Tier 1 Ecological Risk Assessment Policy Decision Summary

Ministry of Environment, Lands and Parks
Environment and Resource Management Department
Pollution Prevention and Remediation Branch
Risk Assessment and Integrated Pesticide Management
Victoria, British Columbia

T1 EcoRA Policy Decision Summary

Executive Summary

This report summarizes the key science policy issues raised by the Ecological Risk Assessment Guidance Team1 and BC Environment and the decisions reached in development of the "Checklist for Tier 1 Ecological Risk Assessment of Contaminated Sites in British Columbia." It documents the items and decision points requiring input and guidance from BC Environment that were considered critical to the ecological risk assessment (EcoRA) work undertaken at sites in this province.

Where possible, policy issues and decisions reflect the philosophy and policy decisions of the Contaminated Sites Soil Task Group (CSST) in the development of the soil standards for the Contaminated Site Regulation.

[1] The Ecological Risk Assessment Guidance Team consists of the following**:**

Institute of Environmental Toxicology and Chemistry
Huxley College of Environmental Studies
Western Washington University
Bellingham, WA 98225-9180

ecological **p**lanning & **t**oxicology, inc.
5010 S. W. Hout Street
Corvallis, OR 97333-9540

EVS Environmental Consultants
195 Pemberton Avenue
North Vancouver, B.C. V7P 2R4

Summary of Issues and BC Environment Decisions

Issue 1: Organization Based on Land Use

The checklist for conducting ecological risk assessments at contaminated sites is organized by the proposed use of the site (industrial, commercial, residential, urban park, and agricultural sites). It is not intended for use with wide area, complex risk assessments. *Should the document organization be based on land use?*

BCE Decision:

When developing the matrix standards for soil contamination, BCE recognized that not all sites need the same level of protection of ecological resources. Therefore, the ecological risk assessment process must also consider these different protection levels when selecting receptors of concern, determining toxicity reference values, and developing site conceptual models and sample collection programs for site characterization. It was simplest to develop separate checklists for each type of land use, rather than have the user figure out how to skip around through a single document.

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Issue 2: Rules for Selecting Species of Potential Concern

The rules for selecting species of concern for the site assessment leave out have the fewest species of concern and urban parks and agricultural lands have the most species of concern. *How were the rules for selecting species of potential concern developed?*

BCE Decision:

The rules were developed in accordance with BCE's policy to provide greater protection of ecological resources on urban parks and agricultural lands than on industrial and commercial sites, with residential areas somewhere in between the two extremes. Thus, the rules were developed to:

1) Ignore migratory species that may spend only a small portion of their time on an industrial, commercial, or residential site. Urban Parks and Agricultural lands may be expected to provide necessary habitat for migrants (feeding, resting).

2) Small streams are not considered critical habitat for waterfowl (ducks, geese, swans) as they cannot support a large enough number of individuals to affect the productivity of the overall population.

3) Only threatened or endangered raptors are considered for industrial, commercial, or residential sites. Raptors require a large foraging area and it is anticipated that most of these sites will be small, capable of providing only a fraction of the total dietary intake for these species. Furthermore, it is not BCE's intent that these types of sites should support a diverse enough plant and animal community to be attractive to raptors.

4) Galliforms (e.g., pheasant and quail), cavity-dwellers (e.g., flickers and woodpeckers), and hummingbirds are not considered for industrial and commercial sites. Residential sites consider cavity-dwellers while urban parks and agricultural lands consider nearly all birds. Most industrial and commercial sites are in urban areas where galliforms are not expected to occur, nor does

BCE intend that they should have habitat suitable to support these birds. Cavity-dwellers generally eat foliar invertebrates which require maintenance of diverse plant communities. Again, it is not BCE's intent that industrial or commercial areas provide this type of habitat. Hummingbirds are nectar feeders and there is no information about the potential for accumulation of contaminants in nectar. It is known that metals do not accumulate in pollen (cf. Stanley and Linskens 1974) so it may be reasonable to suspect that nectar acts in a similar manner. Furthermore, it is assumed that hummingbirds will be sufficiently protected based on the levels of protection developed for insectivorous and herbivorous birds.

Stanley, R.G. and H.F. Linskens. 1974. *Pollen biology, biochemistry, and management*. Springer Verlag, Berlin

5) The absence of other species in certain areas (e.g., shorebirds) is dictated by the type of habitat available (e.g., shallow water marshes).

