on wildlife populations in "agricultural" areas.

The assessment endpoints used to evaluate these objectives were:

Evening Grosbeak

- Wildlife population persistence;
- Wildlife habitat utilization; and,
- Wildlife habitat suitability.

The definition of habitat includes both the physical location (i.e. the types of plants required for cover, the presence of nesting or den sites, etc.) as well as the availability of adequate food resources.

Several measures were used to evaluate the assessment endpoints:

- Line of Evidence #1: wildlife habitat suitability mapping, based on the biophysical habitat map and accompanying interpretation. This was done for species for which risks could not be ruled out in the final stage of wildlife risk modelling (American robin), plus another four species (black-capped chickadee, mallard, white-tailed deer and river otter);
- Line of Evidence #2: field survey data for American robins;
- Line of Evidence #3: field survey data for avian and mammalian populations and communities in the AOI; and,
- Line of Evidence #4: soil invertebrate diversity and abundance measures.

Step 1 of the SALE Process: Screening

Direct toxicity to all representative wildlife species was ruled out using risk modelling, except for the American robin (Intrinsik, 2007). The SALE process was used to evaluate American robin, and avian and mammalian communities in the AOI because only representative populations of wildlife were assessed in the risk modelling.

The SALE Process for the Evaluation of American Robin

The SALE process for American robin included consideration of indirect effects, as well as a review of data collected via field surveys.

Step 2 of the SALE Process: Indirect Effects

Indirect effects may include a change in robin abundance because of changes in the abundance of predators or food items. Another important indirect effect is a change in habitat suitability caused by smelter-related changes in plant communities.

Changes in robin abundance caused by changes in predator abundance were not predicted. This is because direct toxicity of metals to predators was not predicted by the risk modelling.

Beetle

American robins consume a varied diet, including earthworms, insects, and various types of fruit and other vegetation. The proportion of each dietary item changes during the year, with more invertebrates being consumed in the spring and summer, during reproduction.

Three independent studies indicate that there may be, at most, a weak relationship between the abundance of some invertebrate species and metals in soil (Golder, 2007). One of the food items of robins, earthworms, is found in parks, gardens and agricultural fields where soils have been amended. Therefore, factors other than PCOC concentrations in soil are the primary determinants of earthworm presence and abundance.

The magnitude of indirect effects on American robins via food chain changes or effects on habitat is low. Uncertainty is low to moderate.

Uncertainty in soil invertebrate abundance and community structure is moderate. The analysis of earthworm presence was qualitative. One invertebrate study was restricted to low-elevation areas within a single vegetation cover-type. The number of sampling sites and the number of samples within each site were not sufficient to produce high statistical power; therefore, there is a moderate probability that differences across the PCOC gradient could be distinguished from natural variability. Important confounding variables were observed and accounted for (e.g. sites with other disturbances such as roads were not sampled). The third study covered a wider concentration gradient of PCOC in soil and included two vegetation cover types; however, it was a single-season survey only.

Old apple tree

Robin abundance is strongly influenced by habitat; however, the habitat features that affect robin presence the most appear to be: well-tended gardens, watered lawns, freshly turned soil, presence of fruit trees. American robin habitat was evaluated using robin habitat suitability mapping (Figure S-11). Most areas of “excellent” or “good” habitat for robin are urban and agricultural areas. It is noted that robins prefer to have conifer cover nearby, and the presence of conifers in the AOI was impacted by previous SO_2 emissions from the smelter. However, the re-growth of conifers in the valley is dramatic, and is resulting in emergent mixed-wood stands in the valley.

Uncertainty in habitat suitability is low. The habitat requirements and preferences of American robin are well known, and the methods used to assess suitability were modified from BC standard methods to account for unique aspects of the AOI. The mapping of suitability was not extensively ground-truthed at the higher elevations in the map.

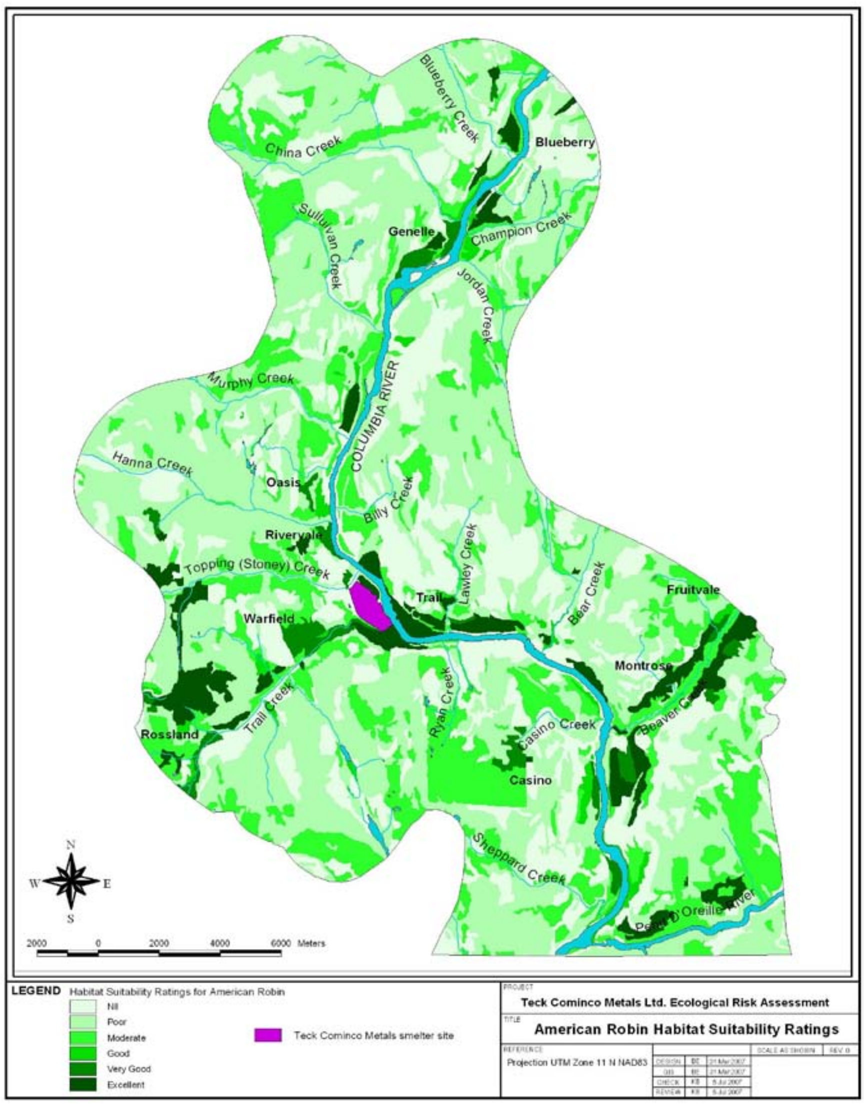


Figure S-11 American Robin Habitat Suitability.

