# Sä Dena Hes Mine

## *Volume 2: Draft Ecological Risk Assessment for the Terrestrial Environment*

Prepared for:

**Teck Resources Limited**
Bag 2000
Kimberley BC
V1A 3E1

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**Azimuth Consulting Group Partnership**

218-2902 West Broadway
Vancouver, BC
V6K 2G8

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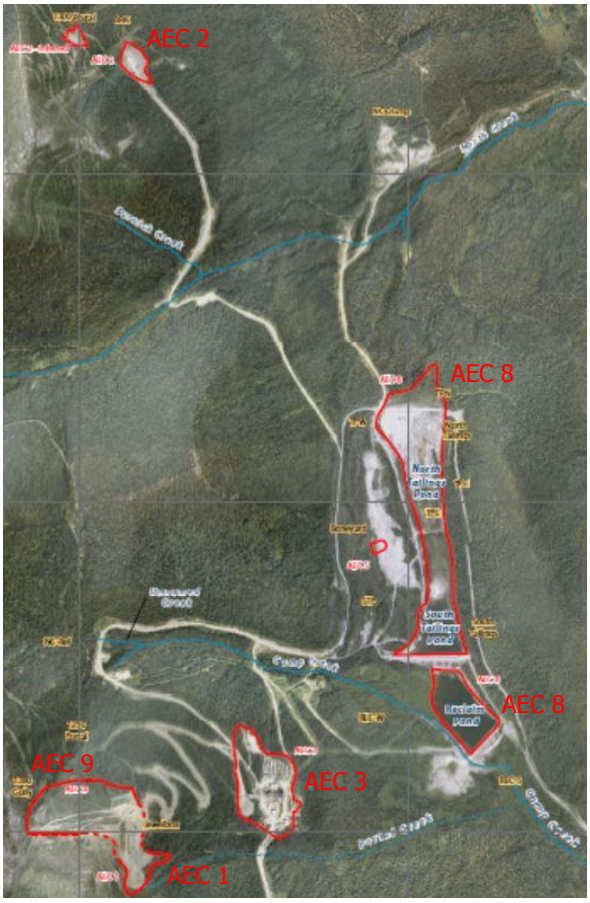
# EXECUTIVE SUMMARY

## Site Background

This document describes results of a Terrestrial Ecological Risk Assessment (TERA) conducted on behalf of Teck Resources Limited (Teck) at the Sä Dena Hes Mine (the Site) near Watson Lake, Yukon Territory (YK). The Site was a zinc-lead mine that operated for 16 months between August 1991 and December 1992. In 1993, the Site was put into a state of care and maintenance, and since 2000, the Site has been in temporary closure. Teck plans to permanently close the Site by the end of 2015 to meet requirements under the Site's Water Licence and Quartz Mining Licence (QML). To support closure, Teck has submitted a Detailed Decommissioning and Reclamation Plan (DDRP) to the Yukon Government and has begun activities related to permanently closing the Mine Site.


The Site has been subject of several environmental investigations since the 1990s. Recent site assessment and related work conducted by Golder Associates Ltd. (Golder), Access Consulting Group (Access) and SRK Inc. (SRK) underpins the ERA study. Golder's site assessment identified several areas of environmental concern (AECs) on the Site, including:

- AEC 1: Jewelbox Hill
- AEC 2: Burnick Zone and 1300 Portal
- AEC 3: Mill Site
- AEC 8: Tailings Management Facility
- AEC 9: Main Zone Pit, 1380 Gully and 1250 Portal

These AECs were evaluated as separate management units in the ERA, with the exception of AECs 1 and 9, which were combined because they are spatially connected. Several metals were identified as contaminants of potential concern (COPCs) in soil and wildlife drinking water at the Site, including antimony,

arsenic, cadmium, copper, lead, molybdenum, selenium, silver, vanadium, and zinc and all were evaluated in the ERA. Hydrocarbons were assumed to be risk-managed (i.e., covered with clean soil [till]) in the ERA; but a pathway analysis was completed to determine appropriate site-specific soil cover depths for closure planning (which ranged from 50 to 60 cm, depending on the AEC).

## Approach

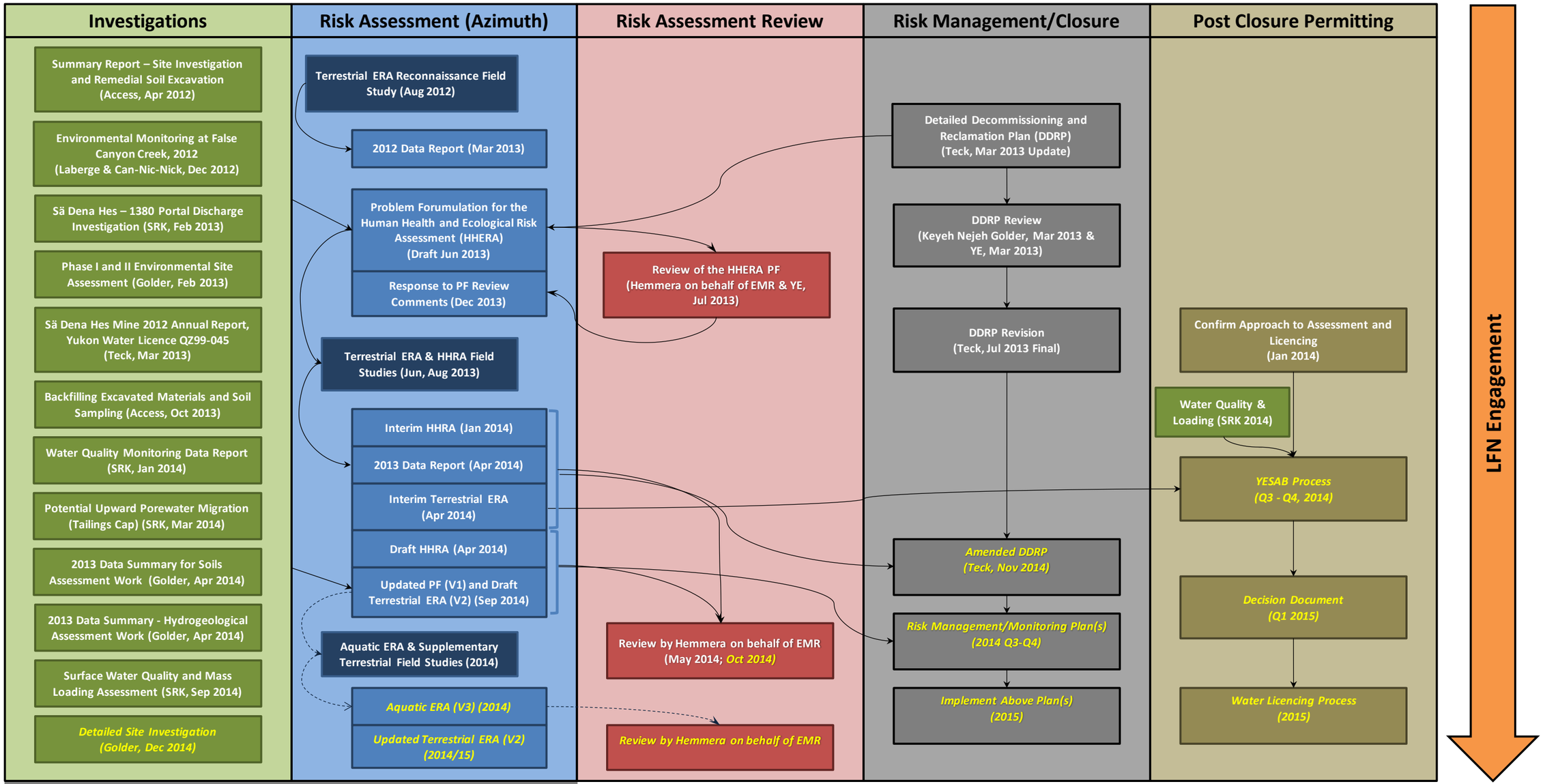
The Sä Dena Hes Mine is one of the first mines to undergo formal closure in the Yukon with the involvement of the mine owner. To oversee the mine's closure, a project-specific technical advisory committee has been formed with representatives of key regulatory agencies. Yukon Energy Mines and Resources (EMR) is chairing the committee, which includes representatives from Environment Yukon (EY) and other organizations as needed. Hemmera EnviroChem (Hemmera) is the third-party expert with the responsibility of reviewing the risk assessment on behalf of EMR. As well, because the Mine Site is located in the traditional territory of the Liard First Nation (LFN) and Ross River Dena, Teck is involved in an ongoing engagement process with both First Nations to support joint decision making for site closure.

ERA is a process that evaluates potential adverse effects to ecological receptors (e.g., plants, insects, birds, mammals, and fish), as a result of exposure to chemicals. The approach taken for this TERA relies on a formal risk assessment framework consistent with guidance from Environment Yukon, Environment Canada, and British Columbia. Azimuth prepared a Problem Formulation for the Human Health and Ecological Risk Assessment (HHERA) in June 2013, which was reviewed by Hemmera on behalf of EMR. Problem Formulation is the first step in a risk assessment process, and clarifies how issues associated with contamination at a site will be assessed.

Azimuth conducted field work for the terrestrial environment in 2013, with assistance from field technicians from the LFN community, and completed a series of reports in 2014, including a Data Report, a Draft Human Health Risk Assessment (HHRA), and an Interim ERA. This report, and companion volumes, comprise the ERA for the Sä Dena Hes Site, which is organized as follows:

- Volume 1: Updated Problem Formulation
- Volume 2: Terrestrial Ecological Risk Assessment (this report)
- Volume 3: Aquatic Ecological Risk Assessment (AERA; scheduled for 2014/15)

ERA studies, related work and the overall risk assessment process for the Site are shown in the table below.



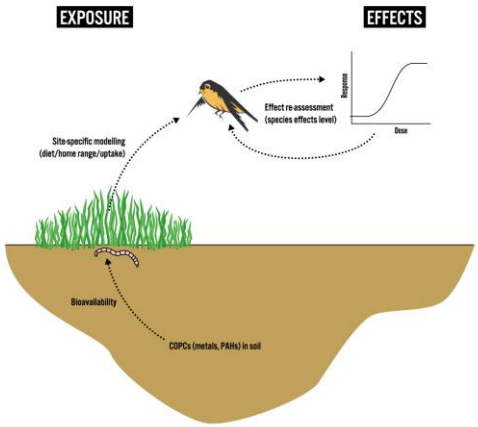

*Notes*

*Items in yellow font represent scheduled deliverables/activites, but have not yet been completed.*

*Dashed arrows represent anticipated items, but need to be determined pending current work.*

*Azimuth, September 16, 2014*

The TERA for the Sä Dena Hes Mine evaluates the risks to ecological receptors inhabiting terrestrial ecosystems from exposure to metal-contaminated soils, water and other media (i.e., food sources such as plants, invertebrates and small mammal prey that may have accumulated higher levels of metals from areas with contaminated soil). Ecological receptors included in the TERA were microbial communities, terrestrial invertebrates, plants, birds and mammals. Aquatic plants, invertebrates, fish and amphibians are addressed in the AERA.




The TERA provides a risk and uncertainty rating for each receptor group and AEC, and evaluates risks under current conditions and a future scenario. The future scenario is based on expected Site conditions and habitats 25 years after closure, using the DDRP as a guide. Risks are evaluated for each receptor group using a weight of evidence (WOE) approach that is described in **Volume 1**. Essentially, this provides the framework for conducting and judging results of the ERA. Integral to this process is the analysis of lines of evidence (LOEs) (**Appendix A** of this report), which are the analytical tools and information that are used to "build the case" for reaching risk conclusions. LOEs are evaluated for relevance to the ecological receptor group, effect size (or degree of contamination), causal linkage to contamination, and uncertainty in the assessment. Risk ratings are defined for each LOE in the ERA, but in general include the following categories:

- Negligible (e.g., concentrations are below standards or no effects observed/predicted)
- Low (e.g., concentrations are 1-3 times above standards or low-level (e.g., 10-20%) sublethal effects are observed/predicted)
- Moderate (e.g., concentrations are 3-10 times above standards or moderate-level (e.g., 20-50%) sublethal effects are observed/predicted)
- High (e.g., concentrations are more than 10 times above standards or high-level sublethal (>50%) effects or lethal (>20%) are observed/predicted).

Uncertainty in risk conclusions are rated as low, moderate or high and consider several factors including sensitivity and specificity of the tool to the chemical stressor, confounding variables such as habitat, level of resolution of the tool, data quality, site and temporal representativeness of the data, natural variability and uncertainty in mathematical models.

The ultimate goal of this TERA is to support risk management decision-making for the Sä Dena Hes Site, and specifically, to confirm whether the reclamation and remedial actions planned in the DDRP will be sufficiently protective of ecological receptors. It is important to be aware that the HHRA also impacts decision-making and in some cases may be the driving factor for determining risk management options at the Site. For example, the threshold concentration of lead in soils to protect human health is lower than

the Yukon standard for protection of ecological receptors. In the lower elevation areas of the Site, Teck will be applying a clean soil (till) cover over disturbed areas to meet the human health soil threshold level.

## Ecological Receptors and Lines of Evidence

Receptors were evaluated in the ERA using different tools, or lines of evidence:

- Microbial communities – These are soil dwelling bacteria, fungi, actinomycetes, and nematodes that may be exposed directly to contaminants in soil. This receptor group was evaluated at the community level. The health of the microbial community was inferred from the health (structure and function) of plant and invertebrate communities that rely on intact soil microbial communities.
- Terrestrial plant communities – These include trees (e.g., subalpine fir), shrubs (e.g., willow, alder, blueberry and currant) and herbaceous species that may be exposed directly to contaminants in soil through root uptake. This receptor group was evaluated at the community level by assessing the structure and ecological function (species distribution and cover) of the plant community as food and habitat for invertebrates and wildlife. Risks to plants were evaluated by examining metal concentrations in soils, vegetation and berries, information on plant composition and cover from a habitat survey, and information on colonization and growth from vegetation test plots and planting studies.

- Terrestrial invertebrate communities – These include ground-dwelling (e.g., spiders, beetles, and ants) and flying insects (e.g., moths, flies, chironomids, mayflies) that may be exposed directly to contaminants in soil or in water. This receptor group was evaluated at the community level by assessing the structure (number of individual invertebrates "abundance" and species "richness") and ecological function (biomass) of the invertebrate community as food for wildlife. Risks to invertebrates were evaluated by examining metal concentrations in soils and invertebrate tissues, and information on invertebrate biomass, abundance, and richness of from a field survey.

- Birds – Seventeen bird species, including both common and rare or endangered ("listed") species, were evaluated in the ERA at the species level. The selection process targeted species with different foraging niches and included plant-eaters ("herbivores") such as dark-eyed junco,

insect-eaters ("insectivores") such as barn swallow, Wilson's warbler and yellow-bellied flycatcher, meat-eaters ("carnivores") such as American kestrel and boreal owl, and mixed-diet birds ("omnivores") such as boreal chickadee and gray jay. Birds may be exposed to contaminants at the Site in drinking water, food items and soil that is incidentally ingested during foraging. This receptor group was evaluated by assessing the viability of common species and the survival, reproduction, and growth of listed species. Risks to birds were evaluated primarily using a food chain model to mimic exposure and potential effects to birds from foraging on the Site. Bird tissue chemistry from two incidental captures and the health of supporting plant and invertebrate communities were included as secondary lines of evidence in the ERA.

- Mammals – Sixteen species of mammals, including both common and rare or endangered ("listed") species, were evaluated in the ERA at the species level. The selection process targeted species with different foraging niches and included plant-eaters ("herbivores") such as Arctic ground squirrel, hoary marmot, and moose, insect-eaters ("insectivores") such as common shrew and little brown myotis, meat-eaters ("carnivores") such as American martin and Canada lynx, and mixed-diet mammals ("omnivores") such as deer mouse and black bear. Mammals may be exposed to contaminants at the Site in drinking water, food items and soil that is incidentally ingested during foraging. This receptor group was evaluated by assessing the viability of common species and the survival, reproduction, and growth of listed species. Risks to mammals were evaluated by examining metal concentrations in small mammal tissues and mammal feces, potential effects predicted from a food chain model, total catch of small mammals from a field trapping program, and information on the health of supporting plant and invertebrate communities.

## *Key Findings*

Some general considerations in the ERA include:

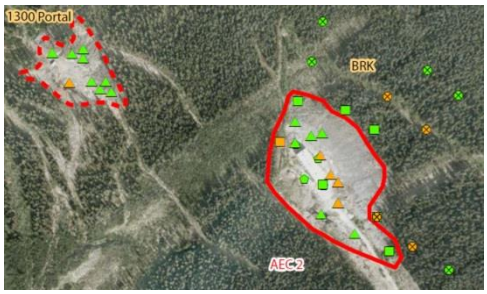
- While a combination of conservative and realistic assumptions were made in the ERA, there is generally a greater chance of reaching overly conservative conclusions.
- There are some outstanding site investigation gaps for the Site and the ERA has been progressing in parallel with the site investigation and closure activities. These factors can lead to greater uncertainty in the ERA.
- Lead and zinc concentrations are very elevated in soils and some tissues at the Site. Incidental ingestion of soil, as well as ingestion of ground invertebrates and small mammal prey (but not

vegetation) are the main drivers of exposure to metals for upper trophic birds and mammals. Risks to mammals and birds with large home ranges and/or plant-based diets are generally considered negligible or low.

- There are residual areas of contamination, in some cases beyond the footprint of physical disturbance, that were assumed would not be remediated under the future scenario (e.g., the TPN area north of the Tailings Management Facility (AEC 8), 1300 Portal in the Burnick Zone (AEC 2), 1380 Gully and the 1250 Portals near the Main Zone area (AEC 1/9). In some cases, these areas are driving elevated risks in the future scenario.
- Areas near the mineralized zone may be naturally elevated in metals (or partially due to mineralization) (e.g., Jewelbox Hill, 1380 Gully) and are being further characterized by Golder in summer 2014.

The key findings are presented by AEC for the various ecological receptors for the current and future scenarios.

### Burnick Zone/1300 Portal (AEC 2)

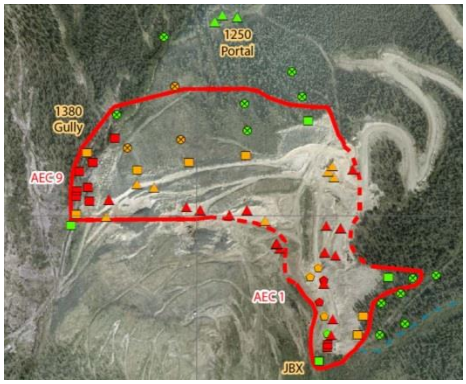



In the ERA, risks under current conditions for microbes, invertebrates, birds, and mammals from the Burnick AEC are considered negligible or low with low or moderate uncertainty, depending on the receptor. The risk rating for birds relied in part on the small size of the Burnick AEC (2.1 ha), relative to other AECs, which makes it unlikely that contamination in this area would affect populations, or provide food or habitat to many individual birds. For plants, risks are also considered low, but uncertainty in this risk prediction was high, due to the low resolution of the assessment tools.

The DDRP indicates that the crest of the 1200 waste rock pile will be pulled back onto the bench for stability, and the area will be re-sloped and re-vegetated. The 1300 Portal is to be sealed, the waste rock re-sloped and the site graded. For the future scenario, it was assumed that the Burnick 1200 bench area will be remediated with clean soil, but not the 1300 Portal area. Future risk predictions are rated as being the same as current conditions. Residual risks to birds in the future scenario are driven by fine grain soils from the 1300 Portal (i.e., no bulk soil samples have been collected here).

Reclamation work has proceeded in 2014 and site characterization of post-reclamation soil chemistry in AEC 2 is underway.

### Jewelbox/Main Zone/1380 Gully/1250 Portal (AEC 1/9)




Under both current and future scenarios, risks to microbial and terrestrial invertebrate communities are considered negligible or low with moderate uncertainty. Risks to plants are considered negligible, but with high uncertainty, due to the low resolution of the assessment tools.

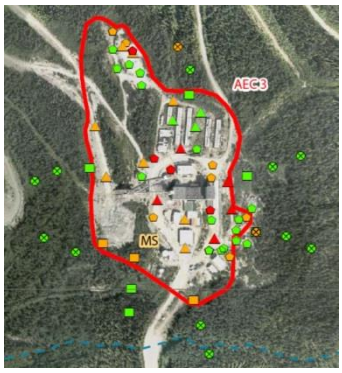
In the current scenario, however, several bird and mammal species are identified as having potentially elevated risks (moderate or high with moderate or high uncertainty) from exposure to metals in AEC 1/9.

The DDRP indicates that the crest of the Jewelbox (Pit, North, and 1408) and Main Zone waste rock piles will be pulled back onto the bench for stability, and the areas will be re-sloped and re-vegetated. For the future scenario, it was assumed that the Jewelbox and Main Zone bench areas will be remediated with clean soil. Contaminated areas that are not targeted for remediation, such as the 1380 Gully and 1250 Portal, were retained in the future scenario.

In the future scenario, even with assuming remediation of the waste rock benches and improved tissue concentrations for part of the AEC, elevated risks to some birds and small mammals (moderate or high with moderate or high uncertainty, depending on the species) from exposure to lead and zinc are predicted to remain post-closure. These residual risks are primarily due to high metals concentrations in soils and tissues (ground insects and estimated small mammal prey) found within the 1380 Gully that is located within the Jewelbox AEC, but where no remedial works are planned.

Reclamation work has proceeded in 2014 and site characterization of post-reclamation soil chemistry in AEC 1/9 is underway.

### Mill Site (AEC 3)




In the ERA, current risks for microbial, plant, and invertebrate communities are considered low with uncertainty ranging from moderate to high (depending on the receptor group). Potentially elevated risks (moderate or high, with moderate to high uncertainty) are identified for several bird and mammal ROCs from exposure to lead, zinc and cadmium in the Mill Site area under current conditions.

At the Mill Site, the DDRP specified discrete areas for capping with a 50 cm cover. However, based on results of the Draft HHRA and Interim ERA, Teck is planning to cover the entire disturbed area with a minimum 20 cm thick clean till soil cover. Assuming the entire disturbed area is remediated, risks are considered negligible to low with low uncertainty for most ROCs in the future scenario. The exception was common shrew, for which risks are predicted to be low, but with high uncertainty. Residual exposure was primarily from a few soil samples located beyond the disturbed area. The uncertainty rating was high because risks are extrapolated to the local population level based on potential effects at the organism-level, such as reproduction, growth and survival.

### Tailings Management Facility (TMF, AEC 8)


Current risks for microbial, invertebrate and plant communities at the forested/treed areas on the periphery of the TMF (but within the AEC) are considered negligible or low with uncertainty ranging from low to moderate (depending on the receptor group). However, potentially elevated risks (high with moderate uncertainty) are identified for microbes and plants in the tailings deposit areas from COPCs. Risks to invertebrates overtop of tailings is considered low with high uncertainty. Uncertainty associated with the tailings area risk ratings is considered high due to the confounding influence of habitat disturbance and the potential physical (rather than chemical) effect of the tailings. In addition, potentially elevated risks are identified for various bird and small mammal ROCs from exposure to lead, zinc and/or selenium in the TMF under current conditions.

The DDRP specified a 30 cm soil cover for tailings deposits/disturbed areas in the TMF. Based on the Interim ERA, a minimum cap depth of 50 cm was recommended to block exposure pathways for ecological receptors. The assumption for the future scenario in the ERA is that a clean, effective till soil cover would be applied over the tailings deposits/disturbed area. Under this scenario, potential risks are considered negligible or low for all groups. Although risks are not completely ruled out for some birds and mammals in particular (i.e., common shrew, Wilson's warbler, boreal chickadee, and gray jay) some inputs used in the model are expected to overestimate exposure under future conditions (i.e., data from the TPN area, which was contaminated due to dusting from the north tailings area, was used in the future scenario).

## *Implications for DDRP*

The final section of the TERA links findings of the ERA to appropriate risk management options. As well, a summary table is provided (**Table 4–1**) that evaluates Teck's DDRP reclamation plans/options in light of results of the Draft HHRA and Draft ERA, with the intention of identifying areas where the DDRP may require amendment. An initial version of this table was presented for discussion purposes at a regulatory and LFN stakeholder meeting held in Whitehorse on May 7, 2014. Next steps and anticipated changes to the DDRP are discussed by AEC below.

### Burnick Zone/1300 Portal (AEC 2)

For the TERA, unless something substantial changes in the soil site assessment, this area is considered a lower priority for further study or additional management action, relative to other AECs. However, site conditions need to be confirmed with post-reclamation soil chemistry. Anticipated changes to the DDRP/risk management options include:

- 1200 Burnick waste rick pile and bench: Prevent public access to prevent human health risks. Additional site characterization of post-reclamation soil chemistry will be re-evaluated in the Updated TERA.
- 1300 Portal: Prevent public access for human health risks. Additional site characterization of post-reclamation soil chemistry will be re-evaluated in the Updated TERA.
- Hydrocarbon area(s): Risk manage by applying a 60 cm soil cover, based on hoary marmot burrow depth.

### Jewelbox/Main Zone/1380 Gully/1250 Portal (AEC 1/9)

Based on the ERA findings, AEC 1/9, and the 1380 Gully in particular, is identified as the highest priority for follow-up work, relative to the other AECs. Follow-up chemistry sampling and additional studies were conducted in AEC 1/9 in 2014. These results will be integrated into the Updated TERA and further management actions (e.g., source control/removal; further study; other solutions) will be re-evaluated at that time.

At this time, anticipated changes to the DDRP/risk management options include:

- Jewelbox waste rock piles, bench and open pit: Prevent public access and limit consumption of plants and small animals from this AEC and peripheral areas to prevent human health risks. Additional site characterization of post-reclamation soil chemistry will be re-evaluated in the Updated TERA and further management actions will be evaluated at that time.
- Main Zone waste rock pile, bench and open pit: Prevent public access and limit consumption of plants and small animals from this area to prevent human health risks. Additional site characterization of post-reclamation soil chemistry will be re-evaluated in the Updated TERA and further management actions will be evaluated at that time.
- Hydrocarbon area(s): Risk manage by applying a 60 cm soil cover, based on hoary marmot burrow depth.
- 1380 Gully: Prevent public access and limit consumption of plants and small animals from this area to prevent human health risks. Action to reduce ecological risks uncertain but follow-up field studies were conducted in 2014.
- 1250 Portal: Prevent public access for human health risks. Collection of bulk soil samples recommended for ERA.

### Mill Site (AEC 3)

If anything changes with respect to the current closure strategy, this area could be further evaluated through refined modeling or study in the ERA. Otherwise, anticipated changes to the DDRP/risk management options include:

- Disturbed area: Apply soil cover throughout disturbed area for reducing human health and ecological risks. A minimum cover depth of 12 cm was recommended in the Interim ERA, but we understand Teck is planning for a 20 cm cover. Limit consumption of plants and small animals from this AEC and peripheral areas to prevent human health risks.
- Hydrocarbon area(s): Risk manage by applying a 50 cm soil cover, based on deer mouse burrow depth.

### Tailings Management Facility (TMF, AEC 8)

The wildlife food chain model could be refined for this area, if considered warranted. Otherwise, anticipated changes to the DDRP/risk management options include:

- North of North Tailings: Limit consumption of plants and small animals from this area on the northern periphery to prevent human health risks.
- North Tailings Pond, North Tailings, South Tailings Area: Apply soil cover throughout disturbed area (overtop of tailings) for reducing human health and ecological risks. A minimum cover depth of 50 cm was recommended in the Interim ERA.
- South Tailings Pond, Reclaim Pond: Apply soil cover over pond footprints (or move sediments to North Tailings Area to be covered) for reducing human health and ecological risks. A minimum cover depth of 50 cm was recommended in the Interim ERA.

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# ACKNOWLEDGEMENTS

This report was authored by Cheryl Mackintosh and Eric Franz, with contributions from Randy Baker and Beth Power (Azimuth Consulting Group Partnership, "Azimuth"). Maggie McConnell, Ryan Hill and Brian Pyper (Azimuth) provided technical contributions to the food chain modelling and pathway analysis work reported in the Interim Ecological Risk Assessment (ERA) (Azimuth 2013c). Martin Gebauer of Gebauer & Associates Ltd. (Gebauer) contributed the wildlife species and habitat assessment. Project management and review was provided by Randy Baker and Beth Power (Azimuth). Technical peer-review was conducted by Patrick Allard (Azimuth). Eric Franz, Martin Gebauer, Norm Healey, Randy Baker and Cheryl Mackintosh conducted field sampling (tissues) to support the terrestrial ERA (TERA). Soil data were provided by Golder Associates Ltd. (Golder) and water data were provided by SRK Consulting (SRK). Maps and GIS inputs were provided by Jason Shaw of Caslys Consulting.

This report was prepared for Michelle Unger and Bruce Donald of Teck Resources Limited (Teck), who have provided substantial input on site closure plans and scenarios. We also acknowledge early inputs on key decisions that support this work from Michael McLeay and Doug Bright (Hemmera Envirochem), third-party reviewers contracted by Yukon Energy Mines and Resources (EMR).