6) The aquatic species were chosen based upon the potential for the land use to be a breeding habitat. In the case of an industrial site, it will be unlikely that fish will breed in the area. In the agricultural site a larger number of species will use the land and adjacent water body as breeding or other habitat. The urban park scenario was also expanded to address the possibility that some common non-native species could be used.

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Issue 3: Using ECx Approach to Set Toxicity Reference Values

The checklist uses as a primary means of setting toxicity reference values a specified ECx, with other methods a backup. *Should the checklist use an ECx approach to setting toxicity reference values?*

BCE Decision:

Compared to the use of NOELs, NOECs and LOELs or LOECs or other statistically derived values, the ECx method is determined from the dose response curve. The ECx method is not tied to mortality, but a variety of other endpoints can be incorporated. The technique also has the flexibility so that different ECx values can be specified for different land uses and more or less protection is desired. The other types of endpoints are derived using the results from an ANOVA followed by a multiple comparison test. The ultimate answer is as dependent upon the power of the ANOVA and the concentrations tests as it is the actual does-response curve. Often a somewhat arbitrary safety factor has to be applied. None of these drawbacks are present using the ECx technique.

An ECx approach has already been adopted for the derivation of matrix standards of the Contaminated Site Regulation.

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Issue 4: Use of Different ECx Values Based on Land Use

The checklist for conducting ecological risk assessments at contaminated sites uses a variety of ECx values for the different land uses and aquatic environments. *Should a variety of ECx values be used and what are the specifications?*

BCE Decision:

When developing the approach for risk assessment is was decided that different land uses should provide varying degrees of protection to ecological receptors. One way of accomplishing this goal is to alter the ECx values to achieve the desired degree of protection. The ECx values chosen are listed below:

Land or Water Type	ECx Value
Agricultural	10
Urban Park	10
Residential	20
Commercial	50
Industrial	50
Aquatic Life	20

The ECx values that selected for Agricultural and Urban Park sites reflects the desire to be very protective of the organisms that reside in these areas. Residential areas are considered intermediate from an ecological viewpoint because of the highly disturbed nature of these areas due to landscaping and other human activity. The least protected sites are the commercial and industrial sites. These sites typically consist of parking areas, vendors, manufacturing sites and other large areas of habitat loss. Since these sites are not expected to be breeding ground or other critical habitat or include valued species, these sites are not as protected.

The aquatic ECx is set at 20. This reflects a low end of the aquatic ECx value and is set this low to protect commercially important species such as Salmonids. Since migrating fish can occupy a variety of aquatic habitats bordering a variety of land uses, a constant ECx is the only means of being equally protective.

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Issue 5: Use of ECx Rather Than LC Values

The checklist for conducting ecological risk assessments at contaminated sites uses ECx values as opposed to LC values. *Should an ECx or LC approach be taken?*

BCE Decision:

Lethality as measured using an LC50, is a one dimensional endpoint. Reproduction, growth, sex determination and other factors important in protecting a viable population are not protected by an LC50 approach. An ECx can incorporate a variety of toxicity tests or bioassays as well as a variety of non-lethal endpoints, and was thus favoured.

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Issue 6: Omission of Plant Evaluation in Winter

When conducting site evaluations in the winter time, it is recommended that plant evaluations be skipped. This may overlook some important ecological responses. *Why is the plant evaluation section skipped if it is winter?*

BCE Decision:

During the British Columbia winters, most plants are senescent. A few species (most notably, coniferous trees) remain green and retain their needles, but most other plants loose their leaves and are bare; grasses frequently turn brown and stop growing. In this condition, it may be difficult to tell whether the plant is alive and nearly impossible to discern contaminant-related changes. Therefore, no relevant information will be gained from a plant evaluation. In fact, misleading information may be obtained if it is recorded that grasses are brown, bushes have lost their leaves, etc. If a reviewer of the risk assessment failed to notice that these observations were made during the winter senescent period, they may be incorrectly interpreted as being contaminant induced changes. Therefore, it is best to skip this section entirely during the winter. However, BCE strongly recommends that ecological risk assessments be conducted in spring or summer, when the plants and animals of concern are likely to be present and active at the site.