Steps 3 and 4 of the SALE Process: Magnitude of Response and Uncertainty from Field Surveys

American Robin

The magnitude of response for American robin populations as determined by field survey data is low. Uncertainty is low to moderate.

Field surveys (Figure S-12) did not indicate effects on American robin presence or relative abundance (Golder, 2007). Surveys of bird community diversity and relative abundance conducted from 2000 to 2004 show that American robin is common in the AOI with abundance and density that are similar to comparable areas of BC. Surveys of American robin presence and nesting in 2004 recorded numbers of adults and juveniles as well as activity (e.g. feeding and perching) and presence of nests (and eggs or young within the nests). Neither the abundance or robins, nor the presence/absence or status of nests, were related to metal concentrations in soils or distance from the smelter.

Uncertainty is low for the bird community survey data and moderate for the nesting survey. The field survey of robins was conducted only once, in a limited number of locations within the AOI and at only one time of the year. The bird community surveys were conducted from 2000 to 2004 at a standard time of year and in several locations within the AOI. However, locations for the 2000 to 2004 bird community surveys were not selected based on suitability of American robin habitat, but rather as representative low elevation habitats for all songbirds in the AOI.

There is no evidence to support direct or indirect adverse effects on American robin based on the field data. Robins are abundant where habitat is suitable, and suitable habitat is found close to the smelter.

Because adverse effects are unlikely, and the uncertainty was low or moderate, no causal analysis (SALE Step 5) was conducted for the American robin.

Step 6 of the SALE Process: Risk Characterization for the American Robin; Should We Proceed to Consideration of Risk Management?

There is no support for Conceptual Models 1 or 2, which predict direct and indirect effects from the smelter.

American robins were evaluated under three risk management objectives, related to minimizing direct and indirect effects on populations of wildlife in wildland, urban and agricultural areas.

The combined results presented above support the conclusions that:

1) American robin populations persist in the AOI in areas of suitable habitat;
2) Habitat is being utilized by American robin; and,
3) There is suitable habitat for American robin in the AOI, and the habitat is strongly influenced by factors unrelated to smelter emissions.

These conclusions are supported by lines of evidence that show low-magnitude effects with associated low-to-moderate uncertainty.

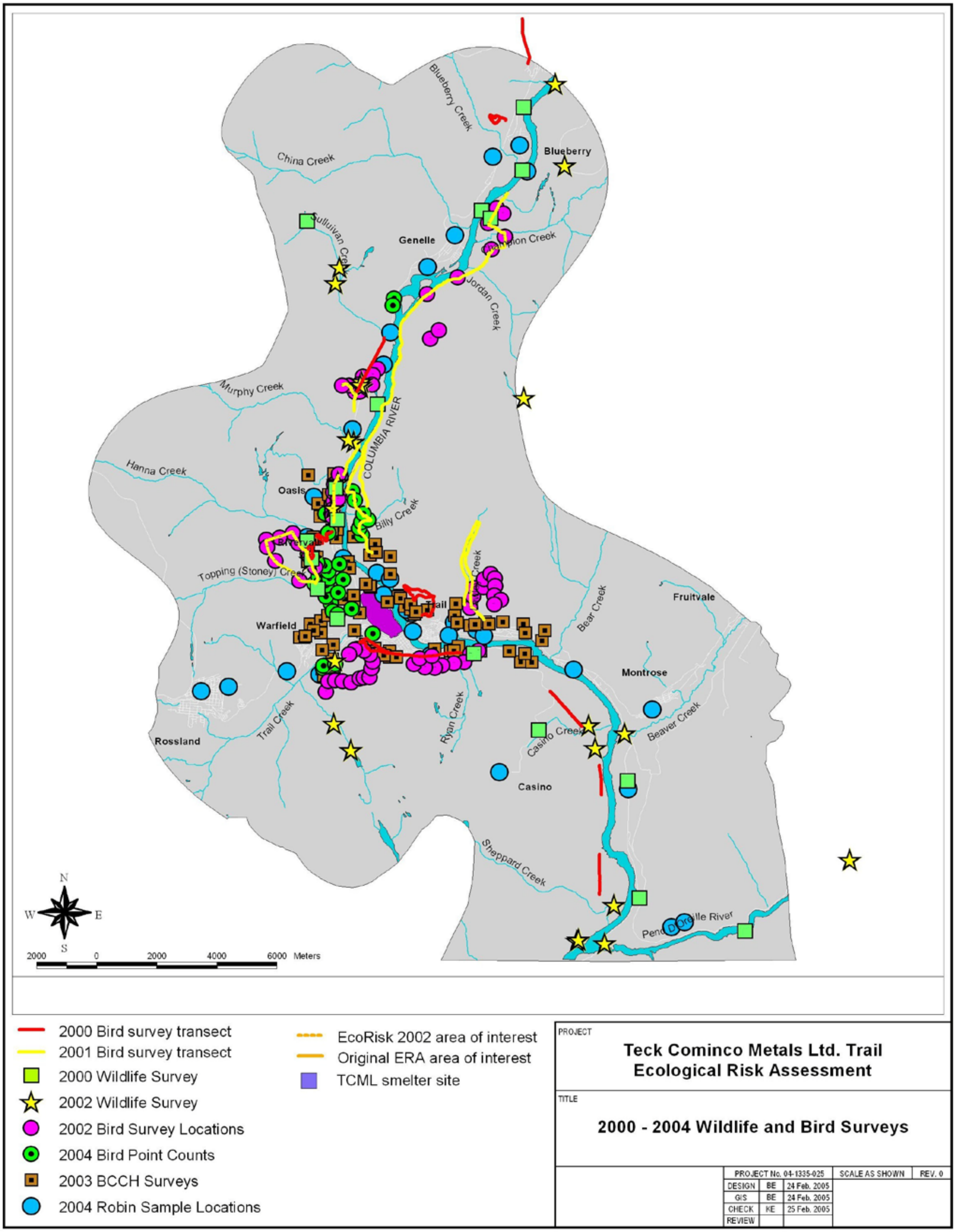


Figure S-12 Wildlife Field Survey Locations in the Area of Interest.