We recognize the input that the Liard First Nation (LFN) has made to this work. From providing field support to learning from elders about the Site and its history - this work has benefited from their insights. In particular, Sarah Newton is recognized for organizing inputs from LFN community members.

# NOTICE TO READERS

The ecological risk assessment (ERA) for the Sä Dena Hes Mine, Yukon Territory is reported in volumes:

- *Volume 1 – Problem Formulation for the Ecological Risk Assessment [Updated], September 2014 (PF).* The Updated PF replaces the Draft PF prepared in June 2013, and is issued in combination with Volume 2.
- *Volume 2 – Ecological Risk Assessment for the Terrestrial Environment [Draft], September 2014 (TERA, This report).* It is envisaged that an Updated TERA will be prepared in 2014/15, which will replace the Interim ERA (Azimuth, 2014c) and the Draft TERA (this report), as well as including the Data Report (Azimuth 2014b) and Wildlife and Habitat Assessment (Gebauer 2014) as appendices. This current report is based on knowledge of the Site and site conditions as of 2013.
- *Volume 3 – Ecological Risk Assessment for the Aquatic Environment [Draft], planned for 2014/15 (AERA).*

Readers are referred to each of these documents for specific information on each topic. Additional information on ERA components and related studies and on the structure of the ERA process is provided in **Section 1** of this report.

# USE & LIMITATIONS OF THIS REPORT

This report has been prepared by Azimuth Consulting Group Partnership (Azimuth) for the use of Teck Resources Limited (Teck; the Client), the Liard First Nation, and the Yukon Government (Departments of Energy Mines and Resources [EMR] and Environment Yukon [EY]) and reviewers under contract to EMR. This report is intended to provide information to Teck to assist with making decisions regarding management options with respect to closure of the Sä Dena Hes Mine. The Client has been party to the development of the scope of work for the subject project and understands its limitations.

In providing this report and performing the services in preparation of this report Azimuth accepts no responsibility in respect of the Site described in this report or for any business decisions relating to the Site, including decisions in respect of the management, purchase, sale or investment in the Site.

This report and the assessments and recommendations contained in it are intended for the sole and exclusive use of the Client, the Liard First Nation, and the Yukon Government (EMR and EY), and reviewers under contract to EMR.

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The findings contained in this report are based, in part, upon information provided by others. In preparing this report, Azimuth has assumed that the data or other information provided by others is factual and accurate. If any of the information is inaccurate, site conditions change, new information is discovered, and/or unexpected conditions are encountered in future work, then modifications by Azimuth to the findings, conclusions and recommendations of this report may be necessary.

In addition, the conclusions and recommendations of this report are based upon applicable legislation existing at the time the report was drafted. Changes to legislation, such as an alteration in acceptable limits of contamination, may alter conclusions and recommendations.

This report is time-sensitive and pertains to a specific site and a specific scope of work. It is not applicable to any other site, development or remediation other than that to which it specifically refers. Any change in the Site, remediation or proposed development may necessitate a supplementary investigation and assessment.

# ACRONYMS

| | |
|---|---|
| AEC | Area of environmental concern |
| AERA | Ecological risk assessment for the aquatic environment |
| APEC | Area of potential environmental concern |
| AEL | Acceptable effect level |
| BTEX | Benzene, toluene, ethylbenzene, and xylenes |
| CCME | Canadian Council of Ministers of the Environment |
| COPC | Contaminants of potential concern |
| CPUE | Catch-per-unit-effort |
| CSM | Conceptual site model |
| CSR | Contaminated sites regulations |
| DDRP | Detailed decommissioning and reclamation plan |
| DL | Detection limit |
| DW | Dry weight |
| DQOs | Data quality objectives |
| EcoSSL | Ecological Soil Screening Level (US EPA source of TRVs) |
| EDx | Effects dose x% (x% of individuals experience a specified level of impairment) |
| EMR | Yukon Government Department of Energy Mines and Resources |
| ERA | Ecological risk assessment |
| ESA | Environmental site assessment |
| EY | Yukon Government Ministry of Environment (i.e., Environment Yukon) |
| FCSAP | Federal Contaminated Sites Action Plan |
| HC | Hydrocarbons |
| HEPHs | Heavy extractable petroleum hydrocarbons |
| HHERA | Human health and ecological risk assessment |
| HHRA | Human health risk assessment |
| HQ | Hazard quotient |
| IDx | Inhibitory dose x% (x% level of impairment occurs) |
| IEE | Initial Environmental Evaluation (for the Mt. Hundere Joint Venture) |
| IL | Industrial Land |
| LEPHs | Light extractable petroleum hydrocarbons |
| LFN | Liard First Nation |
| LOAEL | Lowest observed adverse effects level |

| | |
|---|---|
| LOEs | Lines of evidence |
| NOAEL | No observed adverse effects level |
| ORNL | Oak Ridge National Laboratory (source of TRVs) |
| PAH | Polycyclic aromatic hydrocarbon |
| PF | Problem formulation |
| PL | Parkland |
| QA/QC | Quality assurance/quality control |
| RPD | Relative percent difference |
| ROC | Receptor of concern |
| SAP | Sampling and analysis plan |
| SD | Standard deviation |
| SDHOC | Sä Dena Hes Operating Corporation |
| SPLP | Synthetic precipitation leaching procedure |
| TERA | Ecological risk assessment for the terrestrial environment |
| TMF | Tailings Management Facility |
| TRV | Toxicity Reference Value |
| TWG | Technical Working Group |
| UCLM | Upper confidence limit of the mean |
| UTM | Universal transverse Mercator |
| VOC | Volatile organic compound |
| VPH | Volatile petroleum hydrocarbons |
| WOE | Weight of evidence |
| WW | Wet weight |
| XRF | X-ray fluorescence analysis |

**Tissue sample area acronyms:**

FF-Ref1, FF-Ref2, NC-Ref, Rec-S, Rec-W, STP, TPE, TPW, BRK, JBX, 1380 Gully, MS, North Tailings, South Tailings, TPN, TPN West-berm (see **Figure 4-1 in Volume 1** for locations and Azimuth 2013a form more detailed descriptions).

# 1. INTRODUCTION

## 1.1. Background

Azimuth Consulting Group Partnership (Azimuth) was commissioned by Teck Resources Limited (Teck) to conduct a Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA) for the Sä Dena Hes Mine (the Site) near Watson Lake, Yukon Territory (YK). Sä Dena Hes was operated by Curragh Resources Incorporated as a zinc-lead mine for 16 months between August 1991 and December 1992. Mining operations were suspended in December 1992 in response to low metals prices, at which point in time the Site was put into a state of care and maintenance and has not operated since. In April 1994, the Site was purchased by the Sä Dena Hes Operating Corporation (SDHOC), a Joint Venture between Teck Resources Limited (25% ownership), Teck Metals Limited (25% ownership) and Korea Zinc (50% ownership), and continued being managed in a state of care and maintenance due to the continued low market demand for zinc. Finally, due to a limited resource and low market demand for metals, a formal decision was made in 2000 to temporarily close the mine and a formal decision to permanently close the mine was made in 2012. In 2013, Teck reorganized some of its assets and this resulted in the joint venture being owned 50% by Korea Zinc and 50% by Teck Resources Limited.

The Sä Dena Hes Mine is permitted under a Yukon Quartz Mining Production Licence (QML-0004) regulated by Yukon Energy Mines and Resources (EMR), and a Type A Water Use Licence (QZ99-045) regulated by the Yukon Water Board, both of which expire at the end of 2015. Teck submitted a Detailed Decommissioning and Reclamation Plan (DDRP) in 2000 and updated versions were submitted in January 2006, January 2010, and January 2012, in accordance with the licence requirements for the Site. A final version of the DDRP was submitted to the Yukon Government in March 2013, and an updated final was submitted in July 2013. The closure plan will be amended in 2014/15 to reflect findings of the HHRA and ERA. Teck is completing closure activities by the end of 2015 and, as part of a separate permitting process, they intend to either seek a Type B Water Licence or request a renewal of the existing Type A Water Licence. The new or renewed licence would come into effect in January 2016. Under the QML, Teck has received approval to proceed with some activities specified in the DDRP. However, EMR will review results of the risk assessments before granting approval for additional closure activities and are most interested in whether the DDRP needs to be modified to address findings of the risk assessments.

Teck and the LFN have cooperatively developed an ongoing engagement process to involve the LFN in mine closure.

Implementation of the DDRP (Teck 2013) with anticipated revisions involves the following reclamation/management actions: sealing portals; grading steep slopes; draining, covering and revegetating the Tailings Management Facility (TMF); covering discrete areas of the Mill Site; risk managing hydrocarbon contaminated areas; removing contaminated soils from discrete areas (e.g., settling ponds) and in some cases, depositing contaminated soils in mine shafts; diverting Camp Creek back to its previous location (through the Reclaim Pond); and removing mine site buildings. Closure activities were initiated in 2013 when draining of the ponds was started and building demolition began.

The bulk of the closure work is planned for 2014. Of importance to Azimuth's TERA are Teck's plans for applying soil covers under the DDRP. DDRP activities are discussed further in **Section 2.3** of the **Updated PF** (**Volume 1**).

As reviewed in **Section 4 of Volume 1** in detail, environmental investigations have been ongoing at the Site since the 1990s. SRK Inc. conducted initial environmental evaluations for the Mt. Hundere Joint Venture in 1989. From the time when the SDHOC acquired the Site in 1994, Teck has been conducting water monitoring on Site in compliance with their Water Licence. Water, sediment, and biological monitoring has been also been conducted every two years dating back to 1992 in the downstream environment as per the Water Licence (see Laberge and Can Nic-A-Nick 2012). Golder Associates Ltd. (Golder) and Access Consulting Group (Access) have conducted environmental site assessment work (ESA, Golder 2013, 2014a; Access 2012) and hydrogeological assessment work (HGA, Golder 2014b). Since preparation of the DDRP and pending final groundwater monitoring results, with agreement from EMR and Environment Yukon (EY), Teck made a decision to risk manage hydrocarbons *in situ* and areas of stockpiled contaminated soils were backfilled in September 2013 (Access 2013b).

Azimuth has conducted ERA related field work for the terrestrial environment and prepared a Draft Problem Formulation (PF) for the human health and ecological risk assessments (HHERA)[1] (Azimuth 2013), Data Report (Azimuth 2014a), Draft Human Health Risk Assessment (HHRA, Azimuth 2014b), and Draft Interim ERA (Azimuth 2013c). ERA studies and related work are described in more detail below and are shown, along with the overall risk assessment process, in **Table 1–1**. This report includes a Draft ERA for the terrestrial environment (TERA), and is intended to support any further study and risk management decision-making for the terrestrial portions of the Site. While site investigation work is largely complete, additional sampling is planned for 2014 to address outstanding data gaps and assess Site conditions after reclamation activities are completed in various portions of the Site.

## 1.2. Objectives

In general, ERA is a process that evaluates the likelihood and magnitude of adverse effects to ecological resources (e.g., plants, invertebrates, fish, and wildlife), as a result of exposure to one or more stressors (i.e., usually chemicals but may also include physical stressors). The ultimate goal of this TERA is to support risk management decision-making for the Sä Dena Hes Site, and specifically, to confirm whether the reclamation and remedial actions planned in the DDRP will be sufficiently protective of ecological receptors. With this in mind, specific objectives of this report are to:

1. Assess potential risks to ecological receptors from exposure to mine-related contaminants in the terrestrial environment under current (present-day, assuming the tailings and reclaim ponds are

[1] While the Draft PF contained human health and ecological components, this document, reports only on the ERA (the HHRA is reported separately).

drained) and future (25-years post-closure as per the DDRP) conditions. While, post-closure is generally defined according to Teck's DDRP, it is acknowledged that closure activities may change based on results of the ERA and HHRA and feedback from the LFN and Yukon regulatory agencies, and post-closure conditions will need to be confirmed.

2. Identify any remaining gaps for the TERA and options for additional study or risk management to reduce uncertainty and/or risks from contaminants in the terrestrial environment, if warranted.
3. Assess the adequacy of the DDRP to address potential risks to ecological receptors[2].

Importantly, we note that the PF and ERA have been advanced alongside site investigation work and mine closure activities. While this can result in additional uncertainty in the process, we understand that there was a need to compress timelines for site evaluation and regulatory approvals. Azimuth is adopting an iterative approach to the ERA (e.g., tiered studies and lines of evidence [LOEs]) to support Teck's management goals.

As part of the risk assessment process, we have also supported discussions between Teck, the LFN, and Yukon regulatory agencies to develop and agree the risk assessment strategy that is consistent with the Yukon's regulatory framework and LFN interests.

## 1.3. Study Components

There are several sources of information that contribute to the ERA, including site investigation studies, the DDRP, field studies planned as part of the ERA, the PF and other related reports. These components and their connection to the ERA process in general and this report specifically are presented in **Table 1–1**. More detailed information on related studies is provided in **Section 4 of Volume 1**. Some of the key pieces include:

- **Site investigations and monitoring studies:** Key studies include environmental site assessment work (soils), hydrogeological assessment work (groundwater) and water quality and mass loading assessment work (source water and creek/receiving environment water), and downstream fish and aquatic invertebrate monitoring.
- **Draft PF (Azimuth 2013a):** PF is the first step in ERA and consists of a scoping and planning stage that is one of the most important steps in risk assessment. The PF clarifies the problem associated with contamination at a site and describes how that problem will be addressed (EC 2012). A Draft PF for the HHRA and ERA and (jointly referred to as HHERA) was produced in June 2013 (Azimuth 2013a). Hemmera, on behalf of Yukon Energy Mines and Resources (EMR), provided review comments (Hemmera 2013), to which Azimuth, with input from Golder,

[2] Note that in the final section, the DDRP is assessed relative to the findings of both the HHRA and the TERA. The HHRA is reported separately as Azimuth 2014b.

responded in a memorandum (Azimuth 2013b). **Volume 1** of the ERA represents the Updated PF for both the terrestrial and aquatic components.

- **Terrestrial field studies:** Azimuth conducted a site reconnaissance survey in fall 2012 (Azimuth 2013c) for initial HHERA planning, followed by field programs designed to support the TERA and HHRA in June and August of 2013.
- **Data report (Azimuth 2014a):** Field data from the 2012 and 2013 field programs are contained within the Data Report, intended to be the repository for raw data being used by both the ERA and HHRA. The report presents concentrations of metals in soils (from ecological sampling areas), tissues (berries, willow and alder leaves and twigs, ground and flying invertebrates, and small mammals), and water (subset of data), as well as some matrices sampled specifically for the HHRA. The principal objective of the Data Report was to describe patterns in metal concentrations in environmental media from reference areas and 'on-Site' areas to determine if there is exposure and accumulation of metals within media types relative to what was considered 'background' within the Mine Site boundaries.
- **Draft HHRA (Azimuth 2014b):** Azimuth prepared a Draft HHRA which relies on some of the same data as the ERA; results of both assessments are being used to inform mine closure.
- **Interim ERA (Azimuth 2014c):** The Interim ERA reported draft results of the food chain model, which is only one component of the ERA and targets only bird and mammal receptors. The report also included a pathway analysis, which evaluated the relevant depths of exposure for plants, invertebrates and burrowing animals, to support risk management planning with respect to the application of soil covers, which are key to the remedial strategy for the terrestrial environment. The goal of reporting interim results for the ERA was to provide Teck with initial information to assist in decision-making related to closure planning, refine remedial options as originally proposed in the DDRP and meet approval schedules needed for the Site. The food chain model for birds and mammals is often a key driver for terrestrial ERAs and is one of the most heavily weighted LOEs, and so was the focus of this earlier deliverable.

Because of timelines for this Site and the iterative nature of risk assessment, ERA components have been produced as separate reports/pieces (**Table 1–1** and also see **Section 1.4**).

## 1.4. Organization of the ERA

The entire ERA for Sä Dena Hes is organized into three volumes:

**VOLUME 1: PROBLEM FORMULATION**

Readers who want to review background information (such as previous site investigations) and problem formulations (terrestrial and aquatic) should read **Volume 1**. This PF identifies COPCs in the terrestrial environment, receptors of concern (ROCs) exposure pathways specific to each ROC, and documentation of LOEs that are planned for the ERA to assess risks to receptor groups.

**VOLUME 2: TERRESTRIAL ERA**

The TERA (**Volume 2**, this report) presents terrestrial risk predictions, the rationale behind those predictions and implications for risk management. This Draft TERA is organized as follows:

***Section 1: Introduction***

- Provides background, objectives and the general approach for the updated PF and TERA.

***Section 2: Approach and Assumptions***

- Summarizes the ERA approach and assumptions that are important for understanding the ERA process and findings.

***Section 3: Risk Characterization***

- Documents risks by AEC and by receptor group for soil microbes, plants, terrestrial invertebrates, birds, and mammals. Note that amphibians will be included in the AERA and reptiles are not included because they are not present in this part of the Yukon. Qualitative risk ratings (negligible, low, moderate, high) and associated uncertainty are provided based on a weight of evidence (WOE) assessment of the LOEs evaluated for each ROC group. An LOE technical appendix accompanies this section, which documents the derivation of risk and uncertainty ratings.

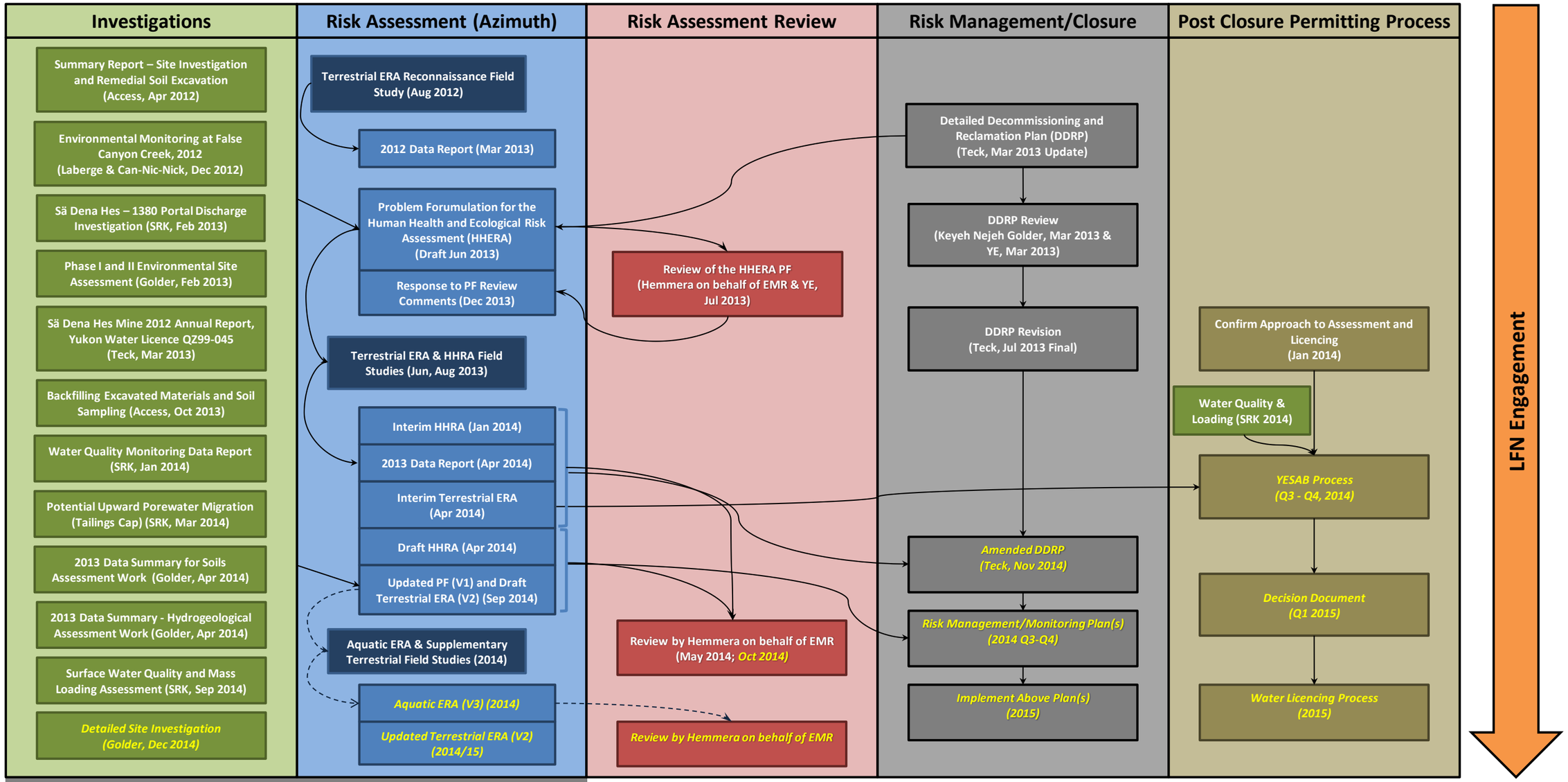
***Section 4: Implications for Risk Management***

- Links risk assessment results and risk management actions to support decision making and provide appropriate options to risk managers. Also evaluates adequacy of the DDRP in light of findings of the ERA and HHRA (as reported in Azimuth 2014b).

**VOLUME 3: AQUATIC ERA (scheduled for 2014/15)**

The AERA (**Volume 3**) is anticipated to be completed by winter 2014/15 and will present aquatic risk predictions, the rationale behind those predictions and implications for risk management.

**Table 1–1: Overall Risk Assessment and Risk Management Process for the Sä Dena Hes Mine Site, Yukon Territory.**




*Notes*

*Items in yellow font represent scheduled deliverables/activites, but have not yet been completed.*

*Dashed arrows represent anticipated items, but need to be determined pending current work.*

*Azimuth, September 16, 2014*

# 2. APPROACH & ASSUMPTIONS

This section provides a summary of the approach and assumptions that are important for understanding the ERA process and findings.

## 2.1. General Approach

The approach taken for this Draft TERA relies on a formal risk assessment framework consistent with guidance from EY (2011), Environment Canada (EC 2012), and the Canadian Council of Ministers of the Environment (CCME 1996, 1997). In addition, guidance from other jurisdictions (i.e., British Columbia [SAB, 2008, 2010], and the US [USEPA 1998, 2007]), and from the scientific literature is relied upon where appropriate.

An Updated PF, with supporting information, is reported as **Volume 1**, which lays out the general approach for the TERA. The site-specific strategy and ERA components are described in **Section 2.2**, including assumptions for current and future conditions (**Table 2–1**). A key step of the ERA involved the detailed analysis of each LOE using the attributes and WOE criteria identified in **Tables 5-2**, and **5-3 of Volume 1**, respectively. The methods, analyses, and results of all LOEs are provided in **Appendix A**. The LOE results are then compiled into two summary tables to help visualize findings by ROC and AEC under the current scenario (**Table 3–1**) and the future (post-closure) scenario (**Table 3–2**). **Figure 3-1** to **Figure 3-5** present the risk and uncertainty conclusions by AEC and ROC group for the current and future scenarios. Implications for risk management are described in **Section 4**, where risk prediction figures are overlayed on likely risk management options (**Figure 4-2 to Figure 4-6**), and the adequacy of the DDRP is evaluated in light of the ERA and HHRA findings (**Table 4–1**) The main components for the ERA are shown below:

| Subject | Location |
|---|---|
| Assumptions of Current and Future Conditions | Table 2-1 |
| LOE technical analysis | Appendix A |
| WOE risk characterization - Current | Table 3-2 |
| WOE risk characterization - Future | Table 3-2 |
| Plots of risk and uncertainty ratings for terrestrial ROCs – by AEC for current and future conditions | Figures 3-1 to 3-5 |
| Likely risk management options associated with risk and uncertainty ratings | Figure 4-1 |
| Overlay of risk and uncertainty ratings and likely risk management options – by AEC for current and future conditions | Figures 4-2 to 4-6 |
| Implications of ERA findings on the DDRP | Table 4-1 |

Note that, as described in **Section 7.5 of Volume 1**, formal protection goals for the ERA were not identified *a priori*. Rather, the ERA attempts to characterize risks with all judgments of acceptability being made as part of a consultative process after the ERA is completed (as per EC 2012). That said, our risk predictions often implicitly consider protection goals typically associated for the receptors assessed herein (i.e., AEL of 20% for common receptors and 10% for listed receptors). Our objective is to provide a thorough description of risk predictions and their uncertainties to support the risk management decision-making process.

## 2.2. Site-specific Strategy

In this section, we describe the strategy used for the Sä Dena Hes TERA. The strategy is based on the management goals described in **Section 1.2** and the AECs identified by Golder (Golder 2014a). The general strategy for the TERA was to:

1. Incorporate existing soil and water data from the ESA, routine monitoring and other investigations into the ERA (e.g., Golder 2014a, see also **Section 4.5 of Volume 1**).
2. Conduct a field program to collect tissue samples from discrete sampling areas, including (see **Figure 4-10** in **Volume 1** and Azimuth 2013a for locations and descriptions):
    - Reference areas (FF-Ref1, FF-Ref2, NC-Ref [on-Site reference]),
    - AEC areas (BRK, JBX, 1380 Gully, MS, North Tailings, South Tailings, TPN, TPN West-berm), and
    - Other on-Site areas that were outside AECs (Rec-S, Rec-W, STP, TPE, TPW) and located around the periphery of the Tailings Management Facility,
3. Update the following PF components for the TERA:
    - COPC screening for soils using an updated data set and Wildlands (PL) standards,
    - COPC screening for wildlife drinking water using an updated data set,
    - The list of wildlife ROCs based on additional field surveys, input from the LFN, and an updated strategy to ensure adequate protection for listed ROCs,
    - Other adjustments such as changing the LOE for microbial function, removing soil chemistry and drinking water chemistry as LOEs for birds and mammals, are described below.
4. Conduct desk-top analyses and assess information from individual LOEs based on field surveys, chemistry data, modeling and other tools (**Appendix A**).
5. Characterize risks by receptor group/assessment endpoint. Risk conclusions are derived by AEC, for plants, invertebrates and wildlife with small home ranges (≤ 25 ha), but are Site-wide for wildlife with large home ranges (> 25 ha). The following describes the AECs and broader areas used in the ERA:

- **AEC 2 Burnick Zone** (2.1 ha) – This area includes the 1200 and 1300 portals, benches and waste rock areas. The Burnick (BRK) tissue area and vegetation samples collected near the 1300 Portal were included in this AEC.
- **AEC 1/9 Jewelbox Hill, Main Zone, 1380 Gully, 1250 Portal** (16.3 ha) – This area includes the 1408 Portal, Jewelbox and Main Zone pits and 1408 Portal, Jewelbox North, Jewelbox Pit and Main Zone waste rock piles and bench areas, as well as the 1380 Gully and the 1250 Portal. Tissue sampling areas included Jewelbox (JBX), and 1380 Gully, as well as vegetation from the 1250 Portal area.
- **AEC 3 Mill Site** (10.0 ha) – This area covers the mill and camp areas including buildings, storage areas, and stockpiles. The Mill Site (MS) tissue area represented dietary exposure at this AEC.
- **AEC 8 Tailings Management Facility** (29.3 ha) – This area covers tailings deposits (the larger tailings area, north of the coffer dam (North Tailings Pond), and the small area south of the coffer dam (South Tailings Pond), as well as ponded water (North and South Tailings Ponds and the Reclaim Pond). The TPN and TPN West-berm areas were included as part of this AEC based on Golder's delineation work and COPC concentrations in tissues from these areas relative to background (Azimuth 2014a).
- **AEC 5 Boneyard** – Soil samples from the boneyard were included in the ERA and food chain model. However, although there was a single exceedance of arsenic in a soil sample identified in the ESA, arsenic did not exceed the background soil concentration used in the COPC screening for the TERA. Therefore, Azimuth did not sample tissues from this area and we do not present results of the risk characterization separately for AEC 5.
- **Overall Mine Site** (419 ha) – For birds and mammals with large home ranges (>25 ha), the spatial scale of assessment was the overall mine site, represented by the surface lease area (419 ha). Exposure for these ROCs in the food chain model included two additional non-AEC areas:
    - **Outside AEC** (361.6 ha) – These include several discrete areas within the bounds of the mine site, on the periphery of the Tailings Facility that, for the most part, have metals concentrations equivalent to off-Site reference areas. These areas were used as part of the on-Site dose for larger home-ranged animals, and for the "off-Site" (outside the Mill Site and Tailings Facility areas) for smaller home ranged animals. Areas included Rec-S, Rec-W, STP, TPE, and TPW (**Figure 4-10 in Volume 1**).
    - **Reference** – These areas were used to represent "background" which is defined as representative of metal concentrations in local environmental media within this geologic region, but un-impacted from mining. Importantly, these data are

used for comparison to background for chemistry-based LOEs and as the "background scenario" run for all bird and mammal species in the food chain model LOE. Reference data also represented the off-Site dose for wildlife with home ranges larger than the Mine Site in the food chain model. The reference areas included soils and tissues collected from the two off-Site reference areas (FF-Ref1, FF-Ref2) and the on-Site reference location (NC-Ref). The Data Report (Azimuth 2014a) confirmed that the on-Site reference area chosen in 2012 (Azimuth 2013) is in fact uncontaminated.