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Issue 7: Selection of Species for Bioassays

The bioassay section of the document recommends several species as test organisms. Many of these species are domesticated plants or animals. Given all the potential species of native and introduced plants and animals in British Columbia, there is a wide selection for potential bioassays. *How were the species recommended for bioassays selected?*

BCE Decision:

The bioassays chosen are available as BCE or Canadian Council of Ministers of the Environment (CCME) methods, or if not available from these sources, Standard Methods, American Society for Testing and Materials (ASTM) or US Environmental Protection Agency (USEPA) bioassay techniques were used. The variety of species chosen is because of the variety of organisms to be protected, especially within the urban park, agricultural and aquatic environments. The species chosen are representative of the types that inhabit the Province. The plants and animals recommended for use in the bioassays are those standard species recommended in the published protocols. These species were not chosen to be the most sensitive species for all chemicals, nor are they the least sensitive. Rather, they are assumed to be representative of a broad group of similar organisms (e.g., rye grass represents all species of grasses). The risk assessor has the option of using species that are known to be onsite or that they propose to grow onsite under the new use scenario. This may be particularly applicable to Residential and Urban Park areas where particular ornamental plants may be desirable or to Agricultural areas where native species are of concern. The risk assessor is encouraged to discuss with BCE the use of optional species for bioassays.

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Issue 8: Use of Uncertainty Factors in Deriving Toxicity Reference Values

The guidance for derivation of Toxicity Reference Values (TRV) for wildlife and plants suggests that reported literature values be divided by appropriate uncertainty factors when extrapolating to other species. *How were the TRV Uncertainty Factors derived and why is this approach preferred to the allometric scaling approach used by others?*

BCE Decision:

The rationale for derivation of the Uncertainty Factors and the arguments against using allometric scaling are in:

Fairbrother, A. and L.A. Kapustka. 1996. *Toxicity extrapolations in terrestrial systems*. (PDF/10 MB) Prepared for California EPA, Sacramento, CA.

Briefly, the Uncertainty Factor approach is preferred because the allometric scaling method introduces too much uncertainty into the data extrapolations and has no mechanism for taking into account differences in physiology that alter either uptake of chemical from the gastrointestinal tract or physiological responsiveness. The allometric scaling approach is very sensitive to which species was tested and to which species the extrapolations are being done. For example, sheep are known to be particularly sensitive to copper, due to the presence of sulfur-reducing bacteria in the upper small intestine which bind the copper and make it available for absorption. Therefore, if data from sheep toxicity studies were being extrapolated to an unknown species, it is likely that the toxicity to the unknown species would be over-estimated. On the other hand, if copper toxicity data from a pig, cow, or deer study were being extrapolated to a sheep, the results would not be protective enough.

The lack of information on body size and dietary intake rates makes it difficult to accurately convert food concentration to dose, make the allometric extrapolation, and then convert back to food concentration. This frequently adds more than an order of magnitude of uncertainty to the extrapolation. It is suggested, therefore, that extrapolations be done by first grouping animals according to gut physiology (e.g., ruminants, hind-gut fermentors, simple monogastrics, etc.), then by feeding guild (meat eaters, insectivores, fish eaters, etc.), and then by what is known about physiological responsiveness to various classes of chemicals (e.g., presence/absence of Ah-receptors or metallothioneins). Depending upon the level of knowledge, extrapolations from known to unknown species can be made with greater or lesser certainty. The Uncertainty Factors suggested for wildlife were derived from a study of available information conducted by Abt, Assoc. for the US EPA's Office of Water, and cited and discussed in the above document by Fairbrother and Kapustka. This study suggests that most wildlife species are within an order of magnitude of each other in regards to toxicity responses, with the possible exception of dioxins and dibenzofurans. Thus, the extrapolation from one species to another should be divided by an Uncertainty Factor of 10, if it is not known whether or not they are likely to have similar physiological responses. Plant Uncertainty Factors were derived by the authors of the above report from a review of the plant toxicity literature similar to what had been done previously for aquatic organisms. The derived Uncertainty Factors capture the variability among plant responses to toxic substances, even given the wide range of experimental conditions used to generate the toxicity data.