The SALE Process for the Evaluation of the Avian Wildlife Community

The assessment of smelter-related risk to the overall avian community was limited to indirect risks via physical effects on habitat and effects via interactions between birds and their food supply. Direct risks to representative species of carnivorous and fish-eating birds (red-tailed hawk, osprey, kingfisher), and omnivorous and herbivorous birds (American crow, American robin, black-capped chickadee, mallard) were assessed through Step 1 of the SALE process (Intrinsik, 2007).

Steps 2 through 4 of the SALE Process: Magnitude of Response and Uncertainty related to Indirect Effects

Predator-Prey Interactions

The evidence does not support adverse effects via changes in predator or prey populations. No unacceptable direct toxicity risks were predicted using risk modelling for avian or mammalian predators or prey in the AOI. Therefore, indirect effects on avian communities due to changes in predator or prey abundance were not carried forward in the SALE evaluation. The evidence for effects on soil invertebrates was weak. Therefore, no adverse effects via reduction in invertebrate food supply are expected. The uncertainty related to this analysis was moderate.

Bird Community Surveys

Bird community diversity and relative abundance data were collected from 2000 to 2004 (Figure S-12). Data from these surveys were used to compare bird communities within the AOI to those outside the AOI (Golder, 2007).

Hairy Woodpecker

Evidence from bird surveys indicates that the magnitude of smelter-related indirect effects on bird density and abundance is low. Density and abundance estimates from surveys conducted in 2001 to 2004 consistently were highest at sites closest to the smelter and lowest at sites further from the smelter. Densities were variable in relation to lead concentration in soil but were highest at concentrations in the 350 to 1,000 mg/kg range.

Evidence from bird surveys indicates that the magnitude of smelter-related indirect effects on bird community composition is low. The community composition in the AOI was similar to the community composition within nearby survey areas (Salmo, Slocan and Syringa).

The bird community composition in the AOI can be explained by the habitat present. The habitat suitability analyses indicate that the magnitude of smelter-related effects on bird habitat is low. Adverse effects are unlikely, because the availability of suitable habitat has not been restricted due to changes in the vegetation community caused by smelter emissions, or the primary factors limiting habitat availability are not related to smelter emissions.

The magnitude of response for the avian community as determined by field survey data is low. Uncertainty also is low.

Because deciduous and riparian dominated habitats tend to have richer (i.e. higher species richness and abundance) bird communities than coniferous-dominated areas, it is not surprising that some sites nearer the smelter, which are near the Columbia River and have re-vegetated mainly with deciduous species, have more birds than some sites further away (which are dominated by conifers). Over longer periods, as coniferous forest begins to replace deciduous vegetation, those species will decline and species that prefer more coniferous forest will increase.

Qualitative evidence for the occurrence of wildlife habitat and the use of that habitat by wildlife was assembled as part of the biophysical habitat mapping (Enns and Enns, 2007). The AOI was divided into 10 geographic areas (Figure S-13).

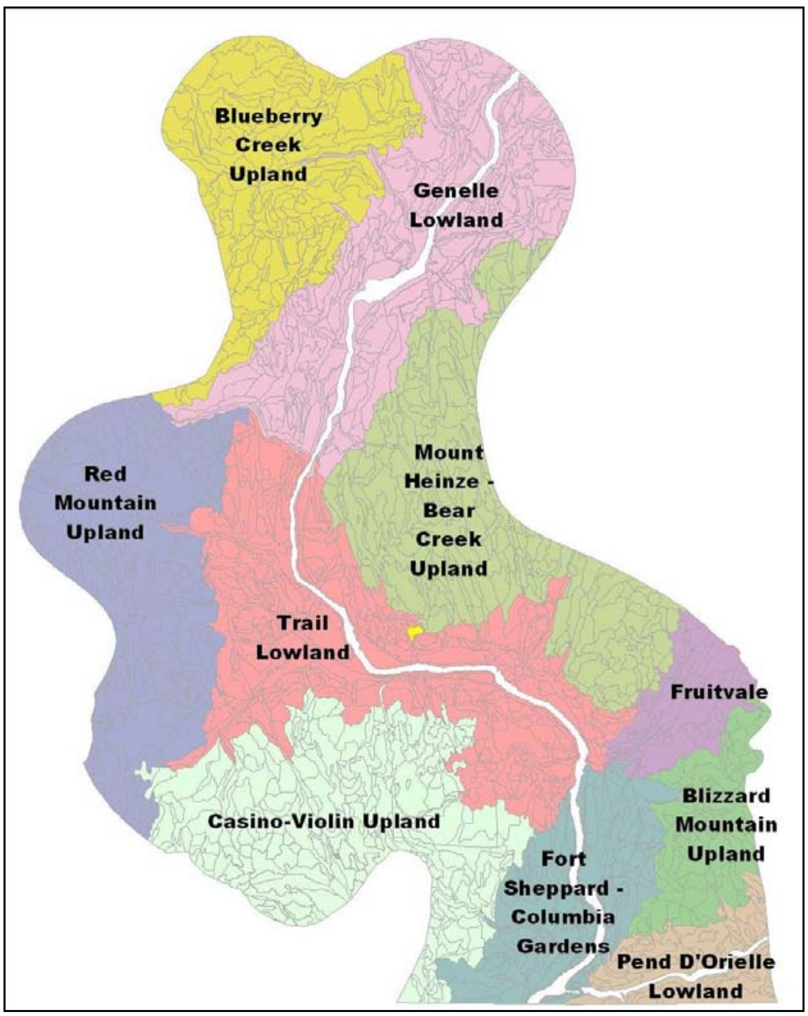


Figure S-13 Ten Geographic Areas within the Area of Interest.