6. Risks to terrestrial receptors are assessed under current and future (post-closure) scenarios (and in some cases additional scenarios have been assessed to guide risk management decisions (see Interim ERA [Azimuth 2013c]). Future conditions are generally based on activities documented in the DDRP, or updated strategies/options that Teck is considering for closure (see **Table 2–1** in next section for specifics related to the DDRP). Our general understanding of key components of the DDRP and our assumptions for current and future (post-closure) conditions in the ERA include the following:
    - **Burnick Zone (1200 and 1300 Portal)** – The DDRP indicates that the crest of the 1200 waste rock will be pulled back onto the bench for stability and the area will be re-sloped and re-vegetated. Waste rock piles have not been sampled for metals chemistry (see **Section 2.4**), and in-place waste rock has not explicitly been included in the ERA. However, the ERA does conservatively include fine grain soils (HHRA dust samples) from the 1200 and 1300 benches (as well as bulk samples for the 1200 bench) in the estimation of incidental soil ingestion by ROCs. Tissues collected from a sampling station located downgradient from the Burnick 1200 waste rock pile were used for wildlife dietary exposure. For the ERA future scenario, it was assumed that the 1200 Burnick bench was covered with clean soil or material that is unavailable for incidental soil ingestion (i.e., coarse waste rock[3]). Reclamation work has recently proceeded at the Burnick Zone with removal of the buildings and re-sloping/covering of the bench areas with nearby soil. As part of the effort, the upper portion of the waste rock pile has been disturbed and re-sloped with a mixture of waste rock and underlying soil, with an unknown metals composition. The lower or downgradient portion of the steep 1200 waste rock pile has been left undisturbed. The contoured bench areas and remaining waste rock piles are currently being characterized by Golder and will be re-evaluated in

[3] During preparation of the Interim ERA and the initial version of this Draft ERA, one option being considered was re-contouring/covering the Burnick and Jewelbox benches with a coarse waste rock cover (boulders). It was assumed that this material would provide a barrier to incidental soil ingestion based on its size and would also slow any natural re-vegetation. This option is no longer being considered for any of the waste rock areas; the Burnick and Jewelbox benches have been re-sloped using a mixture of waste rock and native soil.

the Updated TERA. The tissue samples collected from the forested area immediately below the 1200 waste rock pile (i.e., "BRK") were not elevated and are assumed to represent current and future conditions.

- The ERA assumed that there would be no remediation of the 1300 Portal/bench area. Only HHRA fine grain soil samples [no bulk samples] were collected from the 1300 Portal and were used to estimate incidental soil ingestion of ROCs for this area in the current and future scenarios. However, we understand that the 1300 bench area has been re-contoured with nearby soils, but that some waste rock may still remain in place. The 1300 bench area is being characterized and will be re-evaluated in the Updated TERA. Vegetation collected near the 1300 area is used for current and future scenarios.
- **Jewelbox, Main Zone, 1380 Gully, 1250 Portal** – Like Burnick, the DDRP indicates that the crest of the Jewelbox (Pit, North and 1408 Portal) and Main Zone waste rock piles will be pulled back onto the bench for stability, and the area will be re-sloped and re-vegetated. Two chemistry samples for the waste rock piles were reported in the DDRP (lead was elevated in one of the samples). However, the date and precise location of collection is not known and the method of collection was also uncertain, therefore the data are not considered reliable. In-place waste rock from this area has not explicitly been included in the ERA. However, the ERA does conservatively include fine grain soils (HHRA dust samples) from this AEC (as well as bulk soil samples) to estimate incidental soil ingestion by ROCs, as well as tissues from a sampling station located adjacent to the 1408 waste rock pile. Additional soil and tissue samples were collected at the toe of the 1408 Portal and Jewelbox North waste rock piles in 2014 (data will be reported in the Updated TERA). For the future scenario, it was assumed that the Jewelbox and Main Zone benches were covered with clean soil or material that is unavailable for incidental soil ingestion (i.e., coarse waste rock[4]). Reclamation work has recently proceeded at the Jewelbox/Main Zone area with filling in the Jewelbox and Main Zone pits and re-sloping/covering the various bench areas with nearby soil. As part of the effort, the upper portion of the various waste rock piles have been disturbed and re-sloped with a mixture of waste rock and underlying soils, with an unknown metals composition. The lower or downgradient portions of the waste rock piles have been left undisturbed. The contoured bench areas and any remaining waste rock boulder material will be characterized by Golder and will be re-evaluated in the Updated TERA. Tissues from the JBX station (used for the Alpine portion of this AEC) were elevated. Thus, for the future scenario, we have replaced the JBX data with "background" tissue concentrations (assuming that the waste rock benches are remediated).

[4] See footnote 3.

- We have assumed that no remedial work occurs in the 1380 Gully area; thus, soils and tissues from this area are retained in the future scenario. Additional soil and tissue samples were collected from the 1380 Gully in 2014 and these results will be used to update the TERA.
- The ERA assumed that no remediation was planned for the 1250 Portal, so soils (only HHRA soil/dust data were collected for this area) and vegetation from here are used in the future scenario. We understand that Teck has conducted some minor re-grading of the area, and the site assessors are determining whether further characterization of this area is needed.
- **Mill Site** – While discrete areas of the Mill Site were to be covered with 50 cm of clean till according to the DDRP, we understand that a cover may be expanded over the wider disturbed footprint based on results of the Draft HHRA (Azimuth 2014b) and Interim ERA (Azimuth 2014c). Cover material is expected to come from the south dam, which was originally constructed from uncontaminated borrow areas on-Site. For the ERA future scenario, we have assumed that the entire disturbed footprint of the Mill Site area is covered with clean soil. Some of the tissues from MS were elevated and, for the future scenario, we have replaced the MS data with "background" tissue concentrations (under the assumption that this AEC is remediated), which get applied to entire AEC.
- **Tailings Management Facility** – While most of the Tailings Management Facility (anywhere there is exposed tailings) was to be covered with 30 cm of clean till according to the DDRP, we understand that a 50 cm cover may applied based on results of the Draft HHRA (Azimuth 2014b) and Interim ERA (Azimuth 2014c), as well as for stability purposes. Cover material is expected to come from the reclaim and south dam, which was originally constructed from uncontaminated borrow areas on-Site. For the ERA we have assumed that the majority of AEC 8 is covered with clean soil, except for areas represented by clean samples (Map ID #6, 7, 8, 9, 10, 11, 116, 117, 118) or where no remedial works are planned (TPN [north of the north tailings] and TPN – West Berm [west of the north tailings]). Note that estimates for sediment/soil chemistry were made for the South Tailings Pond and Reclaim Pond in the model for the current scenario (see Interim ERA [Azimuth 2013c]); these areas were assumed covered with clean soil in the future scenario. The current scenario used tissue data from TPN, TPN-West berm, North Tailings, and South Tailings (vegetation only). TPN tissues were used for all of AEC 8 in the future scenario, except flying insects, which included MS, and Rec-S, TPE, TPW from Outside AEC.

7. Evaluate conclusions of the ERA relative to Teck's reclamation plans, as specified in the DDRP (see **Section 4**).

## 2.3. LOE Tools

See **Appendix A** for analysis of LOEs that were included in the TERA. The LOEs included the following types of tools:

- Soil chemistry for plants and invertebrates
- Tissue chemistry (plants, invertebrates and small mammals) and hare and moose fecal pellet chemistry as measures of exposure to the ROC groups themselves (relative to background)
- Field surveys for plants and catch rates for invertebrates and small mammals
- A plant colonization study and revegetation test plots
- Food chain modeling

## 2.4. Assumptions

Some site-specific characteristics and assumptions made in the Sä Dena Hes TERA[5] include:

- The ERA has been advanced alongside site investigation work and Mine Site closure activities. While this can result in additional uncertainty in the process, we understand that there was a need to compress timelines for site evaluation and regulatory approvals. Azimuth is adopting an iterative approach to the ERA (e.g., tiered studies and LOEs) to support Teck's management goals.
- All the risk assessment work relies on Golder's environmental site assessment and hydrogeological work, as well as SRK's water quality and site decommissioning studies. The TERA strategy was based on the AECs defined and delineated by the Golder ESA. Soils and potential capping material not characterized as contaminated by Golder were assumed to be uncontaminated, or, specifically, equivalent to local "background", with a couple of exceptions for the food chain model work[6]. In this context, "background" was determined based on the use of three reference areas (see **Section 2.2**). We note that there may be areas on-Site, such as Jewelbox Hill, that are naturally elevated in metals above the reference area conditions ("background in the mineralized zone"), since this was the area that was targeted for mining because of metal ore deposits. Golder is investigating concentrations of metals in soils in these potentially naturally mineralized areas. In addition, Golder plans to conduct supplementary soil and groundwater sampling in 2014 to address other remaining site characterization data gaps (see **Section 4.6 of Volume 1**).

[5] See **Volume 1** for assumptions related to the aquatic environment.

[6] Estimates were made for sediment/soils from the Reclaim Pond and the South Tailings Pond (see **Section 2.2** above and **Section 4.1.2 of Volume 1**)

- While we have attempted to incorporate some regulatory comments from EMR (2014) and Hemmera (2014) into the Updated PF (**Volume 1**) and the Draft TERA (**Volume 2**, this report), these comments and any gaps will be addressed in a more formal response process, and some may need to be addressed in the Updated TERA (see **Section 4.3** for more details).
- Since preparation of the Draft PF (June 2013) and pending final results of groundwater assessment and the TERA, Teck, with agreement from EMR and EY, has decided to risk manage hydrocarbon contaminated soils *in situ* and stockpiled soils were backfilled in September 2013 (Access 2013; see **Section 4.1.4 of Volume 1**). The ERA progressed with the assumption that hydrocarbon contaminated areas were capped (see **Section 7.2.2 of Volume 1**), and the pathway analysis conducted in the interim ERA was used to advise on soil cover depths for these discrete areas of hydrocarbon contamination.
- The TERA assessed risks under different scenarios (current, future and other), which will be used to support risk management decisions and an amended DDRP for the Site. Future conditions (i.e., concentrations in soils and tissues) for areas assumed to be remediated were generally set equivalent to background (see **Section 2.2** for details). In general, future post-remediation conditions are uncertain and will need to be confirmed for the Updated TERA and then monitored as part of a long-term monitoring program that will be paired with risk-based triggers to identify the need for adaptive management (e.g., refinement of risk controls), where applicable.
- The ERA has not explicitly evaluated potential risks from waste rock (see **Figure 4-10 in Volume 1** for AEC1/9 waste rock piles), in part because reliable waste rock characterization data do not exist[7]. It has been implicitly assumed that coarse waste rock is unavailable to ecological receptors via incidental ingestion because of its large grain size. In the short term, it is also considered poor habitat quality for use by plants, invertebrates and wildlife. However, as documented in **Section 2.2**, recent reclamation work has re-contoured/covered the various waste rock benches on-Site with underlying native soil. As part of this process, the upper portions of the waste rock piles have also been re-worked and disturbed (but with unknown soil chemistry), while the lower portions of the piles remain as intact waste rock, consisting primarily of boulders. Characterization of the re-contoured benches (soil) and any remaining waste rock piles is being carried out to assess the potential long-term conditions and exposures to the material as it weathers. Previous work by SRK has indicated that acid rock generating and leaching potential of the waste rock is low (see **Section 4.3.2 of Volume 1**). Golder has evaluated potential contamination in soil downgradient from the Burnick, Jewelbox and Main Zone waste rock piles (which were generally not elevated, see **Figures 7-2 to 7-7 of Volume 1**). Also, the ERA evaluated potential contamination in tissues (vegetation, invertebrates and

[7] Note that two waste rock samples were reported in the DDRP, but the data are dated and the origin and sampling methods are uncertain.

small mammals) downgradient of the Burnick waste rock pile (BRK), which were not elevated (see Data Report [Azimuth 2013a]). While the JBX sampling area was adjacent to the waste rock pile (and was elevated for some tissues), additional tissue sampling downgradient of the 1408 Portal and Jewelbox North waste rock piles was conducted in 2014 and this information will be used to inform the long-term implications and metals contributions from waste rock to the adjacent forest. It is anticipated that the ERA will be updated to explicitly evaluate potential exposures from waste rock (e.g., incidental exposure to fines on waste rock piles), and to include the post-reclamation soil characterization data from the re-contoured benches and the additional tissue data.

All of the assumptions above are considered key and may have important consequences to the ERA. As additional information emerges and closure planning progresses, these assumptions can be revisited in the ERA as needed.

Risk characterization results are summarized in the next section.

**Table 2-1. Assumptions of the ERA for current and future conditions at the Sä Dena Hes Mine Site, Yukon Territory.**

| Media | Area/Station | Current Scenario[1] | | Future Scenario[2] | |
|---|---|---|---|---|---|
| | | Data Included | Rationale | Data Included | Rationale |
| **AEC 2 – Burnick Area** | | | | | |
| Drinking Water[1] (birds, mammals) | • Burnick Creek (MH-08) | ✓ | Close proximity | ✓ | No change under future scenario |
| | • Burnick Portal (MH-22) | ✓ | Close proximity | ✓ | No change under future scenario |
| | • East Fork Tributary E | ✓ | Close proximity | ✓ | No change under future scenario |
| | • West Fork Tributary E | ✓ | Close proximity | ✓ | No change under future scenario |
| | • North Dam Seepage (MH-02) | ✓ | Close proximity | ✓ | No change under future scenario |
| Soil (all ROCs) | • 1200 WRD[4] | × | Not available | × | Not available |
| | • 1200 Bench | ✓ | Inside AEC | × | Assumed covered[5] (set to average reference) |
| | • 1300 Portal and WRD | × | Not available | × | Not available |
| | • 1300 Bench | ✓ | Inside AEC | ✓ | The ERA assumed there were no remedial plans |
| | • Hydrocarbon areas | × | Assumed covered | × | Assumed covered |
| Diet items (birds, mammals) | • BRK | ✓ | Close proximity | ✓ | Not elevated under current conditions (generally) |
| | • 1300 Portal (vegetation) | ✓ | Close proximity | ✓ | No remedial plans |
| **AEC 1/9 - Jewelbox, Main Zone, 1380 Gully and 1250 Portal** | | | | | |
| Drinking Water[3] (birds, mammals) | • 1380 Portal (MH-25) | ✓ | Close proximity | ✓ | No change under future scenario |
| | • 1250 Portal (SDH-S5) | ✓ | Close proximity | ✓ | No change under future scenario |
| | • Headwater spring (CC-1) | ✓ | Close proximity | ✓ | No change under future scenario |
| | • Headwater spring (PH-01) | ✓ | Close proximity | ✓ | No change under future scenario |
| | • Camp Creek (MH-04, MH-27, MH-28A, MH-11) | ✓ | Close proximity | ✓ | No change under future scenario |
| | • Portal Creek (MH-05, MH-28) | ✓ | Close proximity | ✓ | No change under future scenario |
| | • Access Creek (MH-29) | ✓ | Close proximity | ✓ | No change under future scenario |
| | • South Dam Seepage (MH-01A, MH-01B) | ✓ | Close proximity | ✓ | Although the south and reclaim ponds will be drained, it was conservatively assumed that the wildlife drinking water sources did not change under the future scenario |
| | • Reclaim Pond Outflow (MH-06A, MH-06B, MH-07) | ✓ | Close proximity | ✓ | |
| Soil (all ROCs) | • Jewelbox WRDs | × | Not available | × | Not available |
| | • Jewelbox Portal and Benches | ✓ | Inside AEC | × | Assumed covered[5] (set to average reference) |
| | • Main Zone WRD | × | Not available | × | Not available |
| | • Main Zone Portal and Bench | ✓ | Inside AEC | × | Assumed covered[5] (set to average reference) |
| | • 1380 Gully | ✓ | Inside AEC | ✓ | No remedial plans |
| | • 1250 Portal | ✓ | Inside AEC | ✓ | No remedial plans |
| | • Settling Ponds | ✓ | Inside AEC | × | Assumed remediated |
| | • Hydrocarbon area | × | Assumed covered | × | Assumed covered |
| Diet items (birds, mammals) | • JBX[6] | ✓ | Close proximity | × | Assumed Jewelbox bench remediated (set to average reference) |
| | • 1380 Gully[6] | ✓ | Inside AEC | ✓ | No remedial plans[7] |
| | • 1250 Portal (vegetation) | ✓ | Close proximity | ✓ | No remedial plans |

**Table 2-1. Assumptions of the ERA for current and future conditions at the Sä Dena Hes Mine Site, Yukon Territory.**

| Media | Area/Station | Current Scenario[1] | | Future Scenario[2] | |
|---|---|---|---|---|---|
| | | Data Included | Rationale | Data Included | Rationale |
| **AEC 3 - Mill Site** | | | | | |
| Drinking Water[3] (birds, mammals) | • 1250 Portal (SDH-S5) | ✓ | Close proximity | ✓ | No change under future scenario |
| | • Headwater spring (CC-1) | ✓ | Close proximity | ✓ | No change under future scenario |
| | • Headwater spring (PH-01) | ✓ | Close proximity | ✓ | No change under future scenario |
| | • Camp Creek (MH-04, MH-27, MH-28A, MH-11) | ✓ | Close proximity | ✓ | No change under future scenario |
| | • Portal Creek (MH-05, MH-28) | ✓ | Close proximity | ✓ | No change under future scenario |
| | • Access Creek (MH-29) | ✓ | Close proximity | ✓ | No change under future scenario |
| | • South Dam Seepage (MH-01A, MH-01B) | ✓ | Close proximity | ✓ | Although the south and reclaim ponds will be drained, it was conservatively assumed that the wildlife drinking water sources did not change under the future scenario |
| | • Reclaim Pond Outflow (MH-06A, MH-06B, MH-07) | ✓ | Close proximity | ✓ | |
| Soil (all ROCs) | • Disturbed area | ✓ | Inside AEC | × | Assumed covered[8] (set to average reference) |
| | • Vegetated areas | ✓ | Inside AEC | ✓ | No remedial plans |
| | • Hydrocarbon area | × | Assumed covered | × | Assumed covered |
| Diet items (birds, mammals) | • MS | ✓ | Close proximity | × | Assumed Mill Site bench remediated (set to average reference) |

**Table 2-1. Assumptions of the ERA for current and future conditions at the Sä Dena Hes Mine Site, Yukon Territory.**

| Media | Area/Station | Current Scenario[1] | | Future Scenario[2] | |
|---|---|---|---|---|---|
| | | Data Included | Rationale | Data Included | Rationale |
| **AEC 8 - Tailings Area** | | | | | |
| Drinking Water[3] (birds, mammals) | • North Dam Seepage (MH-02) | ✓ | Inside AEC | ✓ | No change under future scenario |
| | • Camp Creek (MH-04, MH-27, MH-28A, MH-11) | ✓ | Close proximity | ✓ | No change under future scenario |
| | • Portal Creek (MH-05, MH-28) | ✓ | Close proximity | ✓ | No change under future scenario |
| | • Access Creek (MH-29) | ✓ | Close proximity | ✓ | No change under future scenario |
| | • South Dam Seepage (MH-01A, MH-01B) | ✓ | Inside AEC | ✓ | Although the south and reclaim ponds will be drained, it was conservatively assumed that the wildlife drinking water sources did not change under the future scenario |
| | • Reclaim Pond Outflow (MH-06A, MH-06B, MH-07) | ✓ | Inside AEC | ✓ | |
| Soil (all ROCs) | • North Tailings | ✓ | Inside AEC | × | Assumed covered |
| | • South Tailings | ✓ | Inside AEC | × | Assumed covered |
| | • South TP Marsh Area | ✓ | Inside AEC | ✓ | Not contaminated |
| | • TPN | ✓ | Inside AEC | ✓ | No remedial plans |
| | • TPN-West Berm | ✓ | Inside AEC | ✓ | No remedial plans |
| | • South Tailings Pond[9] (estimate) | ✓ | Inside AEC | × | Assumed covered |
| | • Reclaim Pond[9] (estimate) | ✓ | Inside AEC | × | Assumed covered |
| Diet items (birds, mammals) | • North Tailings | ✓ | Inside AEC | × | Used TPN for Tailings in future |
| | • South Tailings | ✓ | Inside AEC | × | Used TPN for Tailings in future |
| | • TPN[10] | ✓ | Inside AEC | ✓ | No remedial plans |
| | • TPN – West Berm | ✓ | Inside AEC | × | Used TPN for Tailings in future |

**Notes:**

[1] Current conditions represent habitats and suitability ratings under current conditions, with the Tailings and Reclaim ponds drained (see Interim ERA [Azimuth 2014c])
[2] Future conditions represent habitats and suitability ratings under a 25-year post-closure scenario (see Interim ERA [Azimuth 2014c])
[3] See Interim ERA (Azimuth 2014c) for proportions
[4] WRD = Waste Rock Dump
[5] DDRP indicates crest of WRD to be pulled back and one option being considered is a coarse material WR cover over the bench
[6] No malaise traps were set here; flying insects from MS were used for current and future scenario
[7] Small mammals from JBX were assigned to 1380 Gully for post-closure
[8] Only discrete areas to be covered in DDRP; but assumed entire footprint in ERA (see Interim ERA for further details)
[9] Portions of the ponds were assumed to be contaminated with tailings (see Interim ERA [Azimuth 2014c] for details)
[10] Flying insects were from MS (current scenario) and MS, Rec-S, TPE, TPW (future scenario)

# 3. RISK CHARACTERIZATION AND UNCERTAINTY ASSESSMENT

## 3.1. Risk Predictions and Uncertainties

### *3.1.1. Microbial Communities*

The assessment endpoint for microbial communities is ecological function and the entity (spatial scale) is assumed to be represented by the AECs.

This assessment endpoint was evaluated using one LOE (see **Table 7-8 in Volume 1,** and **Table 3–1 and Table 3–2 in this report**):

- **LOE 1 – Plant and Invertebrate Community LOEs** (see **Sections 3.1.2 and 3.1.3** below). The rationale for using this LOE is that if the structure and ecological function of plants and invertebrates are not impaired, we can infer that the health of the soil microbial community is sufficient to support these other receptor communities.

Note that this LOE has been added since the Draft PF, with the soil chemistry LOE being removed. Soil chemistry was removed because of uncertainty in the microbial function-based standards. As described in CSST (1996), the CSR soil standards for the protection of microbial function are based on a "check mechanism" recommended by the Canadian Council of Ministers of the Environment (CCME) for the protection of nutrient and energy cycling. SAB (2009) cautions that there is considerable uncertainty related to bioassay data on microbial function (i.e., there is uncertainty in interpreting the meaning of incremental decreases [and increases] in microbial functions). CCME (2006) also recognizes this limitation and specifies that the assessment of the "check mechanism" for microbial function should rely on professional judgment.

Evaluation of the LOE for microbial communities (i.e., plant and invertebrate community LOEs) was conducted in detail in **Appendix A**. Since there was only one LOE, updated risk predictions and uncertainties were based on the LOE-specific information provided below (see **Table 3–1 and Table 3–2 and Figure 3-1 to Figure 3-5**):

**Burnick/1300 Portal –**

- **Current and Future:** Potential risks from COPCs are considered low with a moderate degree of uncertainty (**Figure 3-1**), based on the plant and invertebrate risk ratings (see **Table 3–1 and Table 3–2 and Sections 3.1.2 and 3.1.3** below).

**Jewelbox/Main Zone/1380 Gully/1250 Portal –**

- **Current and Future:** Potential risks from COPCs are considered low with a moderate degree of uncertainty (**Figure 3-2**), based on the plant and invertebrate risk ratings (see **Table 3–1 and Table 3–2 and Sections 3.1.2 and 3.1.3** below).

**Mill Site –**

- **Current and Future:** Potential risks from COPCs are considered low with a moderate degree of uncertainty (**Figure 3-3**), based on the plant and invertebrate risk ratings (see **Table 3–1 and Table 3–2 and Sections 3.1.2 and 3.1.3** below).

**Tailings Management Facility –**

- **Current:**
    - **TPN, TPN-West berm –**Potential risks from COPCs are considered low with a moderate degree of uncertainty for TPN, TPN West-berm and other areas not located overtop of tailings.
    - **Tailings** – Potential risks were considered high with moderate uncertainty for tailings deposit soils (**Figure 3-4**). The ratings were based on the plant and invertebrate risk ratings, which showed potentially high risks to plants with moderate uncertainty in the tailings deposit areas (see **Table 3–1 and Sections 3.1.2 and 3.1.3** below).
- **Future (all areas):** Potential risks from COPCs are considered low with a moderate degree of uncertainty (**Figure 3-4**), based on the planned remediation for the TMF and the resulting plant and invertebrate risk ratings for future conditions (see **Table 3–2 and Sections 3.1.2 and 3.1.3** below).

### *3.1.2. Plants*

The assessment endpoint for terrestrial plants is structure and ecological function (i.e., food and habitat for invertebrates and wildlife) of native plant communities and the spatial scale/entity is the individual AEC.

This assessment endpoint was evaluated using three LOEs for current and future conditions, as follows (see **Table 7-8 in Volume 1, and Table 3–1 and Table 3–2 in this report**):

- **LOE 1 – Soil chemistry:** Comparison of soil chemistry to Yukon CSR soil standards used for COPC screening (Wildlands [PL] use, based on generic or matrix-specific toxicity to soil invertebrates and plants). Evaluation of spatial gradient patterns and extent of contamination.
- **LOE 2 – Plant tissue chemistry:** Comparison of plant and berry tissue chemistry across a gradient of on-Site COPC exposure in soil and in relation to background plant tissue chemistry from reference areas.
- **LOE 3 – Qualitative field survey & plant colonization studies:** Qualitative evaluation (i.e., species distribution and cover) of native vegetation community across a gradient of on-Site COPC exposure in soil (i.e., plant/habitat survey information compared to soil COPC concentration maps and vegetation tissue concentrations). The studies involved evaluation of colonization and growth of planted species in vegetation test plots at the Site.

Evaluation of each of these LOEs was conducted in detail in **Appendix A**. Updated risk predictions and uncertainties obtained by integrating all three LOEs are provided below (see **Table 3–1 and Table 3–2 and Figure 3-1 to Figure 3-4**):

**Burnick/1300 Portal –**

- **Current:** Potential risks from COPCs are considered low with a high degree of uncertainty. This finding reflects:
    - High soil contaminant exposure, and
    - Moderate plant tissue chemistry exposure, but
    - Low effects to native plant communities, based on the habitat survey. While bare areas overlapped with high COPCs in soils within the AECs, plant species distribution and cover did not appear impaired relative to reference/selected habitats in other areas where there was no physical disturbance and concentrations of metals in soils and/or plants were high. As well, the plant community composition at BRK was similar to the reference areas. For these reasons, potential effects to plants in disturbed AEC areas were attributed to physical disturbance, although uncertainty is considered high.
    - The plant colonization LOE was not used specifically for this AEC, but test plots throughout the Site have shown rapid recolonization with seeding and fertilizer applications, as well as recolonization by native "volunteer" species with no treatment; although this was occurring much more slowly in the untreated plots.
    - More weight was placed on the qualitative plant survey than the soil and tissue chemistry because the plant survey LOE was more ecologically relevant and more closely related to the assessment endpoint for plants.
- **Future:** Potential future risks are also considered low with high uncertainty because current risks are considered low with high uncertainty. While reclamation/remediation plans are expected to address potentially limiting factors for native plant recolonization in some portions of the AEC, there is some remaining uncertainty.

**Jewelbox/Main Zone/1380 Gully/1250 Portal –**

- **Current:** Potential risks from COPCs are considered negligible with a high degree of uncertainty. This finding reflects:
    - High soil contaminant exposure, and
    - High plant tissue chemistry exposure, but
    - Negligible effects to native plant communities, based on the habitat survey. While bare areas overlapped with high COPCs in soils within the AECs, plant species distribution and cover did not appear impaired relative to reference/selected habitats in areas where

there was no physical disturbance and concentrations of metals in soils and/or plants were high (i.e., at the 1380 Gully and JBX tissue sampling stations located within this AEC). For this reason, potential effects to plants in disturbed AEC areas were attributed to physical disturbance, although uncertainty is considered high.

  - The plant colonization LOE was not used specifically for this AEC, but test plots throughout the Site have shown rapid recolonization with seeding and fertilizer applications, as well as recolonization by native "volunteer" species with no treatment; although this was occurring much more slowly in the untreated plots.
  - More weight was placed on the qualitative plant survey than the soil and tissue chemistry because the plant survey LOE was more ecologically relevant and more closely related to the assessment endpoint for plants.

- **Future:** Potential future risks are considered negligible with high uncertainty because current risks are considered negligible with high uncertainty. While reclamation/remediation plans are expected to address potentially limiting factors for native plant recolonization in some portions of the AEC, there is some remaining uncertainty.