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Issue 9: Minimum Sample Size for Site Characterization

The checklist recommends a minimum of 10 samples be collected at each site for each medium of concern (soil, water, plants, etc.). Since sites vary in size and complexity, shouldn't the number of required samples also vary? *Why should a minimum of 10 samples per site be collected for site characterization?*

BCE Decision:

BCE recognizes the large variability among potentially contaminated sites in regards to size, heterogeneity of the environment, and spatial pattern of pollution and receptors of interest. Given this complexity, it is impossible to recommend a single sampling design that would be appropriate for all sites. Detailed sampling plans or strategies were thus considered beyond the scope of the document. Further, it is assumed that the risk assessment process is selected following the Detailed Site Investigation (DSI) stage of site assessment. As such, a significant amount of data typically already exists for media such as soils and groundwater at the site. Therefore, the risk assessor is given only general guidance and is provided a reference text to aid in the design of a sampling scheme applicable for a site. However, it is BCE's experience that a minimum of 10 samples per site is required to have reasonable statistical power for risk analysis. *BCE encourages risk assessors to discuss proposed sampling and analysis plans with the agency prior to beginning sample collection.*

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Issue 10: Minimum Analytical Detection Limit for Environmental Samples

A minimum detection limit of 0.1 times the toxicity reference value is suggested for all analyses of environmental samples, unless the best available technology is unable to provide a detection limit that low. *Why should the minimum detection limit be 0.1 X TRV?*

BCE Decision:

During the risk calculation, the environmental concentration is compared to the toxicity threshold (the "toxicity reference value" or TRV) of the species of concern. The most critical area for comparison is at or near the TRV value - is the concentration in the exposure medium greater or less than this value? Therefore, it is imperative that the analytical chemistry technique that is used be able to accurately determine concentrations in environmental media at this value. If the minimum detection limit is no lower than the TRV, then the assessment of minimal risk (i.e., environmental concentration less than the TRV) could never be made. If the minimum detection limit is only slightly lower than the TRV, then there will be unacceptable imprecision in the estimate of the environmental concentration. The precision of any analytical method decreases significantly when measuring values close to the detection limit. Therefore, using a minimum detection limit at least one-tenth of the lowest toxicity reference value for all species exposed to the medium being analyzed is desirable. This should be taken into account in the development of and recommendation of analytical protocols.

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Issue 11: Depth of Sampling of Soil for Plant Exposure Analysis

The checklist recommends that composite soil samples from 0 to 15 cm depth be collected for plant exposure analysis. Deeper samples may be taken but are optional. *Why are composite soil samples taken to 15 cm depth for plant exposure analysis?*

BCE Decision:

The top 15 cm of soil generally are considered the plant root zone and also comprise the area inhabited by most soil-dwelling invertebrates. Some plants may have deeper "tap" roots that extend beyond this depth. If these types of plants are of concern on the site, then soil samples procedures adopted for the site should be reflective of these. Otherwise, BCE concurs with the accepted definition of the plant root zone in the top 0-15 cm of soil.

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Issue 12: Assumption That Animals Consume 2% of Soil in their Diet

The checklist suggests that all risk assessments assume that terrestrial animals consume 2% soil in their diets and that aquatic birds and mammals consume 2% sediment. *Why is it assumed that animals consumed 2% soil in their diet?*

BCE Decision:

Animals consume soil as part of their diet in several ways: by grooming dirt off of their fur, through accidental ingestion during grazing; by eating soil that is in the intestines of prey animals (such as earthworms), or actively seeking to increase the amount of trace elements in their diet. For some compounds, the amount of contaminant in the soil or sediment can exceed the amount in food items by one or two orders of magnitude and, therefore, may be a significant source of exposure. The actual amount of soil ingested, however, is not known for most animal species. Beyer *et. al.* (1994) conducted a study with a few selected species from different groups of animals (mice, raccoons, ungulates) and demonstrated that these animals consume about 2% soil in their diet. BCE suggests using this value as an estimate for all species, recognizing that some (e.g., pronghorn antelope) consume more soil (e.g., up to 13%) while others likely consume none. Furthermore, BCE assumes that all materials in soil are 100% bioavailable, recognizing that this likely is an overestimate of bioavailability for inorganically-bound substances. Thus, taken together, these two assumptions result in a conservative estimate of potential exposure of wildlife species.

Beyer, W. N., E. E, Connor, and S. Gerould. 1994. Estimates of soil ingestion by wildlife. *Journal of Wildlife Management* 58:375-382.