The magnitude of indirect effects on the avian community via food chain changes or effects on habitat is low. Uncertainty is moderate.

The AOI provides a range of habitat for a wide variety of avian species. Natural terrain features (e.g. cliffs) and land use activities (e.g. logging) influence wildlife use of particular areas within the AOI. The information does not provide a species-by-species evaluation of possible relationships between smelter-related changes in habitat and habitat use; however, the plant communities of the Trail lowland area with historic smelter-related damage are now providing habitat for a large number of species.

Uncertainty related to the natural variability of avian abundance and density estimates is moderate. The variance in some of the abundance and density estimates was quite high, and some habitat types and some classes of PCOC concentrations were much better represented than others.

Uncertainty related to natural variability of community composition is low. The differences in bird species detected between this study and the reference survey routes elsewhere can be explained by the different geographic locations of the reference survey routes, different habitat types that are likely present and the duration of the study periods.

Because all adverse effects are unlikely, and the uncertainty was low or moderate, no causal analysis (SALE Step 5) was conducted for avian communities.

Step 6 of the SALE Process: Risk Characterization for the Avian Community; Should We Proceed to Consideration of Risk Management?

The avian community was evaluated under the three risk management objectives related to minimizing direct and indirect effects on populations of wildlife in wildland, urban and agricultural areas.

The combined results presented above support the conclusions that:

There is no support for Conceptual Models 1 or 2, which predict direct and indirect effects from the smelter.

1) Avian wildlife populations persist in the AOI;
2) Available habitat is being utilized to a similar extent as in reference habitat areas; and,
3) The habitat (including areas that are in early- to mid-seral stages) is suitable for a wide range of avian species (although in different proportions than would have been present prior to historical, smelter-related effects).

These conclusions are supported by lines of evidence that show low-magnitude effects with associated low-to-moderate uncertainty. The evidence does not support adverse effects via direct toxicity or indirect effects via food chain interactions or physical changes in habitat.

The SALE Process for the Evaluation of the Mammalian Wildlife Community

The assessment of smelter-related risk to the overall mammalian community was limited to indirect risks via physical effects on habitat and effects via interactions between mammals and their food supply. Direct risks to representative species of carnivorous and fish-eating mammals (coyote, river otter), ungulates (white-tailed deer), and other small and large mammals (black bear, Columbian ground squirrel, deer mouse, dusky shrew, red-backed vole, red squirrel) were assessed through Step 1 of the SALE process (Intrinsik, 2007).

Steps 2 through 4 of the SALE Process: Magnitude of Response and Uncertainty related to Indirect Effects

Predator-Prey Interactions

The evidence does not support adverse effects via changes in predator or prey populations. No unacceptable direct toxicity risks were predicted for avian or mammalian predators or prey in the AOI (Intrinsik, 2007). Therefore, indirect effects on mammalian wildlife communities due to changes in mammalian or avian predator or prey abundance were not carried forward in the SALE evaluation. The evidence for effects on soil invertebrates was weak (Golder, 2007). Therefore, no adverse effects via reduction in invertebrate food supply are expected. The uncertainty related to this line of evidence was moderate.

Habitat Suitability

Habitat suitability was evaluated for white-tailed deer and river otter, representing ungulates and aquatic mammals, respectively. There is abundant “very good” or “good” suitability deer habitat in the AOI. White-tailed deer is common and abundant throughout the AOI, and is only partially excluded from urban areas, industrial sites, scree slopes, cliffs and high elevation ridges. Records for white-tailed deer are the most numerous of all the mammals in the AOI (Enns, 2007a).

River otter habitat is rare in the AOI, but only because it is limited to the Columbia and Pend D’Oreille River drainages. Backwaters at Waterloo Eddy and Birchbank and stream inlets at Blueberry Creek, Sullivan Creek, Bear Creek, Beaver Creek, etc. all provide habitats for river otter, and this species has been noted at the tailrace at Waneta and at various locations throughout the Columbia River channel. Otter kits have been seen each summer by local fishers and although the population of river otter is thought to be small, it is a viable population (Enns, 2007a).

There is no relationship between suitable deer or river otter habitat and smelter-related effects on vegetation.

Uncertainty related to indirect impacts is moderate because, although diverse habitats are known to exist in the AOI, suitability was mapped for only two species.

Field Surveys

The mammals of the AOI have been described in several documents (summarized in Enns, 2007a), based on habitat characteristics and actualrecords. Inventories were conducted annually within the AOI (Figure S-12) by wildlife biologists from 2000 to 2003, noting wildlife sign or actual sightings (Enns, 2007a). Most of these inventories were done at low elevation from south of Castlegar to Trail. They do not cover the entire AOI, only the middle portion of the low elevation valley bottom. Informal and incomplete records of wildlife sign and sightings were also taken during the soil sampling periods in 2000 to 2003 in the vicinity of the soil sample plots throughout the AOI (Enns, 2007a).

Mule Deer

Large-bodied mammals such as black bear, grizzly bear, elk, mule deer, white-tailed deer and moose are relatively commonly occurring (Enns, 2007a). Species that are considered common and increasing in B.C. such as black bear, coyote, raccoon, striped skunk, Columbian ground squirrel, yellow pine chipmunk, deer mouse, porcupine and (increasing in some areas) snowshoe hare are also frequently occurring in the AOI. These species have been able to adapt to present habitats or disperse from other habitats to the AOI (Enns, 2007a).

Pika

Small mammals such as shrews and voles are poorly known in the AOI (Enns, 2007a). This is due to the lack of small mammal surveys conducted in the AOI. Pitfall traps were used to collect insects and as a consequence, deer mice, common water shrew and common shrew are known to occur in the AOI.

The magnitude of indirect effects on the mammalian community via food chain changes or effects on habitat is low. Uncertainty is moderate.