**Mill Site –**

- **Current:** Potential risks from COPCs are considered low with a high degree of uncertainty. This finding reflects:
  - High soil contaminant exposure, and
  - High plant tissue chemistry exposure, but
  - Low effects to native plant communities, based on the habitat survey. While bare areas overlapped with high COPCs in soils within the AECs, plant species distribution and cover did not appear impaired relative to reference/selected habitats in other areas where there was no physical disturbance and concentrations of metals in soils and/or plants were high. As well, the plant community composition at MS was similar to the reference areas. For these reasons, potential effects to plants in disturbed AEC areas were attributed to physical disturbance, although this remains uncertain.
  - The plant colonization LOE was not used specifically for this AEC, but test plots throughout the Site have shown rapid recolonization with seeding and fertilizer applications, as well as recolonization by native "volunteer" species with no treatment; although this was occurring much more slowly in the untreated plots.
  - More weight was placed on the qualitative plant survey than the soil and tissue chemistry because the plant survey LOE was more ecologically relevant and more closely related to the assessment endpoint for plants.

- **Future:** Potential future risks are considered low with moderate uncertainty because current risks are considered low with high uncertainty and reclamation/remediation plans (e.g., applying a soil cover over the Mill Site disturbed area) are expected to address any potential limiting factors for native plant recolonization.

**Tailings Management Facility –**

- **Current:** Potential risks from COPCs are considered high with a moderate degree of uncertainty for areas over tailings deposits, but negligible (TPN) or low (TPN-West berm) with low uncertainty for the forested/treed areas on the periphery of the TMF. This finding reflects:
    - High soil contaminant exposure,
    - High plant tissue chemistry exposure,
    - For areas overtop of tailings, there were high effects to alder planted directly on the tailings (stunted growth and visible stress), relative to alder planted on a 300 mm soil cover overtop of tailings. As well, the habitat survey documented disturbed habitat with limited shrubs, grasses and mostly bare ground. The findings were associated with a moderate degree of uncertainty for these portions of the AEC, because effects could be due to contaminants and/or the physical nature of the tailings.
    - For TPN, effects to native plant communities were considered negligible, based on the habitat survey at TPN showing similar plant species distribution and cover relative to reference Coniferous habitats. For TPN-West berm, effects to native plant communities were considered low, because although plant species distribution and cover was similar to Upland Shrubland reference/select habitat, there was no moss layer at TPN-West berm, which could be related to previous disturbance or microclimate/habitat conditions. Findings for these areas were associated with a low degree of uncertainty because the habitat surveys were conducted within these portions of the AEC, rather than inferred from adjacent tissue sampling areas or other AECs.
    - More weight was placed on the alder planting trials (tailings deposit areas) and the qualitative plant survey (TPN, TPN-West berm and other forested/treed areas on the periphery of the AEC) because these LOEs were more closely related to the assessment endpoint for plants than the soil and plant tissue chemistry LOEs.
- **Future:** Potential future risks were the same as current risks for the forested/treed areas on the periphery of the AEC (i.e., negligible [TPN] or low [TPN-West berm] with low uncertainty). For the areas overtop of tailings, future risks were considered low with moderate uncertainty. This rating reflects:
    - Plant recolonization and growth in the alder trial and test plots overtop of soil covers was considered good, and

- Test plots in the TMF, all conducted on at least 200 mm of soil cover, showed rapid recolonization with seeding and fertilizer applications, as well as recolonization by native "volunteer" species with no treatment; although this was occurring much more slowly in the untreated plots, and
- Reclamation/remedial activities are expected to address factors limiting plant growth overtop of tailings (e.g., applying a soil cover over the TMF disturbed area tailings deposits).

**Figure 3-1 to Figure 3-4** summarize the risk predictions and uncertainties by AEC for terrestrial plants relative to the assessment endpoint.

### *3.1.3. Terrestrial Invertebrates*

The assessment endpoint for terrestrial invertebrates is structure and ecological function (i.e., food and habitat for wildlife) of native plant communities and the spatial scale/entity is the individual AEC.

This assessment endpoint was evaluated using three LOEs for current and future conditions, as follows (see **Table 7-8 in Volume 1, and Table 3–1 and Table 3–2 in this report**):

- **LOE 1 – Soil chemistry:** Comparison of soil chemistry to Yukon CSR soil standards used for COPC screening (Wildlands [PL] use, based on generic or matrix-specific toxicity to soil invertebrates and plants). Evaluation of spatial gradient patterns and extent of contamination.
- **LOE 2 – Ground and flying invertebrate tissue chemistry:** Comparison of ground invertebrate tissue chemistry across a gradient of on-Site COPC exposure in soil and in relation to background plant tissue chemistry from reference areas.
- **LOE 3 – Ground and flying invertebrate field survey using trapping:** Semi-quantitative comparison of biomass[8], abundance, and richness from pitfall traps across a gradient of on-Site COPC exposures in soil and tissues and relative to off-Site reference areas. Emphasis was placed on the biomass endpoint. Information on flying invertebrate biomass from malaise traps was assessed as a secondary endpoint because flying invertebrates have less exposure to soil, relative to ground invertebrates.

Evaluation of each of these LOEs was conducted in detail in **Appendix A**, and considered the risk-characterization stage attributes (**Table 5-2 in Volume 1**). Updated risk predictions and uncertainties obtained by integrating all three LOEs are provided below (see **Table 3–1 and Table 3–2 and Figure 3-1 to Figure 3-4**):

[8] Biomass, abundance and richness measurements are referred to collectively as terrestrial invertebrate community indices, even though the measurements are considered semi-quantitative with a low level of resolution.

**Burnick/1300 Portal –**

- **Current:** Potential risks from COPCs are considered negligible with a moderate degree of uncertainty. This finding reflects:
  - High soil contaminant exposure, but
  - Negligible ground and flying invertebrate tissue chemistry exposure, and
  - Negligible effects to ground invertebrate biomass, abundance or richness. Although flying invertebrate biomass was lower at BRK than background, flying invertebrates are less associated with soil related contaminants, so this was considered a secondary endpoint. As well, there was no difference between BRK flying invertebrate tissue chemistry and background.
  - More weight was placed on the ground invertebrate survey (biomass, abundance and richness) because this LOE was more closely related to the assessment endpoint for invertebrates. There was concordance with this LOE and ground invertebrate tissue chemistry, but not soil chemistry.
  - We acknowledge that invertebrate tissue chemistry and community indices from the survey were measured in the BRK tissue sampling area, just outside of the disturbed footprint of the AEC. However, while the ground invertebrate community may be impaired in the disturbed area, this is most likely due to physical disturbance and/or poor habitat, based on other AECs where COPCs in soil and invertebrate tissues were elevated, but where there were no observed effects to ground invertebrate indices from the survey (e.g., 1380 Gully).
- **Future:** Potential future risks are predicted to remain the same as current risks (i.e., negligible with a moderate degree of uncertainty).

**Jewelbox/Main Zone/1380 Gully/1250 Portal –**

- **Current:** Potential risks from COPCs are considered negligible with a moderate degree of uncertainty. This finding reflects:
  - High soil contaminant exposure, and
  - High ground invertebrate tissue chemistry exposure (no flying invertebrate trapping was conducted here), but
  - Negligible effects to ground invertebrate biomass, abundance and richness.
  - More weight was placed on ground invertebrate survey (biomass, abundance and richness) because this LOE is more closely related to the assessment endpoint for invertebrates, compared to the soil and tissue chemistry LOEs.

- Invertebrate tissue chemistry and community indices from the survey were measured in the JBX tissue sampling area, just within the boundary of the AEC, but in undisturbed Alpine habitat, and in 1380 Gully tissue sampling area, within the AEC in undisturbed Alpine and Subalpine habitats. While the ground invertebrate community may be impaired in the disturbed area of this AEC, this is most likely due to physical disturbance and/or poor habitat, because in both JBX and 1380 Gully, COPCs in soil and invertebrate tissues are elevated, but there are no observed effects to ground invertebrate biomass, abundance or richness.

- **Future:** Potential future risks are predicted to remain the same as current risks (i.e., negligible with a moderate degree of uncertainty).

**Mill Site –**

- **Current:** Potential risks from COPCs are considered low with a moderate degree of uncertainty. This finding reflects:
  - High soil contaminant exposure, and
  - Moderate flying invertebrate tissue chemistry exposure; but COPCs in ground invertebrates were not elevated, and
  - Low effects to ground and flying invertebrates based on the field surveys. Ground invertebrate community indices were the same or higher than background but flying invertebrate biomass was lower here than background, which could in part be due to the relatively smaller forested area around the MS sample area. Because flying invertebrates are less associated with soil related contaminants, this endpoint was considered secondary. A "low" rating was provided for this area, because flying invertebrate tissue concentrations were higher here for lead and some other COPCs than at the reference areas.
  - More weight was placed on the ground invertebrate survey because measurement endpoints from this LOE are more closely related to the assessment endpoint for invertebrates compared to the soil and tissue chemistry LOEs.
  - We acknowledge that invertebrate tissue chemistry and community metrics were measured in the MS tissue sampling area, beyond the disturbed footprint of the AEC. However, while the ground invertebrate community may be impaired in the disturbed area, this is most likely due to physical disturbance and/or poor habitat, based on other AECs where COPCs in soil and invertebrate tissues were elevated, but where there were no observed effects to ground invertebrate indices from the survey (e.g., 1380 Gully).

- **Future:** Potential risks are considered negligible with low uncertainty because current risks are low and remediation of the Mill Site and TMF AECs is expected to reduce COPC concentrations in flying invertebrate from MS. While the link between elevated lead and reduced biomass in flying

invertebrates from MS is unlikely causal, expected improvements in Site conditions resulted in a lower ("negligible") risk rating for this area in the future.

**Tailings Management Facility –**

- **Current:** Potential risks from COPCs are considered negligible with a moderate degree of uncertainty for forested/treed areas on the periphery of the TMF and low with high uncertainty for disturbed areas with tailings deposits. This finding reflects:
    - High soil contaminant exposure, and
    - High ground invertebrate tissue chemistry exposure (no flying invertebrate trapping within this AEC), but
    - Negligible effects to ground invertebrates at TPN and TPN-West berm based on field survey, where ground invertebrate indices were the same or higher than background. A moderate degree of uncertainty was associated with these results.
    - At North Tailings, trapping indicated a depauperate ground invertebrate community, but based on information from the other areas that had high COPC concentrations in soils and invertebrates (and high invertebrate biomass); the cause of the impairment at North Tailings is attributed to habitat. Uncertainty was considered high because of the confounding influence of poor habitat and the possibility that COPCs could contribute to the impaired invertebrate abundance and biomass.
    - More weight was placed on ground invertebrate survey because measurement endpoints from this LOE are more closely related to the assessment endpoint for invertebrates, compared to the soil and tissue chemistry LOEs.
- **Future:** Potential future risks from COPCs are predicted to remain the same as current risks (i.e., negligible with a moderate degree of uncertainty) for forested/treed areas on the periphery of the TMF (i.e., TPN, TPN-West berm). Potential future risks disturbed areas with tailings deposits are predicted to be low with moderate uncertainty. This finding reflects that remediation of the TMF AEC is expected to reduce COPC concentrations soils over the disturbed area, and reclamation is expected to improve habitat. While the link between elevated metal COPCs and reduced biomass in ground invertebrates from North Tailings is unlikely causal (i.e., likely habitat-related), expected improvements in Site conditions resulted in a lower uncertainty rating for this area in the future.

**Figure 3-1 to Figure 3-4** summarize the risk predictions and uncertainties by AEC for terrestrial invertebrates relative to the assessment endpoint.

### 3.1.4. Birds

The assessment endpoint for birds is viability[9] of local bird populations[10] (for common species), and survival, reproduction, growth, and deformities of individual organisms[11] (for listed species).The entity (spatial scale of assessment) is assumed to be represented by the AEC and/or the entire property, depending on home range size, for both common[12] and listed species.

This assessment endpoint was evaluated using three LOEs for current and future conditions, as follows (see **Table 7-8 in Volume 1, and Table 3–1 and Table 3–2 in this report**):

- **LOE 1 – Incidental bird tissue chemistry:** Comparison of tissue chemistry for birds incidentally captured from the Tailings AEC and a reference area.
- **LOE 2 – Food chain model:** Comparison of estimated total dose (from a food chain model using measured contaminant concentrations in dietary items) to available TRVs relevant for effects on survival, reproduction, and growth.
- **LOE 3 – Plant and invertebrate LOEs:** See LOEs and risk conclusions for plants and terrestrial invertebrates; birds and mammals are also assessed indirectly via health of plants and invertebrates upon which they rely for food and habitat.

Note that the soil chemistry and drinking water chemistry LOEs have been removed since issuing the Draft PF (Azimuth 2013). These LOEs are removed because they are considered relatively weak LOEs (i.e., have low ecological relevance) compared to other LOEs, and because the soil and water exposure is integrated into the food chain model LOE. Tissue chemistry is retained as an LOE, as a measure of exposure (relative to background) for the birds themselves.

Evaluation of each of these LOEs was conducted in detail in **Appendix A**, and considered the risk-characterization stage attributes (**Table 5-2 in Volume 1**). Updated risk predictions and uncertainties

[9] We define viability as the ability of a population to sustain itself over the long term. We assume that assessing organism level attributes (e.g., growth and fecundity) will be protective of population level attributes (e.g. abundance).

[10] The assessment population consists of a group of conspecific organisms occupying a defined area that has been selected to serve as an assessment endpoint entity for the ERA (Barnthouse et al. 2008). The assessment population is operationally defined in the ERA as the local population, which consists of all organisms exposed to, or indirectly affected by, contaminants at the Site.

[11] The measurement endpoint is based on an average individual within a test population.

[12] We note that one key uncertainty for the assessment of common species is how defined areas, based on Site characteristics (area of an AEC or surface lease of the mine), overlap with what would be considered a biologically relevant area to support the "local" population. In part to support risk management planning, we have completed the food chain model assessment at the level of the AEC (defined as the entity) for small home range receptors (< 25 ha), even if they are common species. If potential risks at this level are identified for a common species, further quantitative analysis could be conducted to refine risk predictions and reduce uncertainty, if considered warranted.

obtained by integrating all four LOEs are provided below (see **Table 3–1 and Table 3–2 and Figure 3-1 to Figure 3-5**):

**Burnick/1300 Portal** (**Figure 3-1**) **–**

- **Current:** Potential risks from COPCs are considered low with a moderate degree of uncertainty for listed birds and low with a low degree of uncertainty for common species. This finding reflects:
    - There were no incidental bird tissue samples from the Burnick AEC.
    - For this AEC, the risk rating for birds was based on the food chain model. ROC-specific risk and uncertainty ratings from the food chain model overall suggested low risk associated with a moderate degree of uncertainty for listed birds and a low degree of uncertainty for common birds. The rating in part relied on the fact that the Burnick AEC is relatively small and would not provide sufficient food or habitat to support populations of common species or individual listed birds.
    - Plant and invertebrate LOEs suggest low potential risk with moderate uncertainty for COPC-related impacts to wildlife food and habitat at this AEC.
- **Future:** Potential risks from COPCs under the future scenario are predicted to be the same as current (i.e., low with a moderate degree of uncertainty for listed birds and low with a low degree of uncertainty for common birds). These ratings are based on the following predicted changes to LOEs based on post-closure Site conditions:
    - Lower soil exposure at Burnick bench (assuming a clean soil cover), but it was assumed that soils from the 1300 Portal would remain elevated.
    - Residual risks in the food chain model were considered low and were driven largely by HHRA fine grain soils (dust) from the 1300 Portal, which are likely overestimates of exposure to the bulk soil matrix. Note that re-contoured soil and waste rock chemistry from the 1200 and 1300 will be evaluated in the Updated TERA.

**Jewelbox/Main Zone/1380 Gully/1250 Portal** (**Figure 3-2**) –

- **Current:** Potential risks from COPCs are considered high with a moderate degree of uncertainty for listed birds and moderate with a high degree of uncertainty for common species. This finding reflects:
    - There were no incidental bird tissue samples from this AEC.
    - For this AEC, the risk rating for birds was based on the food chain model. ROC-specific risk and uncertainty ratings from the food chain model overall suggested high risk associated with a moderate degree of uncertainty for listed birds and moderate risk associated with a high degree of uncertainty for common ROCs.

- Plant and invertebrate LOEs suggest negligible potential risk with moderate uncertainty for COPC-related impacts to wildlife food and habitat at this AEC.

- **Future:** Potential risks from COPCs under the future scenario are ROC-specific and range from low to high with uncertainty ranging from moderate to high. Specifically, risks were considered:
  - High with moderate uncertainty for high exposure listed birds (e.g., Wilson's warbler as a listed surrogate),
  - Moderate with moderate uncertainty for moderate exposure listed birds (e.g., American kestrel),
  - Moderate with high uncertainty for high exposure common birds (e.g., Wilson's warbler as a common receptor), and
  - Low with high uncertainty for moderate exposure common birds (e.g., dark eyed junco as a common receptor). See **Table 3–2 and Figure 3-2** for more details. These ratings are based on the following predicted changes to LOEs based on post-closure Site conditions:
    - Lower soil exposure at Jewelbox and Main Zone benches (assuming a clean soil cover), but concentrations were assumed to remain elevated in the 1380 Gully and 1250 Portal where no remedial works are planned.
    - Expected reductions in tissue chemistry for the JBX station and the area within the AEC that this was assigned (based on assuming soil cover remediation of the Jewelbox and Main Zone portions of the AEC); but tissues within the 1380 Gully are assumed to remain elevated.
    - Residual risks in the food chain model were driven largely by high metals concentrations in soils and tissues within the 1380 Gully that is located within the Jewelbox AEC, but where no remedial works are planned.

**Mill Site** (**Figure 3-3**) **–**

- **Current:** Potential risks from COPCs are ROC-specific and range from low to high with uncertainty ranging from moderate to high. Specifically, risks were considered:
  - High with moderate uncertainty for high exposure listed birds (e.g., yellow-bellied flycatcher),
  - Moderate with moderate uncertainty for moderate exposure listed birds (e.g., American kestrel),
  - Moderate with high uncertainty for high exposure common birds (e.g., Wilson's warbler as a common receptor), and

- Low with high uncertainty for moderate exposure common birds (e.g., dark eyed junco). See **Table 3–1 and Figure 3-3** for more details. These findings reflect:
  - There were no incidental bird tissue samples from this AEC.
  - For this AEC, the risk rating for birds was based on the food chain model. ROC-specific risk and uncertainty ratings from the food chain model overall suggested moderate to high potential risks associated with a moderate degree of uncertainty for listed birds and low to moderate potential risks associated with a high degree of uncertainty for common birds.
  - Plant and invertebrate LOEs suggest low potential risk with moderate uncertainty for COPC-related impacts to wildlife food and habitat at this AEC.

- **Future:** Potential risks from COPCs under the future scenario are considered low (warbler and chickadee) or negligible (all other birds) with a low degree of uncertainty. These ratings are based on the following predicted changes to LOEs based on post-closure Site conditions:
  - Lower soil exposure across the Mill Site (assuming a clean soil cover over the disturbed area),
  - Expected reductions in tissue chemistry at the MS station, as a result of remediating the Mill Site AEC.
  - Risks from the food chain model future scenario were considered negligible or low with low uncertainty for all bird ROCs.

**Tailings Management Facility** (**Figure 3-4**) **–**

- **Current:** Potential risks from COPCs are ROC-specific and range from low to high with uncertainty ranging from moderate to high. Specifically, risks were considered:
  - High with moderate uncertainty for high exposure listed birds (e.g., Wilson's warbler as a listed surrogate),
  - Moderate with moderate uncertainty for moderate exposure listed birds (e.g., yellow-bellied flycatcher),
  - Moderate with high uncertainty for high exposure common birds (e.g., Wilson's warbler as a common receptor), and
  - Low with high uncertainty for moderate exposure common birds (e.g., dark eyed junco). See **Table 3–1 and Figure 3-4** for more details. These findings reflect:
    - High exposure based on COPCs in one bird incidentally sampled from the North Tailings, relative to one bird incidentally collected from a reference station. A high degree of uncertainty is associated with this single measurement, and

- ROC-specific risk and uncertainty ratings from the food chain model, which overall suggested moderate or high risk associated with a moderate degree of uncertainty for listed birds and low or moderate risk associated with a high degree of uncertainty for common ROCs.
- Risks were primarily based on food chain model predictions, which were supported by bird tissue chemistry.
- Plant and invertebrate LOEs suggest high potential risk from COPC-related impact to wildlife habitat/food overtop of tailings deposits under current conditions, but low risk elsewhere in the AEC.

- **Future:** Potential risks from COPCs under the future scenario are considered negligible with a low degree of uncertainty for most bird ROCs, except Wilson's warbler, boreal chickadee and gray jay for which risks are considered low with a low or moderate degree of uncertainty (see **Figure 3-4**). These ratings are based on the following predicted changes to LOEs based on post-closure Site conditions:
  - Lower soil exposure across the TMF (assuming a soil cover over the tailings deposits disturbed area),
  - Expected reductions in tissue chemistry over the disturbed area (i.e., North Tailings and South Tailings), but TPN and TPN-West Berm were assumed to remain elevated.
  - Risks from the food chain model were considered negligible with low uncertainty for most bird ROCs except Wilson's warbler, boreal chickadee and gray jay for which risks are considered low with a low or moderate degree of uncertainty. Although residual risks were identified for these ROCs from the TMF, post-closure exposure was likely overestimated because of conservative assumptions in the model (e.g., the use of TPN to reflect future tissue concentrations throughout the AEC).

**Overall Mine Site Scenario for Birds with Large Home Ranges** (**Figure 3-5**) **–**

- **Current:** In the Interim ERA (Azimuth 2014c), a food chain model scenario was run covering the entire Sä Dena Hes Mine Site for ROCs with large home ranges. Based on this single LOE, potential risks from COPCs are considered:
  - Low with low uncertainty for great gray owl and boreal owl
  - High with a moderate degree of uncertainty for barn swallow, a listed species.
- **Future:** In the future food chain model scenario covering the entire Mine Site, potential risks from COPCs are considered:
  - Low with low uncertainty for great gray owl and boreal owl
  - Moderate with a moderate degree of uncertainty for barn swallow, a listed species.

**Table 3–1 and Table 3–2 and Figure 3-1 to Figure 3-5** summarize the risk predictions and uncertainties by AEC relative to the assessment endpoint for birds.

### *3.1.5. Mammals*

The assessment endpoint for mammals is viability[13] of local mammal populations[14] (for common species), and survival, reproduction, growth, and deformities of individual organisms[15] (for listed species).The entity (spatial scale of assessment) is assumed to be represented by the AEC and/or the entire property, depending on home range size, for both common[16] and listed species.

This assessment endpoint was evaluated using four LOEs for current and future conditions, as follows (see **Table 7-8 in Volume 1, and Table 3–1 and Table 3–2 in this report**):

- **LOE 1 – Small mammal tissue chemistry and hare and moose pellet chemistry:** Comparison of small mammal tissue and hare and moose pellet chemistry across a gradient of on-Site COPC exposure in soil and relative to small mammal/pellet chemistry from off-Site reference areas.
- **LOE 2 – Food chain model:** Comparison of estimated total dose (from a food chain model using measured contaminant concentrations in dietary items) to available TRVs relevant for effects on survival, reproduction, and growth.
- **LOE 3 – Field survey using trapping:** Semi-quantitative comparison of catch from pitfall traps (e.g., for shrews), and small mammal traps (e.g., for mice and voles) across a gradient of on-Site COPC exposure in soil and tissues and relative to off-Site reference areas.
- **LOE 4 – Plant and invertebrate LOEs:** See LOEs and risk conclusions for plants and terrestrial invertebrates; birds and mammals are also assessed indirectly via health of plants and invertebrates upon which they rely for food and habitat.

Note that the soil chemistry and drinking water chemistry LOEs have been removed since issuing the Draft PF (Azimuth 2013). These LOEs are removed because they are considered relatively weak LOEs (i.e., have low ecological relevance) compared to other LOEs, and because the soil and water exposure is integrated into the food chain model LOE. Tissue chemistry is retained as an LOE, as a measure of exposure (relative to background) for the small mammals themselves. Likewise, fecal pellet chemistry is used as an LOE for mammals, as a measure of exposure, relative to background for the hare and moose themselves.

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[13] See footnote 9.

[14] See footnote 10.

[15] See footnote 11.

[16] See footnote 12.

Evaluation of each of these LOEs was conducted in detail in **Appendix A**, and considered the risk-characterization stage attributes (**Table 5-2 in Volume 1**). Updated risk predictions and uncertainties obtained by integrating all four LOEs are provided below (see **Table 3–1 and Table 3–2 and Figure 3-1 to Figure 3-5**):

**Burnick/1300 Portal**

- **Current:** Potential risks from COPCs are considered low with a low degree of uncertainty for all mammals with small home ranges (Arctic ground squirrel, northern red-backed vole, hoary marmot, porcupine, snowshoe hare, deer mouse and common shrew), which were all common species (see **Figure 3-1**). This finding reflects:
    - Low exposure based on COPCs in small mammal tissues, relative to background;
    - Low exposure based on COPCs in hare feces, relative to background;
    - Negligible effects based on small mammal trapping;
    - ROC-specific risk and uncertainty ratings from the food chain model, which overall suggested low risk associated with a low degree of uncertainty for common mammal ROCs. The rating relied in part on the fact that the Burnick AEC is relatively small and would not provide sufficient food or habitat to support populations of common mammal species.
    - The food chain model and field trapping LOEs were the most heavily weighted in the WOE (because of their higher ecological relevance), and there was agreement between these LOEs for this AEC. As well, there was concordance between these two LOEs and small mammal tissue and hare feces chemistry.
    - Plant and invertebrate LOEs suggest low potential risk with moderate uncertainty for COPC-related impacts to wildlife food and habitat at this AEC.
- **Future:** Potential risks from COPCs under the future scenario are considered negligible with a low degree of uncertainty for all of the small home-ranged common mammals at this AEC. These ratings are based on the following predicted changes to LOEs based on post-closure Site conditions:
    - Lower soil exposure at Burnick bench (application of a clean soil cover). Although soils from the 1300 Portal (using HHRA fine grain (dust) samples) were assumed to remain elevated post-closure (it was assumed that there would be no remediation of this area), residual risks to small-home ranged mammals were considered negligible.

**Jewelbox/Main Zone/1380 Gully/1250 Portal –**

- **Current:** Potential risks from COPCs are considered moderate/high with a high degree of uncertainty for common shrew, deer mouse, Arctic ground squirrel, and snowshoe hare and low

with a low degree of uncertainty for northern red-backed vole, hoary marmot, and porcupine, which were all common species (see **Figure 3-2**). This finding reflects:

- Moderate exposure based on COPCs in small mammal tissues, relative to background;
- High exposure based on COPCs in moose feces, relative to background;
- Negligible effects based on small mammal trapping at JBX;
- High effects based on small mammal trapping at 1380 Gully. Catch data from the 1380 Gully is emphasized in the WOE as it suggests possible effects;
- ROC-specific risk and uncertainty ratings from the food chain model, which overall suggested moderate risks with a high degree of uncertainty for the shrew, mouse, squirrel, and hare and low with a low degree of uncertainty for vole, marmot, and porcupine, which were all common species.
- The food chain model and field trapping LOEs were the most heavily weighted in the WOE (because of their higher ecological relevance). There was concordance between the food chain model results, catch data from the 1380 Gully and small mammal tissue and moose feces chemistry; but not small mammal catch from JBX.
- Plant and invertebrate LOEs suggest negligible potential risk with moderate uncertainty for COPC-related impacts to wildlife food and habitat at this AEC.

- **Future:** Potential risks from COPCs under the future scenario are considered moderate/high with a high degree of uncertainty for the shrew, mouse, and hare and low with a low degree of uncertainty for squirrel, vole, marmot, and porcupine, which were all common species (see **Figure 3-2**). These ratings are based on the following predicted changes to LOEs based on post-closure Site conditions:
  - Lower soil exposure at Jewelbox and Main Zone benches (assuming application of a clean soil cover), but concentrations were assumed to remain elevated in the 1380 Gully and 1250 Portal where no remedial works are planned.
  - Expected reductions in tissue chemistry for the JBX station and the area within the AEC that this was assigned (based on assuming remediation of this area by applying a clean soil cover); but tissues within the 1380 Gully are assumed to remain elevated.
  - Residual risks in the food chain model were driven largely by high metals concentrations in soils and tissues within the 1380 Gully that is located within the Jewelbox AEC, but where no remedial works are planned.