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Issue 13: Use of Human Drinking Water Standards for Wildlife

The checklist suggests that drinking water be considered as a source of contaminant exposure for wildlife only if irrigation water is not used for human drinking water or if there is a contaminated body of water on or adjacent to the site. Furthermore, drinking water exposure is assumed only if the concentration of the contaminant in the water is greater than 1% of the concentration of the contaminant in the food. *Why is human drinking water considered safe for wildlife and why is a default of water concentration equal to or greater than 1% of food concentrations assumed in order for water ingestion to be considered?*

BCE Decision:

Human drinking water is considered safe for wildlife to drink because the level of protection accorded to humans is more stringent than that being applied to wildlife. Criteria protective of humans are set such that the contaminant will not cause any form of toxicant-induced illness, reproductive disorder, or cancer. For wildlife, cancer endpoints generally are not considered, although other toxic responses and reproductive effects are of concern. Furthermore, human standards include several Uncertainty Factors, including an interspecies extrapolation Uncertainty Factor of 10, and are set to be at least an order of magnitude below the NOEL. For wildlife receptors, the most stringent requirement (for Urban Parks and Agricultural Sites) is an

EC10. Furthermore, animal exposure rates to drinking water are of the same relative order of magnitude as humans. Therefore, it is assumed that human drinking water standards will provide the level of protection for wildlife that BCE wishes to achieve. Note, however, that this does not imply that wildlife have negligible risk from ingesting fish or aquatic invertebrates from water that is safe to drink; bioaccumulative compounds may contaminate the food chain without reaching harmful concentrations in the water itself.

The cut-off for requiring that the water concentration be at least 1% of the food concentration before it need be considered in total dietary exposure relates to the general rule that animals drink less than they eat. By the time the concentration in the water reaches 1% of the concentration in the food, the contribution of the water exposure to the total exposure becomes negligible and can be ignored.

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Issue 14: Logic for Calculation of Total Ingestion Rates for Water and Food

The Risk Calculation section of the checklist describes a method for calculating total exposure of wildlife, including both food and drinking water routes of ingestion. The mathematical logic of how the equations were generated is not given. *How was the method for adding food and water concentrations together to calculate total ingestion rates developed?*

BCE Decision:

Most animals consume less water than food (on a volume basis), with the notable exception of waterfowl which drink and eat nearly equal quantities (c.f., EPA 1993). Therefore, assuming equal consumption would be a conservative estimate of risk. This also is the easiest calculation, particularly for species where actual consumption is unknown. The first approach, therefore, is to add the water concentration to the food concentration to generate a total dietary concentration. This is derived from:

(a) (mg/kg-f X kg-f/kg-bw) + (mg/kg-w X kg-w/kg-bw) = mg/kg-bw

where:

mg = milligrams
kg = kilograms
f = food
w = water
bw = body weight

When kg-f/kg-bw = kg-w/kg-bw, then equation (a) can be rearranged to:

(b) (mg/kg-f + mg/kg-w) X kg-f (or w)/kg-bw = mg/kg-bw.

Equation (b) demonstrates that total dose is the equivalent of adding the concentration in food and water, then multiplying by the consumption rate. Since the final desired value is the concentration (not dose), the calculation of dose and then back-calculation to concentration can be ignored, since the same number would be returned.

When food and water consumption is not equivalent, water consumption can be expressed as a fraction of food consumption (note that water consumption is always equal to or less than food consumption rates). Substituting the food to water ratio (f:w) into equation (a):

(c) (mg/kg-f X kg-f/kg-bw) + (mg/kg-w X (f:w)kg-f/kg-bw) = mg/kg-bw

and rearranging as before:

(d) (mg/kg-f + (f:w)mg/kg-w) X kg-f (or w)/kg-bw = mg/kg-bw

demonstrates that calculation of total dietary concentration is simply the concentration in food plus the concentration in water multiplied by the food:water consumption ratio.

References

EPA. 1993. *Wildlife exposure factors handbook*. Office of Health and Environmental Assessment, US Environmental Protection Agency, Washington D.C EPA/600/R-93/187.

Note: The equations used to calculate food or water consumption come from:

Food:

Nagy, K. A. 1987. Field metabolic rate and food requirement scaling in mammals and birds. *Ecological Monographs* 57:111-128.

Water:

Calder, W. A., and Braun, E .J. 1983. Scaling of osmotic regulation in mammals and birds. *American*. *Journal of Physiology* 224:R601-R606.