Habitat is present in the AOI for several species for which no records are available (Enns, 2007a). These include Preble's shrew, Merriam's shrew, vagrant shrew, pygmy shrew, dusky shrew, fringed myotis, western small-footed myotis, northern long-eared myotis, western red bat, spotted bat, great basin pocket mouse. The lack of field records for bats is because few studies have been done. The presence of Townsend's big-eared bat indicates that other species of bats also may occur (Enns, 2007a).

The magnitude of response for the mammalian community as determined by field survey data is low. Uncertainty is high.

The AOI provides a range of habitat to a wide variety of mammalian species. Natural terrain features (e.g. cliffs) and land use (e.g. logging) influence the wildlife use of particular areas within the AOI. The information does not provide a species-by-species evaluation of possible relationships between smelter-related changes in habitat and habitat use; however, the plant communities of the Trail lowland area (Figure S-13) that historically had smelter-related damage are now providing habitat for a large number of species. Therefore, the magnitude of response is considered low.

Uncertainty in the field survey data is high because there is limited information, mostly qualitative, which cannot be related to gradients of PCOC in soil.

Because indirect effects via food web interactions and smelter-related changes in vegetation were classified as "adverse effects unlikely", no causal analysis (SALE Step 5) was conducted for mammalian communities.

Step 6 of the SALE Process: Risk Characterization for the Mammalian Community; Should We Proceed to Consideration of Risk Management?

The mammalian wildlife community was evaluated under three risk management objectives related to minimizing direct and indirect effects on populations of wildlife in wildland, urban and agricultural areas.

The combined results presented above support the conclusions that:

There is no support for Conceptual Models 1 or 2, which predict direct and indirect effects from the smelter.

1) Mammalian wildlife populations persist in the AOI;
2) Mammalian habitat is being utilized; and,
3) The habitat is suitable for a wide range of species.

These conclusions are supported by lines of evidence that show low-magnitude effects with associated moderate-to-high uncertainty. The evidence does not support adverse effects via direct toxicity or indirect effects via food chain interactions or physical changes in habitat.

ASSESSMENT OF RISKS TO THREATENED AND ENDANGERED WILDLIFE

Threatened and endangered species are ranked and listed according to their status in B.C., based on criteria developed by international experts. "Red-listed" species include naturally-occurring species that are or may be locally extinct, endangered or threatened in B.C. "Blue-listed" species are species of special concern (formerly termed vulnerable). Species become "Listed Species" for many reasons, including: occurrence at the limit of their range; habitat loss or fragmentation; etc.

Yellow-breasted Chat

The objective related to threatened and endangered wildlife species (referred to in this section as "Listed Species") is:

- Prevent, now and in the future, smelter operation-related direct and indirect effects on threatened and endangered (Listed) wildlife species in the Area of Interest;

The assessment endpoints are: presence of "Listed Species"; survival and reproduction of individuals of "Listed Species"; habitat suitability for "Listed Species".

Three lines of evidence were used to evaluate the assessment endpoints:

- Line of Evidence #1: prey diversity and abundance (i.e. soil invertebrate, benthic invertebrate, and forage fish diversity and abundance measures)
- Line of Evidence #2: records of Red and Blue Listed species presence in the AOI
- Line of Evidence #3: knowledge of the presence of suitable habitat in the AOI

The national and provincial lists of "Listed Species" are continuously changing as more information is collected. A cut-off date for considering these changes was needed in order to complete the ERA. Therefore, the species assessed under this objective were selected from the list available in 2005.

Step 1 of the SALE Process: Screening

Five bird and one mammal species were recommended for evaluation: bobolink, canyon wren, great blue heron, Lewis's woodpecker, white-throated swift and Townsend's big-eared bat.

Risks from direct toxicity of PCOC in soil, water and food were ruled out only for great blue heron (Intrinsik, 2007).

Steps 2-4 of the SALE Process: Magnitude and Uncertainty

Considering the level of past disturbance in the area, the number and diversity of Listed Species is surprisingly high.

No comprehensive quantitative data are available for abundance of "Listed Species", or assessment of their habitat. The SALE evaluation relied on documentation based on unpublished, collected records of local authorities (Enns, 2007b), and work done by local biologists for other projects (e.g. Machmer *et al*., 2006).

Indirect effects include direct effects of PCOC on predators, prey and other food items, and effects on the suitability of physical habitat. No unacceptable direct toxicity risks were predicted for avian or mammalian predators; therefore, these risks are not considered further.

Effects of PCOC on terrestrial invertebrates (a major food source for many species) were assessed. There is only a very weak relationship between soil invertebrate diversity and metals in soil. The magnitude of response via changes in soil invertebrate food supply was judged to be low. No unacceptable risks were predicted for great blue heron diet sources (e.g. fish, aquatic invertebrates, small mammals).

Habitat suitability was evaluated qualitatively for 21 "Listed Species". Changes in habitat (either positive or negative) resulting from past (higher) smelter emissions, as well as changes likely to result from current and future (lower) emissions are described in Table S-1. Detailed information is provided for the “Listed Species” assessed via direct toxicity modelling.

Townsend’s Big-eared Bat

This “blue-listed” species has been found in the Pend d’Oreille and Fort Sheppard areas. It is unlikely that smelter emissions have had a significant adverse effect on physical habitat of this species because this species has relatively wide habitat preferences and its use of caves, mine sites and rock outcrops is independent of smelter effects. It is possible that noise and disturbance from the smelter and the City of Trail have restricted this species from using suitable habitat near the smelter.

Bobolink

This “blue-listed” species frequents moist fields and agricultural lands such as pastures and hayfields. Only small numbers occur in the AOI, most likely in farm fields along the valley bottom. Habitat for this species is considered limited, due to the lack of extensive wet meadows and farmland. Smelter-related effects on plant communities do not coincide with the habitat requirements for bobolink.