**Mill Site –**

- **Current:** Potential risks from COPCs are considered moderate with a high degree of uncertainty for common shrew, deer mouse, and low with a low degree of uncertainty for northern red-

backed vole, porcupine, and snowshoe hare, which were all common species (see **Figure 3-3**). This finding reflects:

- High exposure based on COPCs in small mammal tissues, relative to background;
- Low exposure based on COPCs in hare feces, relative to background, and
- Negligible effects based on small mammal trapping;
- ROC-specific risk and uncertainty ratings from the food chain model, which overall suggested moderate risk associated with a high degree of uncertainty for the shrew and mouse and low risk associated with a low degree of uncertainty for the vole, porcupine, and hare.
- The food chain model and field trapping LOEs were the most heavily weighted in the WOE (because of their higher ecological relevance), but they did not agree for this AEC. Overall, a "moderate" risk rating was derived based on the food chain model results, which was supported by high small mammal tissue chemistry. Hare feces chemistry collected in the area, was elevated by 2.5 fold above background (rated as "low").
- Plant and invertebrate LOEs suggest low potential risk with moderate uncertainty for COPC-related impacts to wildlife food and habitat at this AEC.

- **Future:** Potential risks from COPCs under the future scenario are considered low with high uncertainty for the shrew and negligible with low uncertainty for the other small-home ranged mammals at this AEC, which were all common species (see **Figure 3-3**). These ratings are based on the following predicted changes to LOEs based on post-closure Site conditions:
  - Lower soil exposure across the Mill Site (assuming a clean soil cover over the disturbed area),
  - Expected reductions in tissue chemistry at the MS station, as a result of remediating the Mill Site AEC.
  - Risks from the food chain model future scenario were considered negligible with low uncertainty for most ROCs, except the shrew, which was considered low with high uncertainty.

**Tailings Management Facility –**

- **Current:** Potential risks from COPCs are considered moderate with a high degree of uncertainty for common shrew, deer mouse, and low with a low degree of uncertainty for northern red-backed vole, porcupine, and snowshoe hare, which were all common species (see **Figure 3-4**). This finding reflects:
  - High exposure based on COPCs in small mammal tissues, relative to background;
  - High exposure based on COPCs in hare and moose feces, relative to background;

- Low effects based on small mammal trapping;
- ROC-specific risk and uncertainty ratings from the food chain model, which overall suggested moderate risk associated with a high degree of uncertainty for the shrew and mouse and low risk associated with a low degree of uncertainty for the vole, porcupine, and hare.
- The food chain model and field trapping LOEs were the most heavily weighted in the WOE (because of their higher ecological relevance). Overall risk predictions for the shrew and mouse were based more heavily on the food chain model (i.e., "moderate" risks), which were supported by "high" COPC exposure measured in small mammal tissues, and hare and moose feces from this AEC. For the other ROCs (vole, porcupine, and hare), the food chain model and trapping information both suggested "low" risks.
- Plant and invertebrate LOEs suggest high potential risk from COPC-related impact to wildlife habitat/food overtop of tailings deposits under current conditions, but low risk elsewhere in the AEC.

- **Future:** Potential risks from COPCs under the future scenario are considered negligible with a low degree of uncertainty for most mammal ROCs, except common shrew, for which risks are considered low with a low degree of uncertainty (see **Figure 3-4**). These ratings are based on the following predicted changes to LOEs based on post-closure Site conditions:
  - Lower soil exposure across the TMF (assuming a soil cover over the tailings deposits disturbed area),
  - Expected reductions in tissue chemistry over the disturbed area (i.e., North Tailings and South Tailings), but TPN and TPN-West Berm were assumed to remain elevated.
  - Risks from the food chain model were considered negligible with low uncertainty for most mammal ROCs except the common shrew, for which risks are considered low with a low degree of uncertainty. Although residual risks were identified for the shrew from the TMF, post-closure exposure was likely overestimated because of conservative assumptions used in the model (e.g., the use of TPN to reflect future tissue concentrations throughout the AEC).

**Overall Mine Site Scenario for Mammals with Large Home Ranges** (see **Figure 3-5**) **–**

- **Current:** In the Interim ERA (Azimuth 2014c), a food chain model scenario was run covering the entire Sä Dena Hes Mine Site for ROCs with large home ranges. Based on this single LOE, potential risks from COPCs are considered:
  - Negligible with a low degree of uncertainty for moose, woodland caribou (L), black bear, and Canada lynx;

  - Low with a low degree of uncertainty for little brown myotis (L), American marten, and wolverine (L).

- **Future:** In the future food chain model scenario covering the entire Mine Site, potential risks from COPCs are considered:
  - Negligible with a low degree of uncertainty for moose, woodland caribou (L), black bear, Canada lynx, and wolverine (L);
  - Low with a low degree of uncertainty for little brown myotis (L), and American marten.

**Table 3–1 and Table 3–2 and Figure 3-1 to Figure 3-5** summarize the risk predictions and uncertainties by AEC relative to the assessment endpoint for mammals.

## 3.2. General Considerations in the ERA

Overall, a combination of conservative and realistic decisions was made in the face of uncertainty in this risk assessment; generally, there is a greater chance of making a Type I error (false positive) than a Type II error (false negative). While risk conclusions are considered robust, they inherently reflect a considerable degree of professional judgment and expert opinion. Our goal was to be as transparent as possible in the risk assessment process.

The findings contained in this report are based, in part, upon information provided by others. In preparing this report, Azimuth assumed that the data or other information provided by others is factual and accurate. If any of the information is inaccurate, site conditions change, new information is discovered, and/or unexpected conditions are encountered in future work, then modifications by Azimuth to the findings, conclusions and recommendations of this report may be necessary.

In addition, the conclusions and recommendations of this report are based upon applicable legislation existing at the time the report was drafted. Changes to legislation, such as an alteration in acceptable limits of contamination, may alter conclusions and recommendations.

This report is time-sensitive and pertains to a specific site and a specific scope of work. It is not applicable to any other site, development or remediation other than that to which it specifically refers. Any change in the Site, remediation or proposed development may necessitate a supplementary investigation and assessment.

ERA is an iterative process where results from initial phases are used to identify uncertainties in risk predictions and inform the need for further studies. Because of the strategy to conduct the ERA in parallel with site investigation work, as well as concurrently with closure and remediation activities, there are some outstanding data gaps for the Sä Dena Hes Site (see **Section 4.6 of Volume 1**), which can lead to uncertainty in the ERA. A series of assumptions made for the ERA are also presented in **Section 2.4 of this report**.

**Table 3-1: WOE risk characterization summary for Sä Dena Hes terrestrial ERA - Current conditions.**

| | | | All AECs | | Burnick/1300 Portal | | | | | | Jewelbox/Main Zone/1380 Gully/1250 Portal | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Data Quality[1] | Eco Relevance | Magnitude[2] | Uncertainty | Causality[3] | Uncertainty | LOE Weighting | Risk Characterization[4] | Magnitude[2] | Uncertainty | Causality[3] | Uncertainty | LOE Weighting | Risk Characterization[4] |
| Microbial Communities | 1 | Plant and Invertebrate LOEs | ✓ | Moderate | Low (see below) | Moderate (see below) | see below | see below | ++ | **Low Risk with Moderate Uncertainty** (based on plant and invertebrate LOEs) | Low (see below) | Moderate (see below) | see below | see below | ++ | **Low Risk with Moderate Uncertainty** (based on plant and invertebrate LOEs) |
| Terrestrial Plants | 1 | Soil chemistry | ✓ | Low | High | High (eff) | N/A; Plausible | High | + | **Low Risk with High Uncertainty:** Exposure based LOEs are "high" but the qualitative survey suggests risks are "low", and more weighting was applied to this LOE. While bare areas overlap with high COPCs in soils within the AECs, there was no apparent effect to plants in other areas where there was no physical disturbance and concentrations of metals in soils and/or plants were high. The plant community composition at BRK was similar to the reference areas. | High | High (eff) | N/A; Plausible | High | + | **Negligible Risk with High Uncertainty:** Exposure based LOEs are "high" but the qualitative survey suggests risks are "low", and more weighting was applied to this LOE. While bare areas overlap with high COPCs in soils within the AECs, there was no apparent effect to plant community composition in areas (i.e., JBX and 1380 Gully) where there was no physical disturbance and concentrations of metals in soils and/or plants were high. |
| | 2 | Plant tissue chemistry | ✓ | Low | Moderate (exp) | High (eff) | N/A | N/A | + | | High (exp) | High (eff) | N/A | N/A | + | |
| | 3 | Qualitative field survey & plant colonization | ✓ | High | Low | High | Negative; Plausible | Moderate | +++ | | Negligible | High | Negative; Plausible | Moderate | +++ | |
| Terrestrial Invertebrates | 1 | Soil chemistry | ✓ | Low | High | High (eff) | N/A; Plausible | High | + | **Negligible Risk with Moderate Uncertainty:** Soil chemistry is "high" but ground invertebrate chemistry and biomass suggests risks are "negligible". More weighting was applied to the invertebrate chemistry and biomass LOEs, particularly biomass, as it is more closely related to the assessment endpoint for invertebrates. | High | High (eff) | N/A; Plausible | High | + | **Negligible Risk with Moderate Uncertainty:** Soil and invertebrate chemistry LOEs were "high", but ground invertebrate biomass suggests risks are "negligible". More weighting was applied to the invertebrate biomass LOE, as it is more closely related to the assessment endpoint for invertebrates. |
| | 2 | Invertebrate tissue chemistry | ✓ | Low | Negligible (exp) | High (eff) | N/A | N/A | + | | High (exp) | High (eff) | N/A | N/A | + | |
| | 3 | Invertebrate biomass, abundance and richness | ✓ | High | Negligible | Moderate | Negative; N/A | Moderate | +++ | | Negligible | Moderate | Negative; N/A | Moderate | +++ | |
| Birds[6] | 1 | Incidental bird tissue chemistry | ✓ | Low | N/A | N/A | N/A | N/A | N/A | **Listed birds (L, L*) (c. sparrow, warbler, chickadee, y. flycatcher, w. sparrow) - Low Risk with Moderate Uncertainty**<br><br>**Common birds (junco, chickadee, c. sparrow, warbler) - Low Risk with Low Uncertainty:**<br><br>Risks were based on food chain model predictions. Plants and invertebrate LOEs suggest low potential risk with moderate uncertainty for COPC-related impacts to wildlife food and habitat at this AEC. | N/A | N/A | N/A | N/A | N/A | **Common birds (junco, c. sparrow, warbler, chickadee, jay) - Moderate Risk with High Uncertainty** |
| | 2 | Food chain model | ✓ | Moderate | Low | Low-Moderate (ROC-specific) | N/A; Plausible | High | +++ | | Moderate-High (ROC-specific) | Moderate-High (ROC-specific) | N/A; Plausible | High | +++ | **Listed birds (L, L*) (warbler, kestrel, y. flycatcher, chickadee) - High Risk with Moderate Uncertainty**<br><br>Risks were based on food chain model predictions. Plants and invertebrate LOEs suggest negligible potential risk with moderate uncertainty for COPC-related impacts to wildlife food and habitat at this AEC. |
| | 3 | Plant and invertebrate LOEs | ✓ | Low | Low (see above) | Moderate (see above) | see above | see above | + | | Negligible (see above) | Moderate (see above) | see above | see above | + | |
| Mammals[6] | 1A | Small mammal tissue chemistry | ✓ | Low | Low (exp) | High (eff) | N/A | N/A | + | **Common mammals (vole, marmot, porcupine, shrew, mouse, squirrel, hare) - Low Risk with Low Uncertainty:**<br><br>The food chain model and field survey LOEs were most heavily weighted in the WOE, and there was agreement between these LOEs for this AEC. Results of these LOEs were supported by small mammal tissue chemistry, and hare feces chemistry (which were less than 3-fold higher than background). Plant and invertebrate LOEs suggest low potential risk with moderate uncertainty for COPC-related impacts to wildlife food and habitat at this AEC. | Moderate (exp) | High (eff) | N/A | N/A | + | **Common mammals (vole, marmot, porcupine) - Low Risk with Low Uncertainty** |
| | 1B | Hare and moose fecal pellet chemistry | ✓ | Low | Low (hare) (exp) | High (eff) | N/A | N/A | + | | High (moose) (exp) | High (eff) | N/A | N/A | + | **Common mammals (shrew, mouse, squirrel, hare) - Moderate/High Risk with High Uncertainty:**<br><br>The food chain model and field survey LOEs were most heavily weighted in the WOE, and the small mammal catch data from 1380 Gully is emphasized, and there was agreement between the model and survey from the 1380 Gully. Results of these LOEs were supported by small mammal tissue chemistry, and moose feces chemistry. Plant and invertebrate LOEs suggest negligible potential risk with moderate uncertainty for COPC-related impacts to wildlife food and habitat at this AEC. |
| | 2 | Food chain model | ✓ | Moderate | Low | Low | N/A; Plausible | High | +++ | | Low-Moderate (ROC-specific) | Low-High (ROC-specific) | N/A; Plausible | High | +++ | |
| | 3 | Field survey using trapping | ✓ | Moderate | Negligible | High | Negative; N/A | Low | ++ | | Negligible (JBX); High (1380 Gully) | High | Negative; N/A (JBX) Moderate, Positive; Plausible (1380 Gully) | Low (JBX); High (1380 Gully) | ++ | |
| | 4 | Plant and invertebrate LOEs | ✓ | Low | Low (see above) | Moderate (see above) | see above | see above | + | | Negligible (see above) | Moderate (see above) | see above | see above | + | |

[1] Data quality - a check mark indicates acceptable data quality; and an "x" indicates unacceptable data quality
[2] Magnitude considers degree of contamination or effect size, as well as spatial extent and temporal representativeness
[3] Causality considers strength of correlation and supporting evidence
[4] Risk characterization considers concordance among LOEs and provides an overall risk and uncertainty rating
[5] See Section 3 figures for risk and uncertainty ratings by ROC.
[6] (L) - denotes listed species.

Risk Ratings (See section 3 figures for risk and uncertainty ratings):

Green = Negligible-Low Risk
Yellow = Moderate Risk
Red = High Risk

**Table 3-1: WOE risk characterization summary for Sä Dena Hes terrestrial ERA - Current conditions.**

| | | | All AECs | | Mill Site | | | | | | Tailings Management Facility | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Data Quality[1] | Eco Relevance | Magnitude[2] | Uncertainty | Causality[3] | Uncertainty | LOE Weighting | Risk Characterization[4] | Magnitude[2] | Uncertainty | Causality[3] | Uncertainty | LOE Weighting | Risk Characterization[4] |
| Microbial Communities | 1 | Plant and Invertebrate LOEs | ✓ | Moderate | Low (see below) | Moderate (see below) | see below | see below | ++ | **Low Risk with Moderate Uncertainty** (based on plant and invertebrate LOEs) | High (tailings); Negligible-Low (other) | Low-High (see below) | see below | see below | ++ | **Low Risk with Moderate Uncertainty (TPN, TPN-West berm)**<br>**High Risk with Moderate Uncertainty (Tailings)** (based on plant and invertebrate LOEs) |
| Terrestrial Plants | 1 | Soil chemistry | ✓ | Low | High | High (eff) | N/A; Plausible | High | + | **Low Risk with High Uncertainty:** Exposure based LOEs are "high" but the qualitative survey suggests risks are "low", and more weighting was applied to this LOE. While bare areas overlap with high COPCs in soils within the AECs, there was no apparent effects to plants in other areas where there was no physical disturbance and concentrations of metals in soils and/or plants were high. The plant community composition at MS was similar to the reference areas. | High | High (eff) | N/A; Plausible | High | + | **Negligible (TPN) or Low (TPN-West berm) Risk with Low Uncertainty** (see other AECs e.g., Mill Site for rationale).<br>**North & South Tailings - High Risk with Moderate Uncertainty:** At the TMF, the plant colonization studies were given the most weight, followed by the habitat assessment and exposure LOEs. Alder planted directly on tailings had stunted growth and were stressed compared to alder planted on a 300 mm soil cover (overtop of tailings). The habitat survey documented disturbed habitat in this area. |
| | 2 | Plant tissue chemistry | ✓ | Low | High (exp) | High (eff) | N/A | N/A | + | | High (exp) | High (eff) | N/A | N/A | + | |
| | 3 | Qualitative field survey & plant colonization | ✓ | High | Low | High | Negative; N/A | Moderate | +++ | | Negligible-High (area-specific) | Low-Moderate (area-specific) | Moderate, Positive; N/A (North Tailings) Negative; N/A (TPN, berm) | Moderate | +++ | |
| Terrestrial Invertebrates | 1 | Soil chemistry | ✓ | Low | High | High (eff) | N/A; Plausible | High | + | **Low Risk with Moderate Uncertainty:** Soil and invertebrate chemistry LOEs were "high" or "moderate", but ground invertebrate biomass suggests risks are "low". More weighting was applied to the invertebrate biomass LOE, as it is more closely related to the assessment endpoint for invertebrates. | High | High (eff) | N/A; Plausible | High | + | **Negligible Risk with Moderate Uncertainty (TPN, TPN-West berm):** Soil and invertebrate chemistry LOEs were "high", but ground invertebrate biomass suggests risks are "negligible".<br>**Low Risk with High Uncertainty (North Tailings):** Impairment of the invertebrate community at TPN is attributed to habitat and physical disturbance due to a negative relationship between soil and tissue COPC concentrations and invertebrate indices in the overall Site dataset. |
| | 2 | Invertebrate tissue chemistry | ✓ | Low | Moderate (exp) | High (eff) | N/A | N/A | + | | High (exp) | High (eff) | N/A | N/A | + | |
| | 3 | Invertebrate biomass, abundance and richness | ✓ | High | Low | Moderate | Negative; N/A | Moderate | +++ | | Negligible-High (area-specific) | Moderate | Negative; N/A | Moderate (TPN, berm) High (North Tailings) | +++ | |
| Birds[6] | 1 | Incidental bird tissue chemistry | ✓ | Low | N/A | N/A | N/A | N/A | N/A | **Common birds (junco, c. sparrow, chickadee, jay) - Low Risk with High Uncertainty** | High (exp) | High (eff) | N/A | N/A | + | **Common birds (junco, c. sparrow, chickadee, jay) - Low Risk with High Uncertainty** |
| | 2 | Food chain model | ✓ | Moderate | Low-High (ROC-specific) | Moderate-High (ROC-specific) | N/A; Plausible | High | +++ | **Listed birds (L, L*) (c. sparrow, kestrel, chickadee, jay, w. sparrow) - Moderate Risk with Moderate Uncertainty**<br>**Common birds (warbler) - Moderate Risk with High Uncertainty** | Low-High (ROC-specific) | Moderate-High (ROC-specific) | N/A; Plausible | High | +++ | **Listed birds (L, L*) (c. sparrow, kestrel, chickadee, jay, w. sparrow) - Moderate Risk with Moderate Uncertainty**<br>**Common birds (warbler) - Moderate Risk with High Uncertainty** |
| | 3 | Plant and invertebrate LOEs | ✓ | Low | Low (see above) | Moderate (see above) | see above | see above | + | **Listed birds (L, L*) (warbler, y. flycatcher) - High Risk with Moderate Uncertainty**<br>Risks were based on food chain model predictions. Plant and invertebrate LOEs suggest low potential risk with moderate uncertainty for COPC-related impacts to wildlife food and habitat at this AEC. | High (tailings); Negligible (TPN); Low (berm) (see above) | High (Tailings); Moderate (TPN, berm) (see above) | see above | see above | + | **Listed birds (L, L*) (warbler, y. flycatcher) - High Risk with Moderate Uncertainty**<br>Risks were primarily based on food chain model predictions, which was supported by bird tissue chemistry. Plant LOEs suggest high potential risk from COPC-related impact to wildlife habitat/food overtop of tailings deposits under current conditions, but low risk elsewhere in the AEC. |
| Mammals[6] | 1A | Small mammal tissue chemistry | ✓ | Low | High (exp) | High (eff) | N/A | N/A | + | **Common mammals (vole, porcupine, hare) - Low Risk with Low Uncertainty** | Moderate (exp) | High (eff) | N/A | N/A | + | **Common mammals (vole, porcupine, hare) - Low Risk with Low Uncertainty** |
| | 1B | Hare and moose fecal pellet chemistry | ✓ | Low | Low (hare) (exp) | High (eff) | N/A | N/A | + | **Common mammals (shrew, mouse) - Moderate Risk with High Uncertainty:**<br>The food chain model and field survey LOEs were most heavily weighted LOEs, but they did not agree for this AEC. Slightly higher weighting was applied to the food chain model because of the coarse resolution of the field survey, so "low" or "moderate" risk ratings with low or high uncertainty (ROC-specific) were derived. Both primary LOEs are associated with a high degree of uncertainty. Small mammal tissue chemistry indicated high exposure, and hare feces suggested low exposure (but elevated over background). Plant and invertebrate LOEs suggest low potential risk with moderate uncertainty for COPC-related impacts to wildlife food and habitat at this AEC. | High (hare, moose) (exp) | High (eff) | N/A | N/A | + | **Common mammals (shrew, mouse) - Moderate Risk with High Uncertainty:**<br>The food chain model and field survey LOEs were most heavily weighted LOEs, but they did not agree for this AEC. Slightly higher weighting was applied to the food chain model because of the coarse resolution of the field survey, so "low" or "moderate" risk ratings with low or high uncertainty (ROC-specific) were derived. Both primary LOEs are associated with a high degree of uncertainty. Small mammal tissue chemistry, as well as hare and moose feces, indicated high exposure in this AEC. Plant and invertebrate LOEs suggest high potential risk from COPC-related impact to wildlife habitat/food overtop of tailings deposits under current conditions, but low risk elsewhere in the AEC. |
| | 2 | Food chain model | ✓ | Moderate | Low-Moderate (ROC-specific) | Low-High (ROC-specific) | N/A; Plausible | High | +++ | | Low-Moderate (ROC-specific) | Low-High (ROC-specific) | N/A; Plausible | High | +++ | |
| | 3 | Field survey using trapping | ✓ | Moderate | Negligible | High | Negative; N/A | Low | ++ | | Low | High | None; N/A | Low | ++ | |
| | 4 | Plant and invertebrate LOEs | ✓ | Low | Low (see above) | Moderate (see above) | see above | see above | + | | High (tailings); Negligible (TPN); Low (berm) (see above) | High (Tailings); Moderate (TPN, berm) (see above) | see above | see above | + | |

[1] Data quality - a check mark indicates acceptable data quality; and an "x" indicates unacceptable data quality
[2] Magnitude considers degree of contamination or effect size, as well as spatial extent and temporal representativeness
[3] Causality considers strength of correlation and supporting evidence
[4] Risk characterization considers concordance among LOEs and provides an overall risk and uncertainty rating
[5] See Section 3 figures for risk and uncertainty ratings by ROC.
[6] (L) - denotes listed species.

Risk Ratings (See section 3 figures for risk and uncertainty ratings):

Green = Negligible-Low Risk
Yellow = Moderate Risk
Red = High Risk

**Table 3-1: WOE risk characterization summary for Sä Dena Hes terrestrial ERA - Current conditions.**

| | | | All AECs | | Risk Evaluation - Overall Mine Site Scenario | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Data Quality[1] | Eco Relevance | Magnitude[2] | Uncertainty | Causality[3] | Uncertainty | LOE Weighting | Risk Characterization[4] |
| Microbial Communities | 1 | Plant and Invertebrate LOEs | ✓ | Moderate | - N/A - | | | | | |
| Terrestrial Plants | 1 | Soil chemistry | ✓ | Low | - N/A - | | | | | |
| | 2 | Plant tissue chemistry | ✓ | Low | | | | | | |
| | 3 | Qualitative field survey & plant colonization | ✓ | High | | | | | | |
| Terrestrial Invertebrates | 1 | Soil chemistry | ✓ | Low | - N/A - | | | | | |
| | 2 | Invertebrate tissue chemistry | ✓ | Low | | | | | | |
| | 3 | Invertebrate biomass, abundance and richness | ✓ | High | | | | | | |
| Birds[6] | 1 | Incidental bird tissue chemistry | ✓ | Low | N/A | N/A | N/A | N/A | N/A | **Great gray owl (L), boreal owl (C) - Low Risk with Low Uncertainty** |
| | 2 | Food chain model | ✓ | Moderate | Low-High (ROC-specific) | Low-Moderate (ROC-specific) | N/A; Plausible | High | +++ | **Barn swallow (L) - High Risk with Moderate Uncertainty**<br>Risk predictions based on food chain model predictions. |
| | 3 | Plant and invertebrate LOEs | ✓ | Low | N/A | N/A | N/A | N/A | N/A | |
| Mammals[6] | 1A | Small mammal tissue chemistry | ✓ | Low | N/A | N/A | N/A | N/A | N/A | **All mammals (moose, caribou (L), b. bear, marten (L), lynx, wolverine (L), myotis (L)) - Negligible or Low Risk with Low Uncertainty:**<br>Risk predictions based on the food chain model LOE. |
| | 1B | Hare and moose fecal pellet chemistry | ✓ | Low | N/A | N/A | N/A | N/A | N/A | |
| | 2 | Food chain model | ✓ | Moderate | Negligible-Low (ROC-specific) | Low | N/A; Plausible | High | +++ | |
| | 3 | Field survey using trapping | ✓ | Moderate | N/A | N/A | N/A | N/A | N/A | |
| | 4 | Plant and invertebrate LOEs | ✓ | Low | N/A | N/A | N/A | N/A | N/A | |

[1] Data quality - a check mark indicates acceptable data quality; and an "x" indicates unacceptable data quality
[2] Magnitude considers degree of contamination or effect size, as well as spatial extent and temporal representativen
[3] Causality considers strength of correlation and supporting evidence
[4] Risk characterization considers concordance among LOEs and provides an overall risk and uncertainty rat
[5] See Section 3 figures for risk and uncertainty ratings by ROC.
[6] (L) - denotes listed species.