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Issue 15: Use of 99% Upper Confidence Limit in Deriving Risk Quotients

The 95% upper confidence limit (UCL) of the mean environmental concentration should be used to estimate environmental exposure when using the single Risk Quotient method, unless the UCL is greater than the maximum measured value in which case the maximum measured value should be used. *Why use 95% UCL to calculate RQs if using single RQ method?*

BCE Decision:

BCE believes that the single Risk Quotient method is an imprecise estimate of risk as it ignores spatial extent of contamination. Therefore, when using this approach for risk estimation, BCE wishes to use a conservative estimate of environmental contamination. The 95% UCL would encompass 95% of all possible measured values, assuming that the contaminant occurs at the site in either a normal or lognormal distribution of concentrations. However, if sample sizes are small or if spatial heterogeneity is extreme, BCE recognizes that the UCL estimation will return a value that is extremely high (assumes a long tail to the distribution) and may never actually occur. In order to avoid these unreasonably high estimates, BCE will accept the use of the highest measured concentration if it is lower than the estimated 95% UCL.

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Issue 16: Prohibition Against Adding Risk Quotients

The checklist states that RQs should never be added, whether they were derived for the same contaminant (but different receptors) or the same receptors (but different contaminant). However, other regulatory agencies do add RQs to generate a single Hazard Index for the site. *Why should RQs never be added?*

BCE Decision:

RQs are dimensionless numbers that compare estimated exposure estimates to the critical toxicity threshold values. Consistent with BCE policy for human health risk assessment, RQs should not be added across species for substances due to number of assumptions incorporated in both the exposure and toxicity assessment values. For single species exposed to multiple substances at a site, RQs should only be considered additive under the following circumstances:

1) For chemicals that have similar modes of action, an estimate of total exposure can be derived by using Toxic Equivalency Factors (TEFs). This is most commonly used for dioxins and PCBs, where the various isomers are known to have relative toxicity relationships to each other. The TEFs are applied to each of the exposure concentrations which are then added to give the total estimated exposure. This value can be compared to the toxicity threshold value for the class of compounds. For example, an organism is exposed to three PCB isomers which have the following TEFs:

Isomer #1 = 1

Isomer #2 = 0.5 (i.e., is half as toxic as Isomer #1)

Isomer #3 = 0.3 (i.e., is as third as toxic as Isomer #1)

[Conc.#1] + 0.5[Conc.#2] + 0.3[Conc. #3] = Estimated Exposure Concentration (EEC)

EEC/TRV = RQ.

2) The concentrations of the various different chemicals in the exposure media can be compared to the toxicity reference value derived from exposure to a similar mixture. BCE recognizes that this information is not currently available in the scientific literature and would need to be generated using site-specific bioassay data.

Qualitative estimates of the overall and relative risk (low, moderate, high) for a site and its receptors may be provided based on the results of the risk assessment and professional opinion.

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Issue 17: Omission of Inhalation and Dermal Exposure Routes for Terrestrial Wildlife

The inhalation and dermal routes of exposure are not considered when estimating total wildlife exposure (only dietary sources of food, water and soil are considered). *Why are the inhalation and dermal exposure routes not considered for terrestrial wildlife?*

BCE Decision:

Dermal exposure is not considered because nearly all wildlife species have pelage characteristics that greatly reduce the actual dermal contact of an environmental contaminant(soil) with skin. For example, fur and feathers are effective at blocking most materials from direct contact with the skin unless the animal becomes soaked in water or other carrier. This is a special case and is beyond the scope of a T1 EcoRA.

Inhalation may be a potential route of exposure, particularly for animals that live close to or in the soil and that are exposed to highly volatile chemicals (VOCs). However, there are three considerations that reduce the importance of this route of exposure in the assessment of risk. First, a highly volatile chemical will generally cause an initial acute exposure, however these concentrations diminish over time, thus reducing chronic exposure and risk. Second, there are few inhalation studies for wildlife species. Although several epizootiological studies suggest there may be effects from air pollutants on birds and other wildlife, these studies have not been designed to distinguish between the inhalation and the dietary components due to deposition. Consequently, there are no toxicity threshold data against which the exposure information could be compared. Most importantly, the contribution to exposure from the ingestion pathway is considered to much greater than via the inhalation pathway, so the proportional amount of exposure not addressed in the estimate of exposure is considered to be small.

For further information on this topic see: Newman, J.R., R.K. Schreiber and E. Novakova. 1996. Air pollution effects on terrestrial and aquatic animals. In: Air pollution effects on terrestrial and aquatic animals. In : Air pollution effects on biodiversity. Barker, J.R. And D.T. Tingey (eds). Van Nostrand Reinhold. NY. pp.177-233.