Canyon Wren

This “blue-listed” species is restricted to dry, rocky habitats along valley bottoms in the AOI. It is known to occur among the massive cliffs directly northeast of the smelter, and is likely a year-round resident at Fort Sheppard. There is abundant, high-suitability habitat in the AOI. Historic smelter emissions may have decreased habitat suitability for this species by making cliff faces too open (i.e. emissions caused loss of vegetative cover). Smelter emissions are now low enough to allow increased vegetation cover on cliffs. However, noise and disturbance may restrict habitat use near the smelter.

White-throated Swift

This species was classified as “blue-listed” in BC, but was downgraded and no longer is considered a Species at Risk. There is only one record for white-throated swift at a site with massive cliffs near Castlegar to the north of the AOI. Although the habitat structure near the smelter may be suitable for white-throated swift, the climate may not be hot and dry enough for this species. It is unlikely that smelter emissions have had a significant adverse effect on physical habitat of this species because of its preference for cliffs.

Great Blue Heron

The interior subspecies of great blue heron is “blue-listed”. It forages in wetlands and open fields. Feeding sites are limited in the AOI. Great blue heron are known to be increasing in the AOI and its habitat is improving as large cottonwood trees are rapidly growing in several areas. There also is potential habitat along Sheppard Creek. Previous impacts on habitat (e.g. loss of riparian habitat diversity, loss of large trees on the river bank, and on gravel bars) may have resulted from both flooding (due to hydro-electric development) and from smelter emissions.

Lewis's Woodpecker

This "blue-listed" species has foraging habitat widely available in the AOI, especially in the Sheppard Flats area, on the east side of the Columbia River at Castlegar and in open areas near Trail. Nesting habitat is present at both the north and south boundaries of the AOI. The scarcity of suitable nest trees that are adjacent to good foraging habitat likely has limited the numbers of this species in the AOI. Open forest with suitable dead and decaying ponderosa pine and cottonwood trees would be most suitable nesting habitat for Lewis's woodpecker. These areas are limited within the AOI, although there are areas where habitat maintenance or enhancement could be conducted. Because Lewis' woodpecker needs large half-dead or fire-killed Ponderosa pine, previous effects of the smelter may have actually been positive for this species (as far as the creation of nesting sites).

Uncertainty

There is low uncertainty in the predicted lack of direct toxicity to predators and prey, based on the risk modeling. There is low uncertainty in the predicted lack of effects on forage fish and benthic invertebrates (diet items of several species) in the Columbia River and its tributaries, based on the results of the aquatic ERA. There is low to moderate uncertainty in soil invertebrate abundance. There is low to moderate uncertainty in habitat suitability, because the habitat requirements are well known, but little field work or suitability mapping was done. There is moderate uncertainty regarding Listed Species presence, due to the lack of systematic surveys.

Summary

The available evidence does not support indirect effects on "Listed" wildlife species via changes in dietary food supply, effects on predators or prey, or via adverse effects on habitat. The physical habitat requirements for these species are well known and do not appear to coincide with areas affected by smelter-related emissions except for great blue heron and Lewis' woodpecker. Surveys have not been conducted for these species in most of the AOI. However, "Listed Species" are known to occur in the AOI. The abundance of habitat and the utilization of habitat by these species are not well known. Overall uncertainty related to this evidence is low to moderate.

Table S-1	Changes in Habitat from Past, Current and Future Smelter Emissions	
Listed Species	***Changes from Past Emissions***	***Changes from Current and Future Emissions***
Western Skink	Negligible. Removed vegetation and exposed bedrock to weathering.	Negligible. Rock outcrop vegetation cover and abundance have increased since the 1970s.
Rubber Boa	Positive. Past emissions may have kept habitats open and shrubby, which is preferred by this species.	Positive. Forest crown closure may increase downed woody debris (used by this species) but will also cause overgrowth of some of the chaparral type habitat, preferred by this species, over time.
Racer	Positive. Emissions influenced the openness of the habitat, but other influences likely more important.	Negligible because they are found in various open habitats.
Townsend's Big-eared Bat	Negligible. Use of habitats (caves, mine sites, rock outcrops) is independent of smelter effects	Negligible. Most habitat features are independent of smelter impacts.
Grizzly Bear	Negative. May have created habitats that were too open for this species.	Negligible. Most restrictions to use of habitat are related to disturbance that is not related to emissions.
American Badger	Positive. Smelter emissions may have increased habitat by creating open areas and allowing increase of prey species.	Negative. Increased crown closure and increased conifer cover may decrease habitat availability through loss of habitat for its prey, Columbia ground squirrel. However, squirrel numbers have increased in the area.
Rocky Mountain Big-horned Sheep	Negative. Emissions may have influenced the openness of the habitat, but other influences likely more important.	Negligible. Habitat is very common but status of species in the AOI is poorly known.
Western Grebe	Negligible. Does not breed in area; uses area for feeding and resting.	Negligible. Does not breed in area; uses area for feeding and resting.
Double-crested Cormorant	Negligible. Does not breed in area; uses area for resting.	Negligible. Does not breed in area; uses area for resting.
Great Blue Heron	Negative. Large cottonwood trees that could be used for rookeries may have been impacted.	Negligible. Emissions are not likely to restrict the use of habitats in the area. Also, numbers of cottonwood trees and their sizes are increasing.
Surf Scoter	Negligible. Infrequent user of river waters.	Negligible. Infrequent user of river waters.
Broad-winged Hawk	Negative. Past emissions and fire may have prevented the development of more mature structural stages used for breeding.	Negligible. Hardwood and mixed wood forests unlikely to be impacted by current or future emissions.
California Gull	Negligible. Does not breed in area; uses area for resting while on migration route.	Negligible. Does not breed in area; uses area for resting while on migration route.
Caspian Tern	Negligible. Does not breed in area; uses area for resting while on migration route.	Negligible. Does not breed in area; uses area for resting while on migration route.
Western Screech Owl	Negative. Past emissions may have impacted the maturation of riparian trees needed by large-cavity nesters.	Negligible because emissions will not continue to impact maturation of riparian trees preferred by this species.
Lewis' Woodpecker	Negative. Past emissions may have impacted the availability of trees needed by large-cavity nesters.	Negligible. Other impacts such as fire suppression may be more important.
Barn Swallow	Negligible. Use of habitat is independent of smelter impacts.	Negligible. Use of habitat is independent of smelter impacts.
Canyon Wren	Negative. Cliff faces may have been kept too open for this species.	Positive. Emissions are low enough to allow increased cover on cliffs.
Yellow-breasted Chat	Positive. Habitat (shrubby, open areas) was created by fire, emissions, etc.	Negative. Habitat may decrease, due to succession, with decreased emissions.
Lark Sparrow	Positive. Emissions may have resulted in increased habitat (open areas, grasslands).	Negligible. Habitat may become more vegetated, but habitat availability is generally independent of smelter emissions.
Bobolink	Negative. Emissions may have increased drying trends in grasslands.	Negligible. Agricultural land management is the major influence on habitat.