Risk Ratings (See section 3 figures for risk and uncertainty ratings):

Green = Negligible-Low Risk
Yellow = Moderate Risk
Red = High Risk

**Table 3-2: WOE risk characterization summary for Sä Dena Hes terrestrial ERA - Future (post-closure) conditions.**

| | | | All AECs | | Burnick/1300 Portal | | | | | | Jewelbox/Main Zone/1380 Gully/1250 Portal | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Data Quality[1] | Eco Relevance | Magnitude[2] | Uncertainty | Causality[3] | Uncertainty | LOE Weighting | Risk Characterization[4] | Magnitude[2] | Uncertainty | Causality[3] | Uncertainty | LOE Weighting | Risk Characterization[4] |
| Microbial Communities | 1 | Plant and Invertebrate LOEs | ✓ | Moderate | Low (see below) | Moderate (see below) | see below | see below | ++ | **Low Risk with Moderate Uncertainty** (based on plant and invertebrate LOEs) | Low (see below) | Moderate (see below) | see below | see below | ++ | **Low Risk with Moderate Uncertainty** (based on plant and invertebrate LOEs) |
| Terrestrial Plants | 1 | Soil chemistry | ✓ | Low | High | High (eff) | N/A; Plausible | High | + | **Low Risk with High Uncertainty:** Exposure based LOEs are "high" or "moderate" but the qualitative survey suggests risks are "low", and more weighting was applied to this LOE. Closure activities in this area are expected to address any factors limiting plant growth in some portions of this AEC. | High[5] | High (eff) | N/A; Plausible | High | + | **Negligible Risk with High Uncertainty:** Exposure based LOEs remain "high" in the future scenario, but the qualitative survey suggests risks are "low", and more weighting was applied to this LOE. Closure activities in this area are expected to address any factors limiting plant growth in some portions of this AEC. |
| | 2 | Plant tissue chemistry | ✓ | Low | Moderate (exp) | High (eff) | N/A | N/A | + | | High (exp) | High (eff) | N/A | N/A | + | |
| | 3 | Qualitative field survey & plant colonization | ✓ | High | Low | High | Negative; Plausible | Moderate | +++ | | Negligible | High | Negative; Plausible | Moderate | +++ | |
| Terrestrial Invertebrates | 1 | Soil chemistry | ✓ | Low | High | High (eff) | N/A; Plausible | High | + | **Negligible Risk with Moderate Uncertainty:** Soil chemistry is expected to remain "high" in the 1300 Portal area, but ground invertebrate chemistry and biomass suggests risks are currently "low". More weighting was applied to the invertebrate chemistry and biomass LOEs, particularly biomass, as it is more closely related to the assessment endpoint for invertebrates. | High[5] | High (eff) | N/A; Plausible | High | + | **Negligible Risk with Moderate Uncertainty:** Soil and invertebrate chemistry LOEs remain "high" in the future scenario, but ground invertebrate biomass suggests risks are currently "negligible". More weighting was applied to the invertebrate biomass LOE, as it is more closely related to the assessment endpoint for invertebrates. |
| | 2 | Invertebrate tissue chemistry | ✓ | Low | Negligible (exp) | High (eff) | N/A | N/A | + | | High (exp) | High (eff) | N/A | N/A | + | |
| | 3 | Invertebrate biomass, abundance and richness | ✓ | High | Negligible | Moderate | Negative; N/A | Moderate | +++ | | Negligible | Moderate | Negative; N/A | Moderate | +++ | |
| Birds | 1 | Incidental bird tissue chemistry | ✓ | Low | N/A | N/A | N/A | N/A | N/A | **Listed birds (L, L*) (c. sparrow, warbler, chickadee, y. flycatcher, w. sparrow) - Low Risk with Moderate Uncertainty**<br><br>**Common birds (junco, chickadee, c. sparrow, warbler) - Low Risk with Low Uncertainty:**<br><br>Risks were based on food chain model predictions. Plants and invertebrate LOEs suggest low potential risk with moderate uncertainty for COPC-related impacts to wildlife food and habitat at this AEC. | N/A | N/A | N/A | N/A | N/A | **Common birds (junco, c. sparrow, jay) - Low Risk with High Uncertainty** |
| | 2 | Food chain model | ✓ | Moderate | Low | Low-Moderate (ROC-specific) | N/A; Plausible | High | +++ | | Moderate-High (ROC-specific) | Moderate-High (ROC-specific) | N/A; Plausible | High | +++ | **Listed birds (L, L*) (c. sparrow, kestrel, jay, w. sparrow) - Moderate Risk with Moderate Uncertainty**<br>**Common birds (warbler, chickadee) - Moderate Risk with High Uncertainty** |
| | 3 | Plant and invertebrate LOEs | ✓ | Low | Low (see above) | Moderate (see above) | see above | see above | + | | Negligible (see above) | Moderate (see above) | see above | see above | + | **Listed birds (L, L*) (warbler, chickadee) - High Risk with Moderate Uncertainty:**<br>Risks were based on food chain model predictions. Plant and invertebrate LOEs suggest low potential risk with moderate uncertainty for COPC-related impacts to wildlife food and habitat at this AEC. |
| Mammals | 1A | Small mammal tissue chemistry | ✓ | Low | Low (exp) | High (eff) | N/A | N/A | + | **Common mammals (vole, marmot, porcupine, shrew, mouse, squirrel, hare) - Low Risk with Low Uncertainty:**<br><br>The food chain model and field survey LOEs were most heavily weighted in the WOE, and there was agreement between these LOEs for this AEC. Results of these LOEs were supported by small mammal tissue chemistry, and hare feces chemistry (which were less than 3-fold higher than background). Plant and invertebrate LOEs suggest low potential risk with moderate uncertainty for COPC-related impacts to wildlife food and habitat at this AEC. | Moderate (exp) | High (eff) | N/A | N/A | + | **Common mammals (vole, marmot, porcupine, squirrel) - Low Risk with Low Uncertainty** |
| | 1B | Hare and moose fecal pellet chemistry | ✓ | Low | Low (hare) (exp) | High (eff) | N/A | N/A | + | | High (moose) (exp) | High (eff) | N/A | N/A | + | **Common mammals (shrew, mouse, hare) - Moderate/High Risk with High Uncertainty:**<br>The food chain model and field survey LOEs were most heavily weighted in the WOE, and the small mammal catch data from 1380 Gully is emphasized, and there was agreement between the model and survey from the 1380 Gully. Results of these LOEs were supported by small mammal tissue chemistry, and moose feces chemistry. Residual risks in the food chain model are driven by high metals concentrations in soils and tissues within the 1380 Gully, where no remedial works are planned. Plant and invertebrate LOEs suggest negligible potential risk with moderate uncertainty for COPC-related impacts to wildlife food and habitat at this AEC. |
| | 2 | Food chain model | ✓ | Moderate | Negligible | Low | N/A; Plausible | High | +++ | | Low-Moderate (ROC-specific) | Low-High (ROC-specific) | N/A; Plausible | High | +++ | |
| | 3 | Field survey using trapping | ✓ | Moderate | Negligible | High | Negative; N/A | Low | ++ | | Negligible (JBX); High (1380 Gully) | High | Negative; N/A (JBX) Moderate, Positive; Plausible (1380 Gully) | Low (JBX); High (1380 Gully) | ++ | |
| | 4 | Plant and invertebrate LOEs | ✓ | Low | Low (see above) | Moderate (see above) | see above | see above | + | | Negligible (see above) | Moderate (see above) | see above | see above | + | |

[1] Data quality - a check mark indicates acceptable data quality; and an "x" indicates unacceptable data quality
[2] Magnitude considers degree of contamination or effect size, as well as spatial extent and temporal representativeness
[3] Causality considers strength of correlation and supporting evidence
[4] Risk characterization considers concordance among LOEs and provides an overall risk and uncertainty rating
[5] Ratings are based on the highest of AEC 1 (Jewelbox Hill) and AEC 9 (Main Zone, 1380 Gully, 1250 Portal) in the future scenario
[6] See Section 3 figures for risk and uncertainty ratings by ROC.
[7] (L) - denotes listed species.

Risk Ratings (See section 3 figures for risk and uncertainty ratings):

Green = Negligible or Low Risk
Yellow = Moderate Risk
Red = High Risk

**Table 3-2: WOE risk characterization summary for Sä Dena Hes terrestrial ERA - Future (post-closure) conditions.**

| | | | All AECs | | Mill Site | | | | | | Tailings Management Facility | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Data Quality[1] | Eco Relevance | Magnitude[2] | Uncertainty | Causality[3] | Uncertainty | LOE Weighting | Risk Characterization[4] | Magnitude[2] | Uncertainty | Causality[3] | Uncertainty | LOE Weighting | Risk Characterization[4] |
| Microbial Communities | 1 | Plant and Invertebrate LOEs | ✓ | Moderate | Low (see below) | Moderate (see below) | see below | see below | ++ | **Low Risk with Moderate Uncertainty** (based on plant and invertebrate LOEs) | Low (see below) | Moderate (see below) | see below | see below | ++ | **Low Risk with Moderate Uncertainty** (based on plant and invertebrate LOEs) |
| Terrestrial Plants | 1 | Soil chemistry | ✓ | Low | Low | High (eff) | N/A; Plausible | High | + | **Low Risk with Moderate Uncertainty:** The plant tissue LOE is "high", but soil quality is expected to be improved in the future based on remediation plans. As well, the qualitative survey suggests risks are "low", and more weighting was applied to this LOE than the others. Reclamation and remediation plans are expected to address any factors limiting plant recolonization in the disturbed portion of the Mill Site. | Moderate | High (eff) | N/A; Plausible | High | + | **Negligible (TPN) to Low (TPN-West berm) Risk with Low Uncertainty**<br>**Tailings - Low Risk with Moderate Uncertainty:** At the TMF, results of the alder planting trial and the test plots over soil covers were emphasized for the future scenario because these plant colonization studies were specific to this AEC and there was less uncertainty in the findings, relative to the qualitative habitat survey. Studies showed good growth in alder planted with a 300 mm soil cover and recolonization in test plots seeded and fertilized over a soil cover of at least 200 mm. |
| | 2 | Plant tissue chemistry | ✓ | Low | High (exp) | High (eff) | N/A | N/A | + | | High (exp) | High (eff) | N/A | N/A | + | |
| | 3 | Qualitative field survey & plant colonization | ✓ | High | Low | Moderate | Negative; Plausible | Moderate | +++ | | Negligible-Low (area-specific) | Low-Moderate (area-specific) | None; N/A (Tailings) Negative; Plausible (TPN, berm) | Moderate | +++ | |
| Terrestrial Invertebrates | 1 | Soil chemistry | ✓ | Low | Low | High (eff) | N/A; Plausible | High | + | **Negligible Risk with Moderate Uncertainty:** Soil and invertebrate chemistry LOEs are expected to be "low" in the future scenario, and ground and flying invertebrate biomass LOEs are currently "low" expected to be "negligible" in the future after reclamation of the site. More weighting was applied to the invertebrate biomass LOE, as it is more closely related to the assessment endpoint for invertebrates. | Moderate | High (eff) | N/A; Plausible | High | + | **TPN, TPN-West berm - Negligible Risk with Moderate Uncertainty**<br>**Tailings - Low Risk with Moderate Uncertainty:** Soil and invertebrate chemistry LOEs are expected to be "moderate" in the future scenario, and ground invertebrate biomass suggests risks are currently "negligible" for the TPN and TPN-West berm areas. After remediation of the TMF, future risks to invertebrates are predicted to be "low" on the tailings areas. |
| | 2 | Invertebrate tissue chemistry | ✓ | Low | Low (exp) | High (eff) | N/A | N/A | + | | Moderate (exp) | High (eff) | N/A | N/A | + | |
| | 3 | Invertebrate biomass, abundance and richness | ✓ | High | Negligible | Moderate | Negative; N/A | Moderate | +++ | | Negligible-Low (area-specific) | Moderate | Negative; N/A | Moderate | +++ | |
| Birds | 1 | Incidental bird tissue chemistry | ✓ | Low | N/A | N/A | N/A | N/A | N/A | **All birds - Negligible-Low Risk with Low Uncertainty:**<br>Risks were based on food chain model predictions. Plant and invertebrate LOEs suggest low potential risk with moderate uncertainty for COPC-related impacts to wildlife food and habitat at this AEC. | Moderate (exp) | High (eff) | N/A | N/A | + | **Common birds (warbler, chickadee, jay) - Low Risk with Low Uncertainty**<br>**Listed (L*) birds (warbler, chickadee, jay) - Low Risk with Moderate Uncertainty**<br>**Other birds - Negligible Risk with Low Uncertainty:**<br>Risks were primarily based on food chain model predictions. Bird tissue chemistry is expected to improve assuming remediation of AEC 8 in the future scenario. Plant and invertebrate LOEs do not suggest potential for COPC-related impacts to wildlife food and habitat at this AEC. |
| | 2 | Food chain model | ✓ | Moderate | Negligible-Low (ROC-specific) | Low | N/A; Plausible | High | +++ | | Negligible-Low (ROC-specific) | Low-Moderate (ROC-specific) | N/A; Plausible | High | +++ | |
| | 3 | Plant and invertebrate LOEs | ✓ | Low | Low (see above) | Moderate (see above) | see above | see above | + | | Low (see above) | Moderate (see above) | see above | see above | + | |
| Mammals | 1A | Small mammal tissue chemistry | ✓ | Low | Low (exp) | High (eff) | N/A | N/A | + | **Common mammals (mouse, vole, porcupine, hare) - Negligible Risk with Low Uncertainty**<br>**Common mammal (shrew) - Low Risk with High Uncertainty:**<br>The food chain model and field survey LOEs were most heavily weighted LOEs, and for the future scenario, these LOEs agree. Exposure represented by small mammal tissue chemistry, and hare feces chemistry is expected to improved after closure, so exposure LOEs are rated as "low". Plant and invertebrate LOEs suggest low potential risk with moderate uncertainty for COPC-related impacts to wildlife food and habitat at this AEC. | Moderate (exp) | High (eff) | N/A | N/A | + | **Common mammals (mouse, vole, porcupine, hare) - Negligible Risk with Low Uncertainty**<br>**Common mammal (shrew) - Low Risk with Low Uncertainty:**<br>The food chain model and field survey LOEs were most heavily weighted LOEs, and for the future scenario, these LOEs agree. While small mammal tissue chemistry is expected to improve overtop the clean soil cover in the future scenario; elevated metals in TPN may not be addressed (so these LOEs were rated as "moderate"). Plant and invertebrate LOEs suggest low potential risk with moderate uncertainty for COPC-related impacts to wildlife food and habitat at this AEC. |
| | 1B | Hare and moose fecal pellet chemistry | ✓ | Low | Low (hare) (exp) | High (eff) | N/A | N/A | + | | Moderate (hare, moose) (exp) | High (eff) | N/A | N/A | + | |
| | 2 | Food chain model | ✓ | Moderate | Negligible-Low (ROC-specific) | Low | N/A; Plausible | High | +++ | | Negligible-Low (ROC-specific) | Low | N/A; Plausible | High | +++ | |
| | 3 | Field survey using trapping | ✓ | Moderate | Negligible | High | Negative; N/A | Low | ++ | | Negligible-Low | High | None; N/A | Low | ++ | |
| | 4 | Plant and invertebrate LOEs | ✓ | Low | Low (see above) | Moderate (see above) | see above | see above | + | | Low (see above) | Moderate (see above) | see above | see above | + | |

[1] Data quality - a check mark indicates acceptable data quality; and an "x" indicates unacceptable data quality
[2] Magnitude considers degree of contamination or effect size, as well as spatial extent and temporal repr
[3] Causality considers strength of correlation and supporting evidence
[4] Risk characterization considers concordance among LOEs and provides an overall risk and uncertainty rating
[5] Ratings are based on the highest of AEC 1 (Jewelbox Hill) and AEC 9 (Main Zone, 1380 Gully, 1250 Portal) in the future scenario
[6] See Section 3 figures for risk and uncertainty ratings by ROC.
[7] (L) - denotes listed species.

Risk Ratings (See section 3 figures for risk and uncertainty ratings):

Green = Negligible or Low Risk
Yellow = Moderate Risk
Red = High Risk

**Table 3-2: WOE risk characterization summary for Sä Dena Hes terrestrial ERA - Future (post-closure) conditions.**

| | | | All AECs | | Risk Evaluation - Overall Mine Site Scenario | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Data Quality[1] | Eco Relevance | Magnitude[2] | Uncertainty | Causality[3] | Uncertainty | LOE Weighting | Risk Characterization[4] |
| Microbial Communities | 1 | Plant and Invertebrate LOEs | ✓ | Moderate | - N/A - | | | | | |
| Terrestrial Plants | 1 | Soil chemistry | ✓ | Low | - N/A - | | | | | |
| | 2 | Plant tissue chemistry | ✓ | Low | | | | | | |
| | 3 | Qualitative field survey & plant colonization | ✓ | High | | | | | | |
| Terrestrial Invertebrates | 1 | Soil chemistry | ✓ | Low | - N/A - | | | | | |
| | 2 | Invertebrate tissue chemistry | ✓ | Low | | | | | | |
| | 3 | Invertebrate biomass, abundance and richness | ✓ | High | | | | | | |
| Birds | 1 | Incidental bird tissue chemistry | ✓ | Low | N/A | N/A | N/A | N/A | N/A | **Great gray owl (L), boreal owl (C) - Low Risk with Low Uncertainty** |
| | 2 | Food chain model | ✓ | Moderate | Low-Moderate (ROC-specific) | Low-Moderate (ROC-specific) | N/A; Plausible | High | +++ | **Barn swallow (L) - Moderate Risk with Moderate Uncertainty**<br>Risk predictions based on food chain model predictions. |
| | 3 | Plant and invertebrate LOEs | ✓ | Low | N/A | N/A | N/A | N/A | N/A | |
| Mammals | 1A | Small mammal tissue chemistry | ✓ | Low | N/A | N/A | N/A | N/A | N/A | **All mammals (moose, caribou (L), b. bear, marten (L), lynx, wolverine (L), myotis (L)) - Negligible or Low Risk with Low Uncertainty:**<br>Risk predictions based on the food chain model LOE. |
| | 1B | Hare and moose fecal pellet chemistry | ✓ | Low | N/A | N/A | N/A | N/A | N/A | |
| | 2 | Food chain model | ✓ | Moderate | Negligible-Low (ROC-specific) | Low | N/A; Plausible | High | +++ | |
| | 3 | Field survey using trapping | ✓ | Moderate | N/A | N/A | N/A | N/A | N/A | |
| | 4 | Plant and invertebrate LOEs | ✓ | Low | N/A | N/A | N/A | N/A | N/A | |

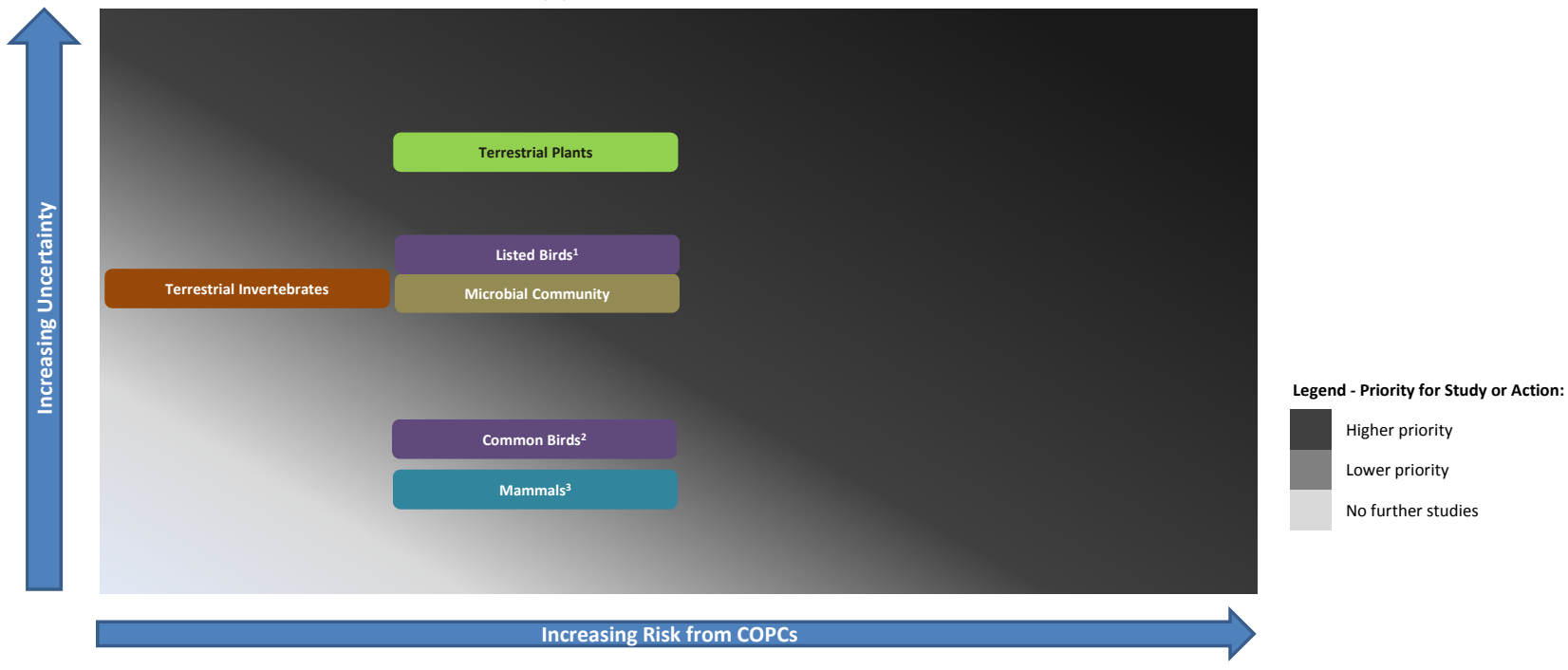
[1] Data quality - a check mark indicates acceptable data quality; and an "x" indicates unacceptable data quality
[2] Magnitude considers degree of contamination or effect size, as well as spatial extent and temporal representativen
[3] Causality considers strength of correlation and supporting evidence
[4] Risk characterization considers concordance among LOEs and provides an overall risk and uncertainty rating
[5] Ratings are based on the highest of AEC 1 (Jewelbox Hill) and AEC 9 (Main Zone, 1380 Gully, 1250 Portal) in the fut
[6] See Section 3 figures for risk and uncertainty ratings by ROC.
[7] (L) - denotes listed species.

Risk Ratings (See section 3 figures for risk and uncertainty ratings):

Green = Negligible or Low Risk
Yellow = Moderate Risk
Red = High Risk

Figure 3-1: Summary of Risk Predictions and Uncertainties and Relative Priorities for the Terrestrial ERA for the Sä Dena Hes Mine Site - Burnick/1300 Portal. (A) Current Scenario - top panel, (B) Future scenario - bottom panel.

**(A) CURRENT SCENARIO**



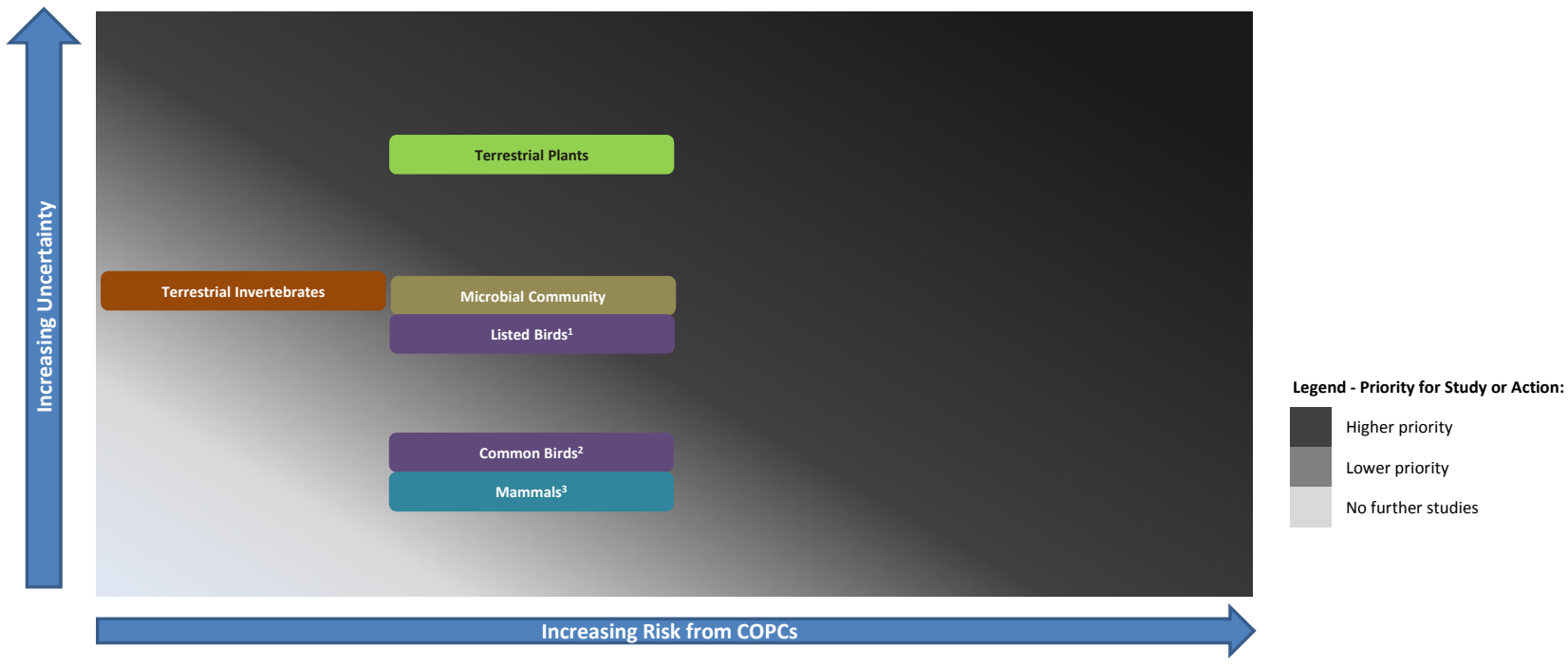

**Notes:**

[1] Listed or Listed Surrogate: C. sparrow, warbler, chickadee, y. flycatcher, w. sparrow

[2] Common: Junco, chickadee, c. sparrow, warbler

[3] Common: Vole, marmot, porcupine, shrew, mouse, squirrel, hare

**(B) FUTURE SCENARIO**




**Notes:**

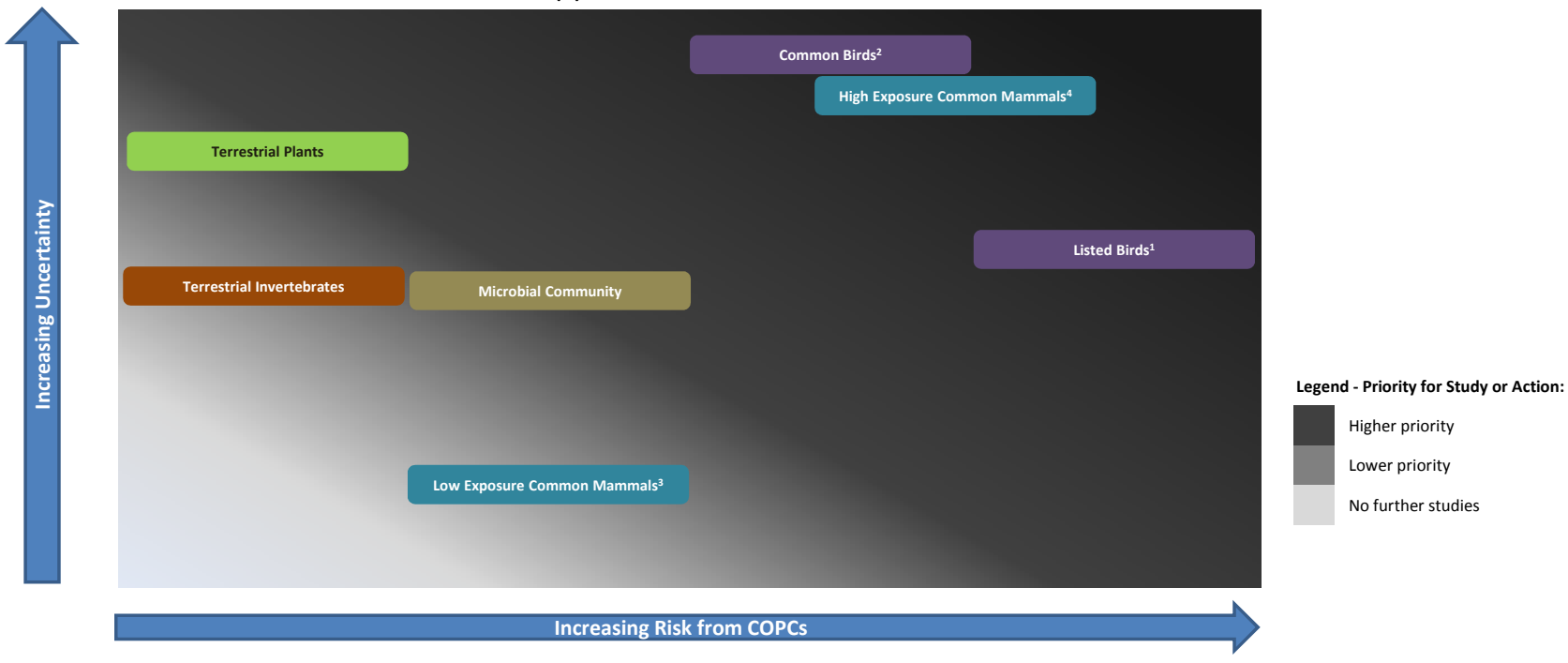
[1] Listed or Listed Surrogates: C. sparrow, warbler, chickadee, y. flycatcher, w. sparrow

[2] Common: Junco, chickadee, c. sparrow, warbler

[3] Common: Vole, marmot, porcupine, shrew, mouse, squirrel, hare

**Figure 3-2: Summary of Risk Predictions and Uncertainties and Relative Priorities for the Terrestrial ERA for the Sä Dena Hes Mine Site - Jewelbox/Main Zone/1380 Gully/1250 Portal. (A) Current Scenario - top panel, (B) Future scenario - bottom panel.**

**(A) CURRENT SCENARIO**




**Notes:**

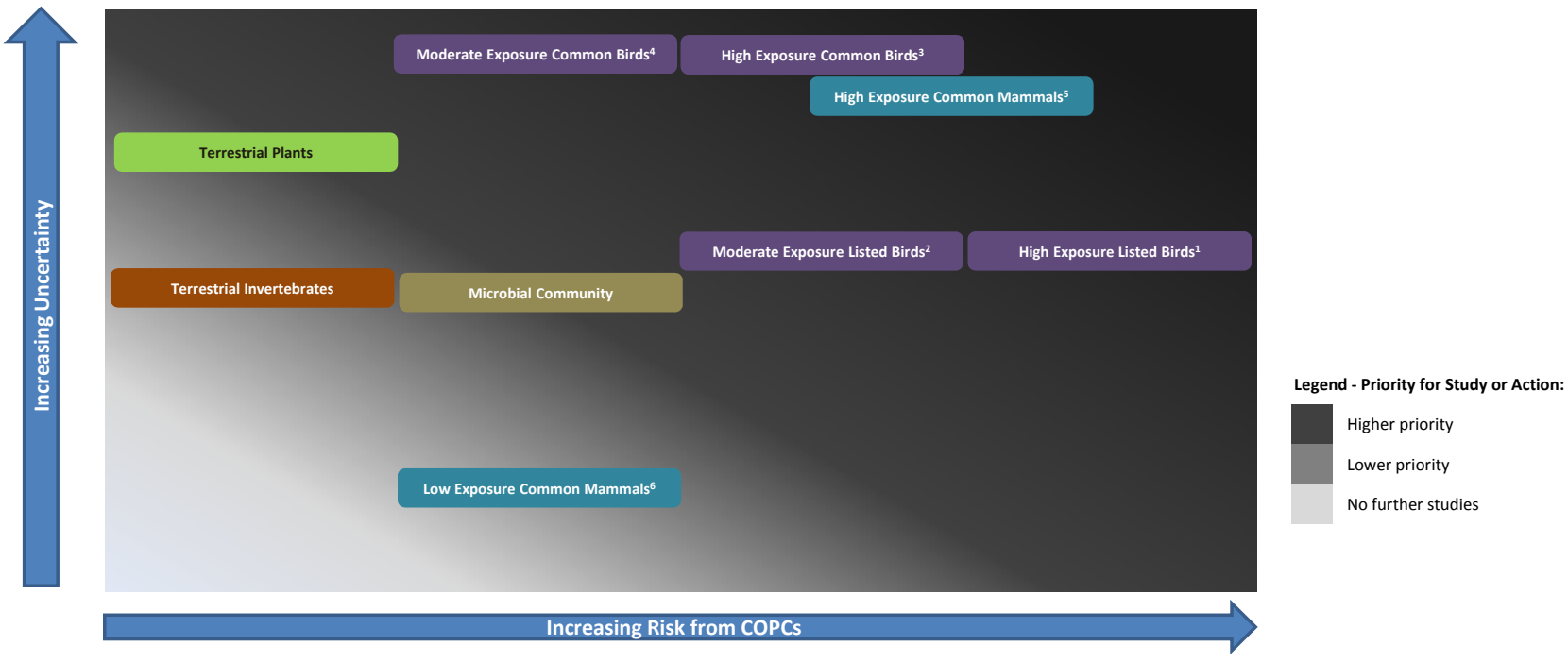
[1] Listed or Listed Surrogates: Warbler, kestrel, y. flycatcher, chickadee