Step 6 of the SALE Process: Risk Characterization for Listed Species; Should We Proceed to Consideration of Risk Management?

Canyon Wren

Risks to each "Listed Species" were evaluated with respect to several lines of evidence. The available evidence indicates that the risk management objective for most of the "Listed" wildlife species is being met, with the possible exception of Lewis' woodpecker. The evidence for this includes:

- Canyon wren and white-throated swift have abundant suitable habitat near the smelter, and their foraging habits (on rocky talus at the base of cliffs for wren and aerially on small insects near vertical cliffs for swift) minimize the potential for exposure to PCOC in soil or soil-based food chains;
- Most of the Townsend's big-eared bat habitat is located farther away from the smelter (e.g. in the Pend d'Oreille) and is not influenced by smelter emissions;
- The number of great blue heron is increasing in the AOI as habitat improves;
- Impacts on bobolink habitat suitability are not related to smelter emissions, but more due to agricultural land management, urban development, etc. (Enns, 2007b);
- Lewis' woodpecker may be limited in the AOI due to the lack of old growth forest availability in the AOI.

There are significant uncertainties. There are no quantitative or published data confirming habitat utilization and abundance of these species.

The highest priority for consideration of risk management is for Lewis's woodpecker nesting habitat.

The highest priority for consideration of risk management is for Lewis's woodpecker, related to availability of suitable nesting habitat. There are areas within the AOI where habitat maintenance or enhancement could be conducted for this species (Machmer *et al*., 2006).

Best management practices for maintaining or enhancing habitat suitability in the Pend d'Oreille for some of the "Listed Species" are described in Machmer *et al*. (2006). In addition, prior to any risk management activity, a field survey for presence of individuals of "Listed Species", as well as an evaluation of habitat suitability for "Listed Species", should be conducted at an appropriate scale within the area subject to remediation.

ASSESSMENT OF RISKS TO LIVESTOCK

Three types of animals were selected as representatives of domestic livestock: chickens, cattle and horses. The objective related to livestock was:

Prevent, now and in the future, smelter operation-related direct and indirect effects on agricultural animals in the Area of Interest.

The assessment endpoints defined to evaluate this objective are:

- Survival, growth, development, and reproduction of individuals of livestock species

Step 1 of the SALE Process: Screening

Risks to chickens and cattle were ruled out in the risk modelling report (Intrinsik, 2007). However, because risk modelling did not specifically address overall “health” or milk production of dairy cows, a local dairy farmer was interviewed (Golder, 2007). The dairy farm was selected because there is no other cattle grazing in the Columbia River valley proper. Risks to horses could not be ruled out via risk modelling.

Metal concentrations in soil were compared to BC CSR Soil Standards for the protection of livestock ingestion of soil and fodder, and groundwater used for livestock watering. The portions of the AOI where CSR standards are exceeded are shown in Figure S-14.

An evaluation of groundwater quality was completed to determine whether groundwater had been impacted by soil (i.e. to determine whether groundwater would be considered safe for livestock watering and crop irrigation). The evaluation found:

- No measured concentrations of cadmium, chromium, cobalt, copper, selenium or zinc exceeded the livestock watering or crop irrigation standards;
- Detection limits for arsenic, cadmium, mercury and selenium were too high for several samples (between 5 and 30% of samples) to determine whether standards were exceeded;
- One lead measurement within the AOI exceeded the standards in 1997 but not in subsequent years.

The map in Figure S-14, illustrating the area where CSR soil standards for the protection of livestock are exceeded, likely over-estimates the risk to livestock. This is because the CSR standards were developed using several layers of safety and do not account for factors that reduce uptake of PCOC into crops and livestock. In addition, actual groundwater data do not indicate that metals are exceeding standards in water.

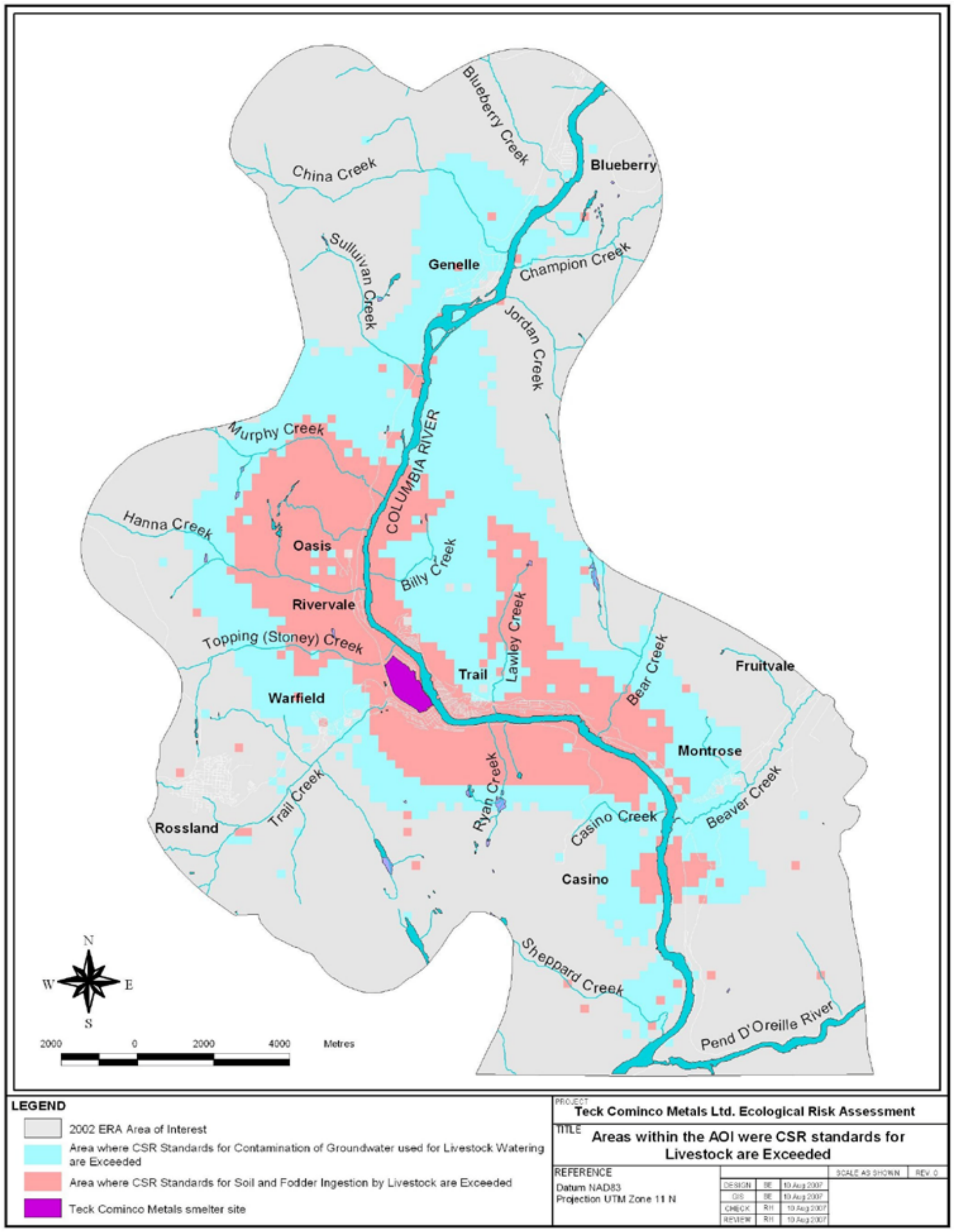


Figure S-14 Areas where the CSR Soil Standards for Livestock are Exceeded.

Steps 3 and 4 of the SALE Process: Evaluation of Magnitude of Response and Uncertainty for Cattle

A local dairy farmer, who has been farming for 21 years in the Columbia River valley, was interviewed. Mr. Bouma's farm is the only dairy farm known to be present in the AOI. It is located in the Columbia Gardens area, which is an area with elevated metal concentrations in soil. Mr. Bouma was asked several questions related to: health of the cows; forage and feed for his cows; milk production; and, concerns about smelter emissions related to his cows.

Cattle grazing

Mr. Bouma irrigates his forage crops (hay and corn) with groundwater, and amends his fields. He reported that the forage crops grow very well. He did not report any incidences of health issues with his livestock (150 head of dairy cattle, two beef cattle and other livestock) during the time he has been in operation. He did report an increase in milk production over the years, and attributed this to improvements in feed and breeding practices.

The magnitude of response can be assessed only qualitatively. No impacts, attributable to the smelter, were identified by the farmer. There are several uncertainties associated with this survey, including the fact that conditions at only one farm were surveyed. Responses could have been different at other locations (where metal concentrations in soil or groundwater could be different), and if different farming practices were used (e.g. fewer soil amendments).

Because all responses were classified as “adverse effects unlikely” with moderate uncertainty, no causal analysis (SALE Step 5) was conducted.

Step 6 of the SALE Process: Risk Characterization for Livestock; Should We Proceed to Consideration of Risk Management?

Horses grazing

Impacts on survival, growth, development and reproduction of individual cattle due to smelter emissions are not predicted, based on the direct toxicity modelling for cattle, and the results of the survey with the dairy farmer.

The results of the groundwater quality assessment combined with the risk modelling suggest that groundwater quality within the AOI will not adversely impact livestock due to crop irrigation or livestock watering.

Impacts on survival, growth, development and reproduction of individual horses, due to smelter emissions, could not be ruled out using risk modelling. Comparisons of recent soil and forage data to older data (when impacts on foals were observed) suggest risks are up to 16-fold lower now than in the early 1970s. Smelter emissions also are much lower now than in the early 1970s. No additional data or information is available regarding horses and thus no additional SALE analysis could be conducted.

The advisory and restriction against raising foals should be maintained.

The risk management objective is being met for chickens and cattle in the AOI. The risk management objective for horses may not be met under very specific scenarios; however, the uncertainty regarding this statement is high. Raising foals is prevented on Teck-sold lands through a restrictive covenant on title. In addition, there is an advisory against raising foals in the area; notification was given to veterinarians in the area. It is recommended that the restrictive covenant on title for lands currently holding such a covenant be maintained, as well as any future Teck lands that are sold. Local veterinarians will be reminded about the restrictive covenant. However, it is also recommended that any future opportunities to study exposures to horses, particularly young horses, be acted upon by Teck Metals Ltd.

CONCLUSIONS

The SALE analysis indicated that risk management objectives were being met for urban plants, agricultural crops, avian and mammalian wildlife, most Listed Species, and most livestock. Therefore, an evaluation of risk management options is not required for these plants and animals.

Risk management objectives may not be met for up to 7900 ha of the AOI for wildland plant communities. However, the plant communities within the AOI have continued to develop since the time period used to develop the biophysical habitat map (aerial photograph taken in 1999) and the field data were collected for statistical analysis of plant community characteristics (2001). Therefore, consideration of risk management options should be based on an updated assessment of plant community structure.

Risk management should be considered for the Lewis' woodpecker (a Listed species) related to availability of suitable nesting habitat. Prior to any risk management activity, a field survey for presence of individuals of Listed Species, as well as an evaluation of habitat suitability for Listed Species, should be conducted at an appropriate scale within the area subject to remediation. In addition, it is recommended that the restrictive covenant on title for lands currently holding such a covenant be maintained, as well as for any future Teck lands that are sold, due to the potential risks to young horses.

Lookout Mountain south of the Teck Smelter

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