[2] Common: Junco, chickadee, c. sparrow, warbler, jay

[3] Common: Vole, marmot, porcupine

[4] Common: Shrew, mouse, squirrel, hare

**(B) FUTURE SCENARIO***




**Notes:** *Future exposure and potential risks for birds and mammals are driven by the 1380 Gully

[1] Listed or Listed Surrogates: Warbler, chickadee

[2] Listed or Listed Surrogates: C. sparrow, kestrel, jay, w. sparrow

[3] Common: Warbler, chickadee

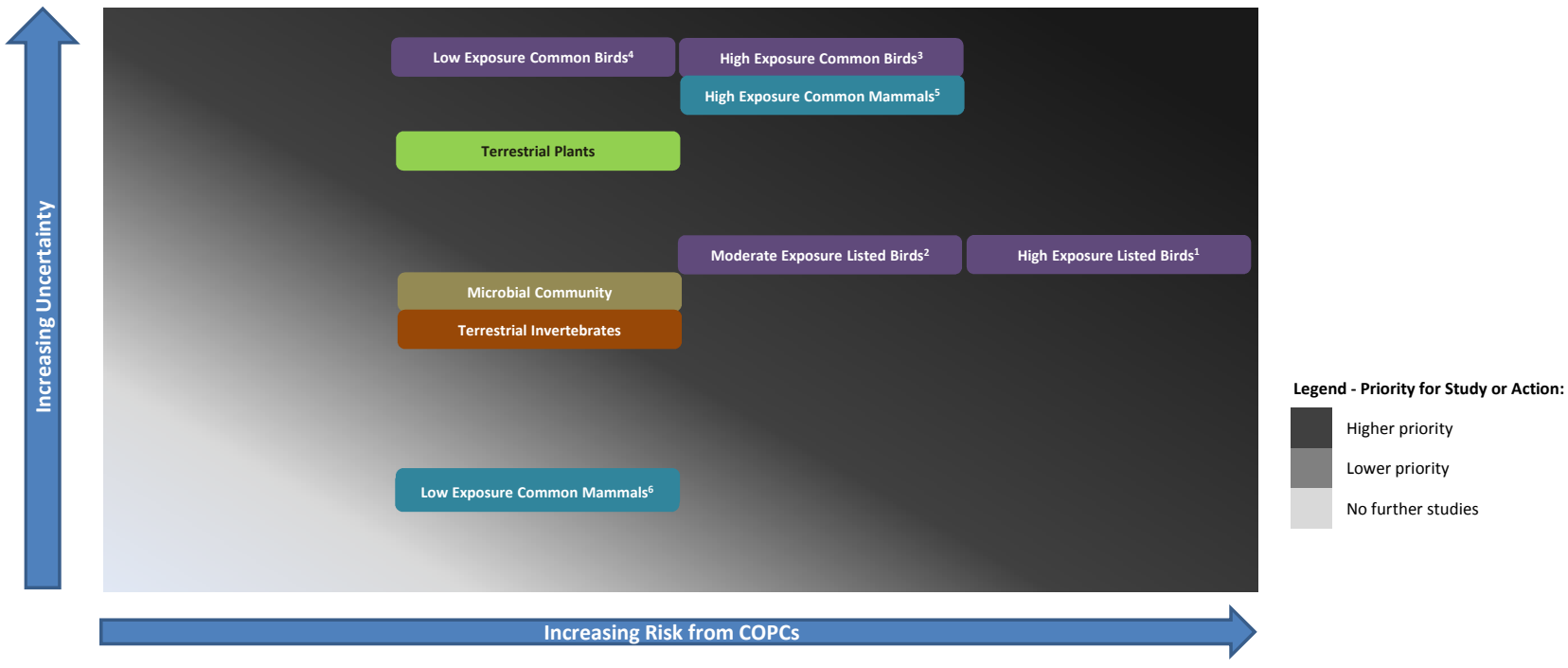
[4] Common: Junco, c. sparrow, jay

[5] Common: Shrew, mouse, hare

[6] Common: Vole, marmot, porcupine, squirrel

Figure 3-3: Summary of Risk Predictions and Uncertainties and Relative Priorities for the Terrestrial ERA for the Sä Dena Hes Mine Site - Mill Site. (A) Current Scenario - top panel, (B) Future scenario - bottom panel.

**(A) CURRENT SCENARIO**




**Notes:**

[1] Listed or Listed Surrogate: Warbler, y. flycatcher

[2] Listed or Listed Surrogate: C. sparrow, chickadee, kestrel, jay, w. sparrow

[3] Common: Warbler

[4] Common: Junco, c. sparrow, chickadee, jay

[5] Common: Shrew, mouse

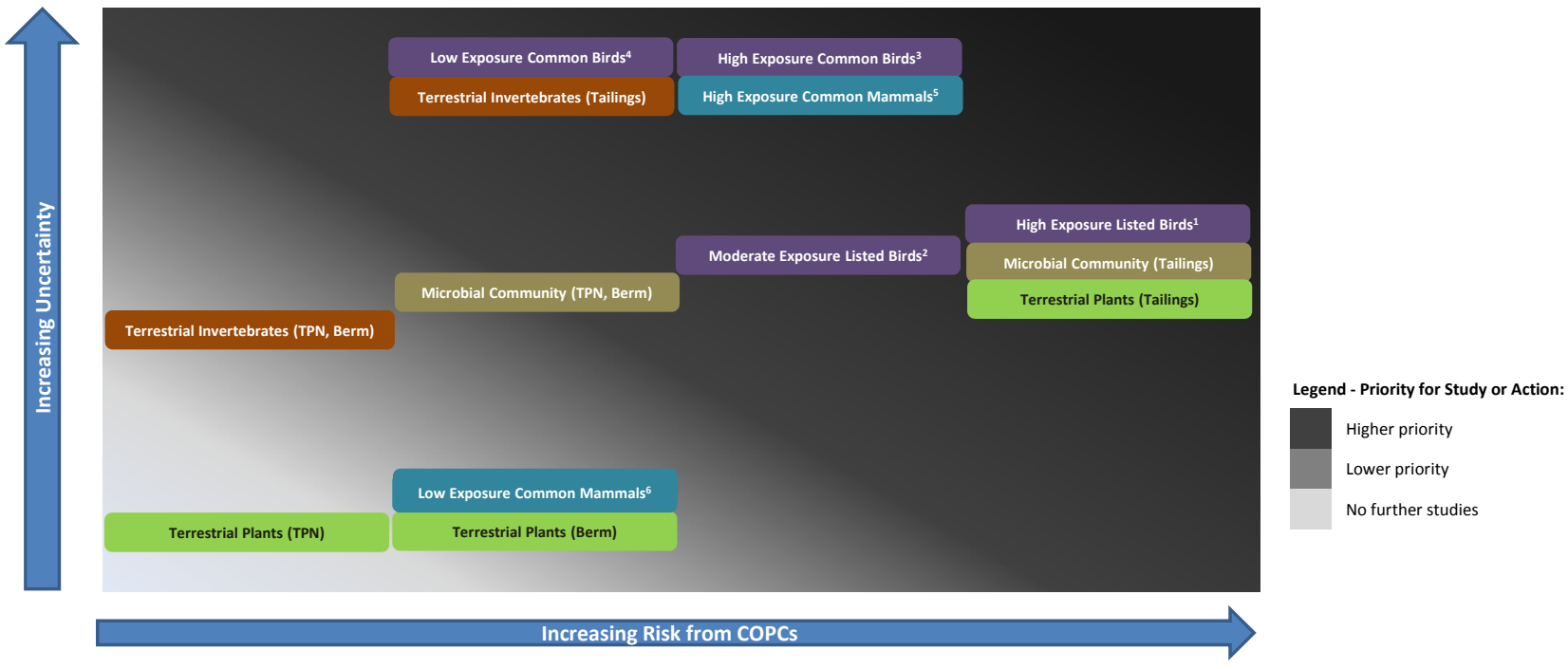
[6] Common: Vole, porcupine, hare

**(B) FUTURE SCENARIO**


**Notes:**

Figure 3-4: Summary of Risk Predictions and Uncertainties and Relative Priorities for the Terrestrial ERA for the Sä Dena Hes Mine Site - Tailings Management Facility. (A) Current Scenario - top panel, (B) Future scenario - bottom panel.

**(A) CURRENT SCENARIO**




**Notes:**

[1] Listed or Listed Surrogate: Warbler, y. flycatcher

[2] Listed or Listed Surrogate: C. sparrow, chickadee, kestrel, jay, w. sparrow

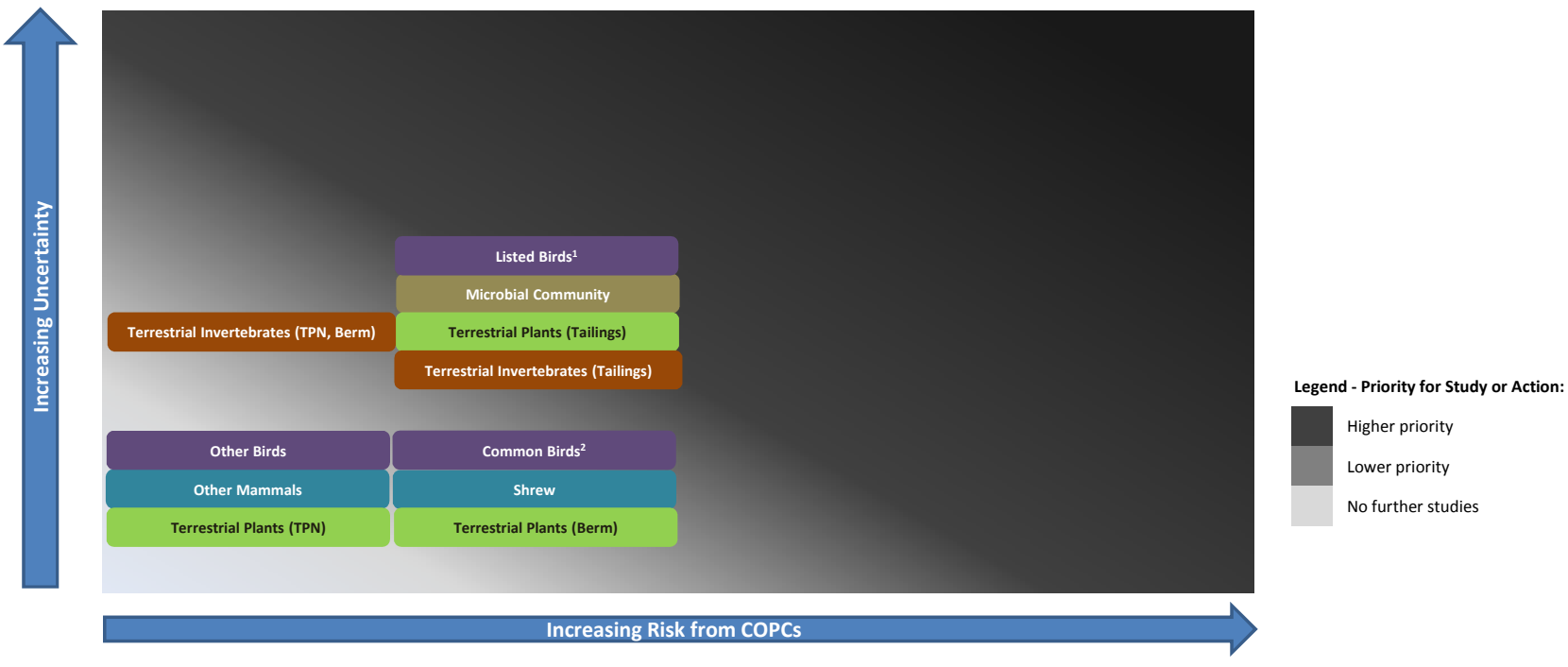
[3] Common: Warbler

[4] Common: Junco, c. sparrow, chickadee, jay

[5] Common: Shrew, mouse

[6] Common: Vole, porcupine, hare

**(B) FUTURE SCENARIO**



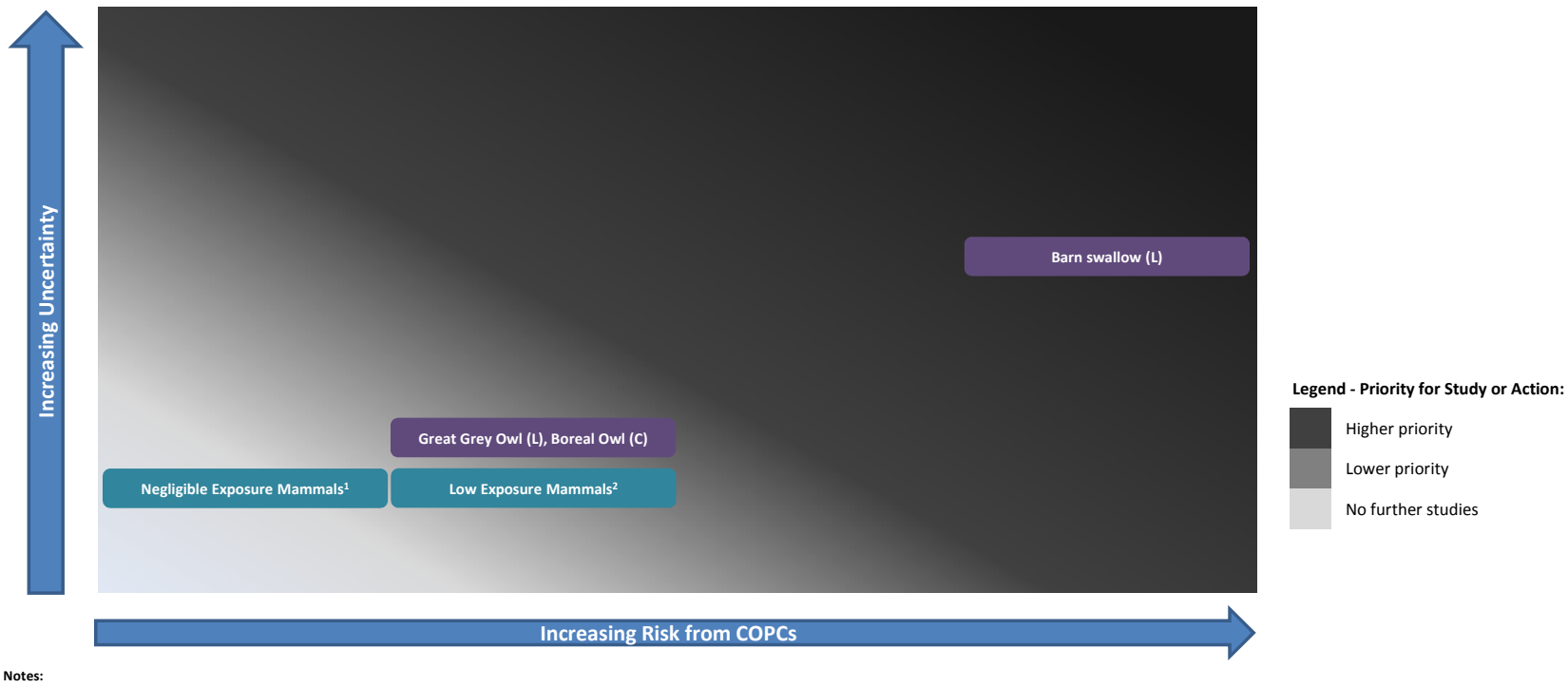

**Notes:**

[1] Listed or Listed Surrogate: Warbler, chickadee, jay

[2] Common: Warbler, chickadee, jay

Figure 3-5: Summary of Risk Predictions and Uncertainties and Relative Priorities for the Terrestrial ERA for the Sä Dena Hes Mine Site - Overall Mine Site (Large Home Range ROCs). (A) Current Scenario - top panel, (B) Future scenario - bottom panel.

**(A) CURRENT SCENARIO**




**Notes:**

[1] Moose (C), caribou (L), b. bear (C), lynx (C)

[2] Marten (L), wolverine (L), myotis (L))

**(B) FUTURE SCENARIO**


**Notes:**

[1] Moose (C), caribou (L), b. bear (C), lynx (C), wolverine (L),

[2] Marten (L), myotis (L))

# 4. IMPLICATIONS FOR RISK MANAGEMENT

## 4.1. Decision-making Framework

The Draft TERA for the Sä Dena Hes Mine Site is meant to provide Teck with information for risk management decision-making and support closure planning and approval schedules for the Site. Risks to ecological receptors were assessed under current and post-closure (i.e., future) conditions. The decision-making framework was discussed in detail in **Section 3 of Volume 1 of the ERA - Updated Problem Formulation**. To review, results of the risk assessment process will ultimately lead to four possible outcomes for each AEC:

1. *No further action* – Risks are acceptable and either no risk controls are needed or planned risk controls as part of the DDRP (and evaluated in the risk assessment) are sufficient;
2. *Risk controls and/or source removal* – Risks are unacceptable and new/improved risk controls and/or source removal are needed;
3. *Other Solutions*[17] – Risks are unacceptable, however, risk controls and/or source removal are considered impractical or may have greater impact than contamination; and,
4. *Further studies* – Residual uncertainty is considered too large for making sound risk management decisions.

These risk management options are shown conceptually on the risk and uncertainty plot in **Figure 4-1**.

The decision-making process for the Sä Dena Hes Mine (i.e., final closure planning) will be guided by whether predicted ecological and human health risks and associated uncertainties are considered acceptable or not and will require concurrent evaluation of many types of information, such as:

- Results of the HHRA;
- Results of the ERA, specifically the potential magnitude of ecological effects (effect size, spatial extent) associated with exposure to COPCs, and uncertainty in the risk predictions (i.e., degree of confidence in the estimate of magnitude and cause of impact);
- Proposed end-land use scenarios, particularly by the LFN;
- The likelihood of future releases (or increased releases) from contaminant sources at the Site (e.g., changes in groundwater inputs to surface water; potential migration of contaminants through caps (e.g., TMF); possible increases in zinc or cadmium contaminant loads from the 1380 Portal if the natural attenuation capacity of the crushed marble is exhausted);

[17] There are situations, particularly in wildlands settings, where the remedy is more harmful than the contaminant risk and/or where natural mineralization may result in unacceptable risks. In such situations, other solutions (e.g., monitoring, habitat enhancement or restoration in uncontaminated areas) may be considered.

- Input from the LFN and the TWG, as well as any other local stakeholders;
- Input and direction from Yukon regulatory agencies, and
- Teck's environmental policies.

Unlike HHRA, there are no clear, functional criteria established to distinguish acceptable from unacceptable effects in ERA. This is true from both a federal and territorial[18] perspective. Even with some guidance on AELs from the BC MOE, there are technical challenges when attempting to interpret whether risks are acceptable or unacceptable for any particular receptor group at a contaminated site.

What we hope to achieve with this project is to mitigate uncertainty through consultation with stakeholders over the course of the risk assessment process. To-date, this has involved: (1) meetings with regulatory agencies to brief them on Site and approach, (2) discussions with external reviewers (Hemmera) and input on key decisions, and (3) ongoing engagement with the LFN, particularly elders (site visits, meetings, open houses).

## 4.2. Linkage Between ERA Results and Reclamation Plan Activities

To assist Teck in evaluating management options, ERA conclusions for each receptor group ERA and AEC (under present and future scenarios) were depicted in terms of risk (i.e., magnitude of contaminant-related impacts) and in terms of uncertainty (i.e., degree of confidence in the estimate of magnitude and cause of impact) (see **Figure 3-1 to Figure 3-5**). These conclusions can be considered in light of the range of likely management options that might be considered under various scenarios (**Figure 4-1**). Risk predictions by AEC are overlayed on the likely risk management options in **Figure 4-2 to Figure 4-6**. This approach allows for a transparent evaluation of the options available for each ERA conclusion and provides the risk manager with an opportunity to consider other information (outside of ERA) that might be important for decision-making (see **Section 4.1**). Note that while Azimuth does not provide recommendations for specific risk management options, we do identify various tasks that could be implemented if Teck decides that uncertainty needs to be reduced before informed decisions can be made (**Section 4.3**). **Table 4–1** provides a link between Teck's DDRP reclamation plans/options in light of results of the Draft HHRA and Draft ERA, with the intention of identifying areas where the DDRP may require amendment, based on the risk assessment results. An initial version of this table was presented for discussion purposes at a regulatory and LFN stakeholder meeting held in Whitehorse on May 7, 2014.

Highlights of ERA conclusions and options for risk management are summarized by AEC below:

**Burnick Area (1200/1300 Portal) (AEC 2)**

- The DDRP indicates that the crest of the 1200 waste rock will be pulled back onto the bench for stability, and the area will be re-sloped and re-vegetated. No remediation was planned at the

[18] This is also true in BC, from where the Yukon has adopted its CSR and ERA guidance.

1300 Portal, but we understand that, recently, both the 1200 and 1300 benches and upper portions of the waste rock piles have been re-sloped/covered with local soil of undetermined metals concentration, while the lower portions of the 1200 and 1300 waste rock pile remain undisturbed. Updated mapping information and characterization of these areas will be provided by Golder and used in the Updated TERA.

- Any hydrocarbon contaminated soils identified during demolition will be moved elsewhere (e.g., Mill Site) or covered with clean till (see **Table 4–1** for other specific reclamation plans). The pathway analysis from the Interim ERA recommended a 60 cm soil cover over any hydrocarbon contaminated areas at Burnick, based on hoary marmot burrowing depth
- The assumption for the future scenario in the ERA was that the Burnick bench area was covered with clean soil [till] and soil concentrations were set equivalent to background. Concentrations in media from the BRK tissue sampling area are currently similar to background (so BRK concentrations were assumed for the future). HHRA soil samples (fine grain) from the 1300 Portal bench and vegetation measured nearby were used for both the current and future scenarios, because it was thought that there would be no remediation in this area.
- In the ERA, current risks for most terrestrial ROC groups (microbes, invertebrates, birds, and mammals) for the Burnick AEC were considered negligible or low with low or moderate uncertainty, depending on the ROC. For plants, risks were also considered low, but the associated uncertainty in the risk prediction was high (see **Table 3–1 and Figure 3-1** for details). As well, these risk rating predictions were maintained for the future scenario.
- Potential risks were identified for listed birds; although risks were considered low with moderate uncertainty. This rating relied in part on the consideration of the small size of Burnick AEC (2.1 ha) relative to other AECs, which makes it unlikely that contamination in this area would affect populations, or provide sufficient food or habitat to many individual birds. As well, residual risks in the future scenario were driven by HHRA (fine grain) soils from the 1300 Portal, which may overestimate exposure to bulk soil from incidental soil ingestion.
- Exposure for wildlife was ROC and COPC-specific (see Appendix E of the Interim ERA [Azimuth 2013c]), but in general was driven by soils (with HHRA fine grain soils often contributing a larger portion of the dose) and ground insects. Risks to herbivorous wildlife were considered negligible.
- Updated soil sampling from the 1200 and 1300 Burnick bench and waste rock areas will be reviewed and integrated into the Updated TERA. Depending on these results, the food chain modeling could be refined in the Updated TERA with updated assumptions and soil data. However, unless something substantial changes in the ESA (i.e., if soil concentrations are *higher* after re-contouring than previously measured/used for the "current" scenario), based on **Figure 4-2 to Figure 4-6**, this area is considered a lower priority for further study or additional management action, relative to other AECs.

**Jewelbox/Main Zone/1380 Gully/1250 Portal Area (AEC 1/9)**

> **Note:** In **Table 4–1**, AEC 1 and AEC 9 are presented separately because they are separated in the DDRP. However, ecological risks were evaluated for AEC1/9 as a combined area, since the ESA update (Golder 2014a) indicates that these AECs are spatially connected (see AEC boundaries in **Figure 4-1 of Volume 1**).

- The DDRP indicates that the crest of the Jewelbox (Pit, North and 1408 Portal) and Main Zone waste rock piles will be pulled back onto the bench for stability, and the area will be re-sloped and re-vegetated. Recently, the Jewelbox and Main Zone Pits were filled in and the various waste rock benches and upper portions of the waste rock piles have been re-sloped/covered with local soil of undetermined metals concentration. We understand that the lower portions of the waste rock piles remain undisturbed. Updated mapping information and characterization of these areas will be provided by Golder and used in the Updated TERA.
- In addition, the area at Jewelbox that received backfilled hydrocarbons will be capped with a clean till soil cover. The pathway analysis from the Interim ERA recommended a 60 cm soil cover over any hydrocarbon contaminated areas at Jewelbox, based on hoary marmot burrowing depth. (See **Table 4–1** for additional reclamation plans specific to AEC 1/9.)
- The assumption for the future scenario in the ERA was that the Jewelbox and Main Zone benches were covered with clean soil [till] and soil concentrations were set equivalent to background. Concentrations in tissues from the JBX sampling area located adjacent to the waste rock bench, were also set to background because remediation was assumed for the bench areas. No remediation is planned for the 1380 Gully and 1250 Portal areas. Consequently, existing soil and tissue data from these areas were used for both the current and future scenarios.
- In the ERA, current risks for microbial and terrestrial invertebrate communities are considered negligible or low with moderate uncertainty. Risks to plants are considered negligible, but with high uncertainty (see **Table 3–1 and Figure 3-2** for details for AEC 1/9).
- On the other hand, many bird and mammal species were identified as having potentially elevated risks from exposure to metals in AEC 1/9 in the current scenario. While, the current remedial plans address risks from the secondary COPCs, elevated risks to birds, small mammals from exposure to lead and/or zinc are predicted to remain post-closure. Residual risks are driven primarily by high metals concentrations in soils and tissues (ground insects and estimated small mammal tissue[19]) within the 1380 Gully that is located within the AEC 1/9. Because of good

[19] Small mammals were not captured at the 1380 Gully in 2013, so concentrations from the JBX tissue sampling area were used in the future scenario.

habitat quality in the gully, the high metals concentrations are highly influential on risk predictions in the larger AEC.

- Note that the barn swallow (an ROC with a large home range size), had elevated predicted risks in the future scenario (**Figure 4-2 and Figure 4-6**), due to lead exposure. The exposure pathway for lead for this ROC is driven by incidental ingestion of soils in the 1380 Gully (Appendix E of Interim ERA).
- The assessment work completed to-date indicates the potential for post-closure risks in AEC 1/9. As well, because of the change in site conditions as a result of reclamation, there is high uncertainty in the TERA conclusions for AEC 1/9, and follow-up work is recommended (see **Figure 4-2 to Figure 4-6**). To this end, additional work has been conducted in 2014, including:
    - Characterization of 'background' conditions in the potentially naturally mineralized area of the Jewelbox Hill,
    - Collection of additional soil, vegetation, berry, ground invertebrate, and small mammal samples from the 1380 Gully, and the base of the Jewelbox North and 1408 waste rock piles.
    - Characterization of post-reclamation metals chemistry in re-contoured/covered benches and waste rock piles, as well as in undisturbed waste rock piles.

  All additional data will be integrated into the Updated TERA, and further management actions (e.g., source control/removal; further study; other solutions) will be re-evaluated at that time.

**Mill Site Area (AEC 3)**

- While the DDRP specified discrete areas for capping at the Mill Site AEC with a 50 cm soil cover (see **Table 4–1**), our understanding is that, based on the results of the Draft HHRA and Interim ERA, Teck is planning to cover the entire disturbed area with a clean till soil cover. The pathway analysis from the Interim ERA recommended a minimum cap depth of 12 cm to block exposure pathways for ecological receptors. This was based on a pathway analysis that identified burrowing depth for ROCs with elevated risks under the current scenario (i.e., common shrew, which has a burrowing depth of 12 cm). We understand that Teck is planning a cover depth of 50 cm over the mill footings and ore stockpile area and approximately 20 cm throughout the remaining AEC 3 disturbed area for stability and reclamation purposes.
- As well, backfilled and any residual hydrocarbons at the Mill Site will be capped with a clean till soil cover. The pathway analysis from the Interim ERA recommended a 50 cm soil cover over any hydrocarbon contaminated areas this AEC, based on deer mouse burrowing depth. (See **Table 4–1** for additional reclamation plans specific to AEC 3.)

- The assumption for the future scenario in the ERA is that a clean till soil cover would be applied over the entire disturbed footprint and would act to block the incidental soil ingestion pathway and soil-to-tissue (e.g., ground invertebrates) pathway.
- In the ERA, current risks for microbial, plant, and invertebrate communities are considered low with uncertainty ranging from moderate to high (ROC-specific; see **Table 3–1 and Figure 3-3** for details).
- However, potentially elevated risks were identified for several bird and mammal ROCs from exposure to lead, zinc and cadmium in the Mill Site area under current conditions. Under the future scenario, risks were considered negligible to low with low uncertainty for most ROCs when a soil cover was assumed to be placed over the disturbed area of AEC 3. The exception of common shrew (a common species), for which risks were assumed to be low, but with high uncertainty (**Table 3–2 and Figure 3-3**).
- We understand that Teck will be applying a soil cover over the entire disturbed footprint of the Mill Site (rather than following the July 2013 DDRP) to manage for human health risks and address findings of the Interim ERA. If anything changes with this strategy, this area could be further evaluated through refined modeling or study for the ERA.

**Tailing Management Facility (AEC 8)**

- The DDRP specified a 30 cm soil cover for tailings deposits/disturbed areas in the TMF (see **Table 4–1** for details for this AEC). The pathway analysis from the Interim ERA recommended a minimum cap depth of 50 cm to block exposure pathways for ecological receptors. This was based on a pathway analysis that identified burrowing depth for ROCs with elevated risks under the current scenario (i.e., deer mouse, which has a burrowing depth of less than 50 cm).
- The assumption for the future scenario in the ERA is that a clean till soil cover would be applied over the tailings deposits/disturbed area (see **Section 2.2**) and would block incidental soil ingestion of contaminated material and the soil-to-tissue pathway (e.g., via ground invertebrate uptake). Note that we have assumed an effective cap that provides a barrier to prevent recontamination, and this is supported by a tailings cap evaluation conducted by SRK (SRK 2014e).
- In the ERA, current risks for microbial, invertebrate and plant communities at TPN, TPN-West berm (and anywhere else that is not overtop of tailings) are considered negligible or low with uncertainty ranging from low to moderate (ROC-specific; see **Table 3–1 and Figure 3-4** for details).
- However, potentially elevated (moderate or high) risks were identified for microbes, invertebrates and plants in the tailings deposit areas from COPCs. Uncertainty is considered moderate or high due to the confounding influence of habitat disturbance and the potential physical (rather than chemical) effects of the tailings (**Figure 3-4**).

- In addition, potentially elevated risks were identified for various bird and small mammal ROCs from exposure to lead, and/or zinc and selenium in the TMF under current conditions. Potential risks were considered negligible or low for these ROC groups under a post-closure scenario. Risks were not completely ruled out for some ROCs in particular (common shrew, Wilson's warbler, boreal chickadee, and gray jay) from ingestion of ground insects and small mammals from TPN (lead) and flying invertebrates from Outside AEC (selenium and zinc). Risk ratings for these ROCs were reduced to low with moderate uncertainty for the three birds as surrogates for listed species and to low with low uncertainty for common ROCs because post-closure exposure was likely overestimated in the model. This is because the TPN area data was used for ground invertebrate and small mammal concentrations in the future scenario, and this area is elevated in contaminant exposure due to historical dusting from tailings. Future exposure to flying invertebrates was estimated using data from Outside AEC areas, which were slightly elevated for zinc and selenium, relative to reference, and may reflect exposure to the North and South Tailings Ponds (which are being drained) during larval stages or from foraging.
- Model assumptions could be refined for this area with updated data for "soils" from the ponds and refined estimates of tissue concentrations in the future scenario, if considered warranted. Application of a 50 cm cap over tailings areas is considered sufficient to reduce ecological risks, which would be a slight amendment from the current DDRP, which specifies 30 cm.

Overall, the findings reported in this Draft ERA are consistent with the Interim ERA as they relate to assessing the adequacy of the DDRP and identifying areas and priorities for follow-up work or study.

## 4.3. Possible Next Steps to Reduce Uncertainty in Risk Predictions

The goal of the Draft TERA is to help guide Teck's closure process, particularly related to planning remedial works and any other follow-up over the next two seasons. However, if uncertainty in the ERA is considered too high to support decision-making at this time, further analyses could be completed.

Options for further study related to the TERA, include:

- *Additional Desktop Evaluation* – This could involve more quantitative evaluation of the datasets and risks (e.g., using dose-response modeling), updating or refining the food chain model and/or other investigative tools such as qualitative or quantitative population modeling. Depending on the tool, there may be more value if additional analyses (refined modeling) were conducted after Golder has collected additional soil data (2014 field season) and once closure/remediation plans are more finalized.
- *Field Studies* - Evaluate options for further study (e.g., field studies of resident organisms/populations; burrowing depths) to evaluate potential risks to birds and/or small mammals, particularly in AECs such as the 1380 Gully/Jewelbox area.

As indicated in **Section 2.4**, Hemmera and EMR have recently provided some comments on the Interim ERA, HHRA and risk management table (an earlier version of **Table 4–1** that was presented

at the May 7, 2014 Regulatory and LFN meeting in Whitehorse). The comments provided by Hemmera pertaining to the ERA, identify the following potential sources of uncertainty:

- Gaps related to characterization of waste rock deposits and the long-term future exposure levels associated with these deposits as-is and if they are used as cover material,
- The degree of conservatism in the lead TRVs for birds and mammals,
- Process for extrapolating risk ratings based on organism-level endpoints to common bird and mammal species,
- Incorrect receptor inputs (body weights) for the common shrew and little brown myotis[20],
- Possibly including collection of some additional food items for wildlife in the ERA,
- Comparing small mammal tissue and scat data from the Data Report, to food chain model outputs[21],
- Contaminant sources, distribution and exposure pathways in the 1380 Gully,
- Reviewing minimum soil cover thickness recommendations based on the pathway analysis,

As indicated in **Section 2.4**, while we have attempted to address some comments within this report, others will require further evaluation and/or response.

We also note that since preparing the Interim ERA (Azimuth 2014c) and the original version of this Draft TERA, reclamation activities have proceeded and further site characterization and supporting data have been collected on-Site. As part of the preparing an Updated TERA, we intend to review the new data and validity of the assumptions made in this Draft TERA and revise the TERA as appropriate. At this time, we anticipate the following tasks:

- Comparing soil and waste rock metals concentrations from the re-contoured benches and remaining waste rock piles in the 1200 Portal and 1300 Portal areas of the Burnick Zone to soil data used in this Draft TERA
- Re-evaluating the footprint of AEC 2.

[20] Azimuth has done an initial evaluation of the body weights error and found that exposure doses are overestimated by a factor of 4.7 and 2.7 for the shrew and myotis, respectively. However, risk ratings for AEC 1/9 for the shrew did not change. A more thorough re-evaluation will be conducted for the Updated TERA.

[21] The small mammal tissue data, scat data and food chain model are evaluated as LOEs in this ERA.

- Comparing soil and waste rock metals concentrations from the re-contoured benches and remaining waste rock piles in the Jewelbox and Main Zone areas to soil data used in this Draft TERA.
- Incorporating new tissue data from AEC 1/9 into the Updated TERA.
- Re-evaluating the footprint of AEC 1/9.
- Depending on the new soil and tissue chemistry results, we anticipate conducting some additional analyses/modeling for AEC 1/9, where we will evaluate the relative contribution of various sources/management units (e.g., benches and waste rock piles, 1380 Gully, 1250 Portal) separately and in combination, to wildlife exposure and potential risks.
- Comparing the reclamation activities conducted at the Mill Site and Tailings Management Facility to the assumptions in this Draft TERA.
- Responding to any further regulatory comments and other tasks may arise from the review of new information for the Site.

**Table 4-1: Risk Management Planning - Review of Detailed Decommissioning and Reclamation Plan (DDRP) in Light of Results of the Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA), Sä Dena Hes Mine, Yukon Territory.**

*This table is based on site conditions and information available as of 2013. In 2014, reclamation work has proceeded at the Site and additional data has been collected. The information from 2014 will be reported in an Updated TERA.*

| Area Description (Associated HHRA/ERA Tissue Sampling Area) | Current Reclamation Plan[1] | | | HHRA Results | | ERA Results | | Changes to DDRP & Next Steps | |
|---|---|---|---|---|---|---|---|---|---|
| | Reclamation Plan as Specified in the DDRP | Vegetation Cover | Supplementary Comments | Are there Potential Human Health Risks? And if so, in what Media? | Risk Control or Remedial Activity | Are there Potential Ecological Risks (Moderate to High) under Current Conditions? And if so, to which Receptors and in what Media? | Risk Control or Remedial Activity | Adequacy of DDRP to Manage Risk | Data Gaps & Next Steps |
| **Tailings Management Facility (AEC 8)** | | | | | | | | | |
| North of North Tailings Pond (TPN) | This area is north of the North Tailings Pond and not addressed by the DDRP | N/A | Supplemental sampling and delineation is needed | YES, from elevated lead concentrations in berries | Prevent harvesting plants from this area for country foods or traditional medicines | YES,<br>- Potential risks to plants and the microbial community overtop of tailings deposits (soil);<br>- Potential risks to some birds and mammals from lead, zinc and selenium in soils, and ground insect, small mammal and flying insect tissues;<br>TPN (north of north tailings) area assumed uncovered in future scenario and risks considered low with low to moderate uncertainty. | Pending review of the ERA - no action currently recommended; further model refinement and/or delineation of TPN area are alternate options | Minor change to DDRP (Limit consumption) | HHRA: Option to delineate metals in berries and medicinal plants in 2015 (post-remediation) and sample country foods and biota used as traditional medicines |
| North Tailings Pond and Tailings Area (North Tailings) | Tailings will be recontoured to provide positive drainage towards the south end. Minimum 30 cm soil cover to provide a growth medium for vegetation. Where required, waste rock placed on tailings to provide sub-base for heavy equipment; soil cover material is till from South and Reclaim dam | Soil (till) cover, scarify and revegetate (Table 3-4) | Updated planning suggests a 50 cm cover is needed for stability.<br>A contingency for a thicker soil cover may be required in the event of soft, unstable ground | YES, from elevated metals concentrations in soil | A thin soil or organic cover is sufficient to prevent contact and break the pathway | | Soil cover of at least 20 cm for plants and 50 cm recommended to block incidental soil ingestion and soil-to-tissue pathways for birds and mammals<br>Monitor soil cover integrity | Minor change to DDRP (Increase soil cover depth to 50 cm) | None |
| South Tailings Area (South Tailings) | Water behind the South Dam drained and 30 cm soil cover placed over tailings. To reduce the risk of post closure release of covered tailings, a small berm will be left from South Dam | Sol (till) cover, scarify and revegetate (Table 3-4) | Updated planning suggests a 50 cm cover is needed for stability.<br>A contingency for a thicker soil cover may be required in the event of soft, unstable ground | YES, from elevated metals concentrations in soil | A thin soil or organic cover is sufficient to prevent contact and break the pathway | | Soil cover of at least 20 cm for plants and 50 cm recommended to block incidental soil ingestion and soil-to-tissue pathways for birds and mammals<br>Monitor soil cover integrity | Minor change to DDRP (Increase cover depth to 50 cm) | None |
| South Tailings Ponded Area | Remaining ponded water above the South Dam will be siphoned to Reclaim Pond<br>As the southern extent of the existing tailings deposit is currently covered with water, the proximity of the tailings to the upstream toe of the dam and the depth of the tailings is unknown. However, an estimate of the extent of the tailings was made and is shown on Figure 3-5. | Sol (till) cover, scarify and revegetate (Table 3-4) | Data for the submerged portion of the South Tailings Pond is limited; if tailings are identified under water, then the soil cover will be extended. | YES, from elevated lead in exposed sediment | A thin soil cover is sufficient to prevent contact and break the pathway | YES, elevated metals in exposed sediment confirmed (see risks above) | Soil cover of at least 20 cm for plants and 50 cm recommended to block incidental soil ingestion and soil-to-tissue pathways for birds and mammals<br>Monitor soil cover integrity | Minor change to DDRP (Extend soil cover into submerged portion of South Tailings Pond; Increase cover depth to 50 cm) | HHRA/ERA: Sediment/soil chemistry from the submerged portion of the South Tailings Pond collected in 2014 |
| South TP Marsh Area | Not specified in DDRP (do not disturb/leave natural) | N/A | Boundary of area to be delineated in 2014 | No, based on available soil data | No action | No, based on available soil data | No action | DDRP adequate | HHRA/ERA: Area further delineated in 2014 |
| Reclaim Pond | Sediment from submerged area to be analyzed for metals; if metals concentrations are elevated, a soil cover will be placed over the reclaim pond, or sediments will be removed and hauled to the main tailings pond area to be capped with a soil cover. | Sol (till) cover, scarify and revegetate (Table 3-4) | Will depend on metal concentrations once ponds are drained; Repatriation of Camp Creek; Possible jute cover and/or soil cover | To Be Confirmed by Golder | If elvated metals, a thin soil cover is sufficient to prevent contact and break the pathway | To Be Confirmed by Golder | If elevated metals, a soil cover of at least 20 cm for plants and 50 cm recommended to block incidental soil ingestion and soil-to-tissue pathways for birds and mammals<br>Monitor soil cover integrity | To Be Confirmed, but if elevated metals then: Minor change to DDRP (Extend soil cover to Reclaim Pond [or move sediments]; Increase cover depth to 50 cm) | HHRA/ERA: Sediment/soil chemistry from the Reclaim Pond collected in 2014 |
| Borrow Areas | | | | | | | | | |
| Borrow C: North Creek Garbage Dump and Borrow Area (APEC 4) | Landfill areas graded to prevent ponding of water, decompacted (if required) and revegetated (Section 3.7.2.6). Capping of the landfill with a soil cover will comply with associated landfill permit requirements. | Scarify and revegetate (Table 3-4) | Landfill area; uncertain whether soil (till) cover required | No | No action | No | No action | DDRP adequate | N/A |
| Borrow B: Northern tip of Boneyard (AEC 5) | Borrow pit areas graded to prevent ponding of water, decompacted (if required) and revegetated (Section 3.7.2.6). | Scarify and revegetate (Table 3-4) | Uncertain whether soil (till) cover required | No | No action | No | No action | DDRP adequate | N/A |
| Borrow D: Boneyard (AEC 5) | Borrow pit areas graded to prevent ponding of water, decompacted (if required) and revegetated (Section 3.7.2.6). | Scarify and revegetate (Table 3-4) | The area is rocky and a soil (till) cover for revegetation is likely required | No | No action | No | No action | DDRP adequate | N/A |

[1]References refer to sections and table/figure numbers in the DDRP.

[2]DDRP indicates that HHERA will review soil concentrations on WRDs. These areas will be designated as a "no-go" zone for human access.

N/A = not applicable

WRD = Waste Rock Dump

Color Legend:

Uncertain: Further site delineation data is required to assess risks and adequacy of DDRP

DDRP is adequate or no remedial action is recommended. The ERA and HHRA results supporting this recommendation are also shaded.

Minor change in DDRP is recommended (e.g., preventing public access, recommending a deeper soil cover depth). The ERA and/or HHRA results supporting this recommendation are also shaded.

Change to DDRP is recommended (e.g., soil cover to be placed over larger area; further investigation of relatively "high" risk areas). The ERA and/or HHRA results supporting this recommendation are also shaded.

**Table 4-1: Risk Management Planning - Review of Detailed Decommissioning and Reclamation Plan (DDRP) in Light of Results of the Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA), Sä Dena Hes Mine, Yukon Territory.**

*This table is based on site conditions and information available as of 2013. In 2014, reclamation work has proceeded at the Site and additional data has been collected. The information from 2014 will be reported in an Updated TERA.*

| Area Description (Associated HHRA/ERA Tissue Sampling Area) | Current Reclamation Plan[1] | | | HHRA Results | | ERA Results | | Changes to DDRP & Next Steps | |
|---|---|---|---|---|---|---|---|---|---|
| | Reclamation Plan as Specified in the DDRP | Vegetation Cover | Supplementary Comments | Are there Potential Human Health Risks? And if so, in what Media? | Risk Control or Remedial Activity | Are there Potential Ecological Risks (Moderate to High) under Current Conditions? And if so, to which Receptors and in what Media? | Risk Control or Remedial Activity | Adequacy of DDRP to Manage Risk | Data Gaps & Next Steps |
| Burnick Zone (AEC 2) | | | | | | | | | |
| 1200 WRD and Bench[2] (BRK) | Crest of Burnick dump will be further pulled back to reduce loading on crest, improve stability; Revegetation to focus on flat surface of the waste rock dump; de-compacted and seeded; import fine materials if too rocky | The resloped portion of the waste rock area will be revegetated with the same prescription as recommended for the mill area (see Section 3.7.2.1) excluding seedlings | Sampling of waste rock conducted to determine If metals concentrations pose risk to humans or to wildlife; remedial plans adapted based on findings | YES, from elevated lead concentrations in soil | Prevent public access | No, risks rated as low with moderate uncertainty for listed birds from Zn, Cd, Se. Rating considered small size of Burnick AEC, which reduced overall risk rating. | Pending review of the ERA, current DDRP may be sufficient; confirmatory sampling of metals in 'new' soil benches and waste rock piles needed and then comparison to data used in Draft ERA; possibly update food chain model. | Change to DDRP (Prevent public access; Metals chemistry on recontoured bench and WRD needed to assess adequacy of DDRP) | HHRA: Delineate the elevated lead in soil boundary, or risk manage the entire area HHRA/ERA: Review metals chemistry from soil on recontoured bench and any remaining waste rock. |
| 1300 Portal, Bench and WRD[2] (1300 Portal) | Portal will be sealed; waste rock will be sloped from top to base for aesthetics; Safety shack removed; site regraded; No other measures proposed; no heavy vehicle access | Revegetation efforts will focus on the relatively small flat surface of the waste rock dump. Surface will be de-compacted and seeded (Section 3.2.3.3) | Sampling of waste rock conducted to determine If metals concentrations pose risk to humans or to wildlife; remedial plans adapted based on findings | YES, from elevated metals concentrations in soil | Prevent public access | No, risks rated as low with moderate uncertainty for listed birds from Zn, Cd, Se. Risk rating considered size of area and use of fine grain HHRA soils. | Pending review of the ERA, current DDRP may be sufficient; confirmatory sampling of metals in 'new' soil benches and waste rock piles needed and then comparison to data used in Draft ERA; possibly update food chain model. | Minor change to DDRP (Prevent public access; Metals chemistry on recontoured bench and WRD needed to assess adequacy of DDRP) | HHRA: Delineate elevated lead in soil boundary and update HHRA for cadmium beyond lead boundary or risk manage the entire area; Option to collect berry data. HHRA/ERA: Review metals chemistry from soil on recontoured bench and any remaining waste rock. |
| Burnick Maintenance Shop Residual Hydrocarbons | At Burnick 1200 Portal, the metal shop and concrete foundations removed to ground level; Soil hydrocarbons to be removed for treatment and/or left on site and risk assessed; Since the DDRP was issued a Remediation Plan was approved and hydrocarbon contaminated soils will be capped with a soil cover in-situ | Decompact and revegetate (Table 3-4) | Stockpiled hydrocarbons have been removed; residual hydrocarbon contamination to be assessed after demolition of buildings | Assumed hydrocarbons capped with a soil cover in HHRA; need to block soil contact | Prevent direct contact; apply a thin soil cover | Assumed hydrocarbons capped with a soil cover in ERA; need to block incidental ingestion and soil contact | Soil cover (till) of 60 cm recommended to block incidental soil ingestion and direct contact (based on hoary marmot burrow depth) | Minor change to DDRP (Risk manage hydrocarbons in-situ by applying a 60 cm soil cover) | HHRA/ERA: Delineation of hydrocarbon residuals. |
| Burnick Settling Pond | The metal contaminated soils will be either capped with a minimum 1m thick soil cover or excavated deposited in the open ventilation shaft at Jewelbox mine workings, and the sites will be regraded and revegetated. (Section 3.7.2.5) | Revegetate | N/A | No, assumed remediated | Planned DDRP sufficient | No, assumed remediated | Planned DDRP sufficient | DDRP adequate | N/A |
| Mill Site/Camp Area (AEC 3) | | | | | | | | | |
| Concentrator Building | Ore concentrator ("mill") is comprised of the mill building, the crusher house, conveyors, and truck load out facility. All are steel frame on concrete slab flooring; Concrete foundations will be demolished to ground level, rubble buried on site and covered with a minimum 50-cm soil cover. | Scarify, recontour and revegetate (Table 3-4); Section 3.7.2.1 | N/A | Undetermined (not sampled) but soil cover planned in DDRP | Planned DDRP sufficient | Undetermined (not sampled) but soil cover planned in DDRP | Planned DDRP sufficient | DDRP adequate | N/A |
| Mill Ore Stockpile | Figure 3-11 - cap with 50 cm soil cover and revegetate | Revegetate | N/A | Undetermined (not sampled) but soil cover planned in DDRP | Planned DDRP sufficient | Undetermined (not sampled) but soil cover planned in DDRP | Planned DDRP sufficient | DDRP adequate | N/A |
| Mill Site Disturbed Footprint, Including Accommodation and Camp Area (MS) *Note the concentrator building, mill ore stockpile are within this footprint. | Once all structures are removed these areas will be prepared by decompaction and recontouring where necessary; Accommodation trailers will be demolished, burned and/or buried in a permitted landfill site on site; Any hazardous wastes will be managed within applicable regulations; Ground surface regraded, recontoured, and revegetated. (Section 3.4.1, 3.4.2, and 3.7.2.1) | Scarify, recontour and revegetate (Table 3-4) | N/A | YES, from elevated lead in soil and berries in nearby forested area | A thin soil cover or organic layer is sufficient to break HH pathway (throughout disturbed area where lead in soil is elevated); Prevent harvesting of plants and small animals from Mill Site | YES, - Potential risks to some birds and mammals from lead and zinc in soil, and ground invertebrate and flying invertebrate tissues | Soil cover of at least 12 cm to block incidental soil ingestion and soil-to-tissue pathways (throughout disturbed area) | Change to DDRP (Expand soil cover throughout disturbed area; Limit consumption) We understand that Teck is planning a 50 cm soil cover over the mill footings and ore stockpile areas and a 20 cm soil cover over the remaining disturbed area footprint. | HHRA: Delineate the elevated lead in soil boundary, or risk manage entire disturbed area; Option to sample berries and medicinal plants in 2015 to establish baseline after remedial works are complete. ERA: Confirm assumptions of ERA are valid based on reclamation activities. |
| Hydrocarbon Contaminated Areas (Golden Hill Shop, Drum Storage, etc..) | DDRP - indicates options will be evaluated, since the DDRP was issued and the Remediation plan was approved the soils will be capped in-situ | Area will be revegetated, similar to surrounding mill revegetation | N/A | Assumed hydrocarbons capped with a soil cover in HHRA; need to block soil contact | Prevent direct contact; apply a thin soil cover | Assumed hydrocarbons capped with a soil cover in ERA; need to block incidental ingestion and soil contact | Soil cover (till) of 50 cm recommended to block incidental soil ingestion and direct contact (base deer mouse burrow depth) | Minor change to DDRP (Risk manage hydrocarbons in-situ by applying a 50 cm soil cover) | HHRA/ERA: Delineation of hydrocarbon residuals |

[1]References refer to sections and table/figure numbers in the DDRP.

[2]DDRP indicates that HHERA will review soil concentrations on WRDs. These areas will be designated as a "no-go" zone for human access.

N/A = not applicable

WR = Waste Rock

Color Legend:

Uncertain: Further site delineation data is required to assess risks and adequacy of DDRP

DDRP is adequate or no remedial action is recommended. The ERA and HHRA results supporting this recommendation are also shaded.

Minor change in DDRP is recommended (e.g., preventing public access, recommending a deeper soil cover depth). The ERA and/or HHRA results supporting this recommendation are also shaded.

Change to DDRP is recommended (e.g., soil cover to be placed over larger area; further investigation of relatively "high" risk areas). The ERA and/or HHRA results supporting this recommendation are also shaded.

**Table 4-1: Risk Management Planning - Review of Detailed Decommissioning and Reclamation Plan (DDRP) in Light of Results of the Human Health Risk Assessment (HHRA) and Ecological Risk Assessment (ERA), Sä Dena Hes Mine, Yukon Territory.**

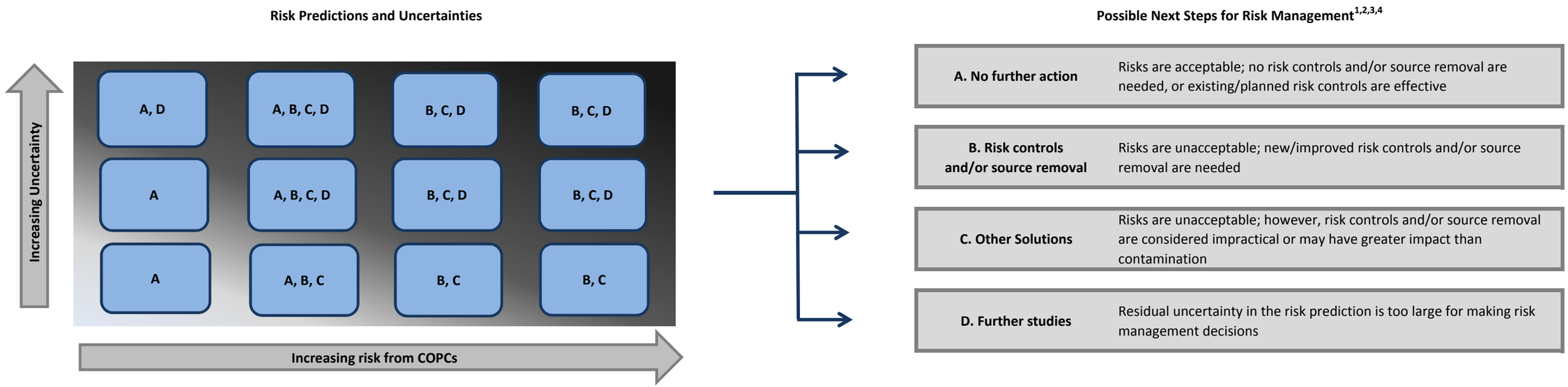
*This table is based on site conditions and information available as of 2013. In 2014, reclamation work has proceeded at the Site and additional data has been collected. The information from 2014 will be reported in an Updated TERA.*

| Area Description (Associated HHRA/ERA Tissue Sampling Area) | Current Reclamation Plan[1] | | | HHRA Results | | ERA Results | | Changes to DDRP & Next Steps | |
|---|---|---|---|---|---|---|---|---|---|
| | Reclamation Plan as Specified in the DDRP | Vegetation Cover | Supplementary Comments | Are there Potential Human Health Risks? And if so, in what Media? | Risk Control or Remedial Activity | Are there Potential Ecological Risks (Moderate to High) under Current Conditions? And if so, to which Receptors and in what Media? | Risk Control or Remedial Activity | Adequacy of DDRP to Manage Risk | Data Gaps & Next Steps |
| Jewelbox Area (AEC 1) | | | | | | | | | |
| Waste Rock Dumps (Jewelbox Pit, Jewelbox North and 1408) and Benches[2] (JBX) | Crest of the waste dumps will be pulled back and rounded for aesthetics; Revegetation will focus on flat surfaces; Surface will be decompacted and seeded | Pull back crest of dump, decompact and revegetate (Table 3-4) | Sampling of waste rock conducted to determine If metals concentrations pose risk to humans or to wildlife; remedial plans adapted based on findings | YES, from lead in soil, plants and small animals consumed as country foods and traditional medicines | Prevent public access and harvesting of plants and small animals from this area | YES, (Includes Jewelbox, Main Zone, 1380 Gully and 1250 Portal)<br><br>- Potential moderate or high risks to many birds and mammals from lead and zinc in soil, and ground invertebrate and small mammals tissues; | Pending review of the ERA, block incidental ingestion of contaminated soil and soil to tissue exposure pathways (e.g., ground invertebrate uptake); characterization of metals in recontoured soil benches and waste rock piles needed and then comparison to data used in Draft ERA; update food chain model. | Change to DDRP (Prevent public access; Limit consumption; Metals chemistry on recontoured benches and WRDs needed to updated ERA and assess adequacy of DDRP) | HHRA: Delineate elevated lead in soil boundary, or risk manage the entire area; Option to sample berries and medicinal plants in 2015 to establish baseline after remedial works are complete.<br>ERA: Establish local background for Jewelbox Hill/Main Zone; Additional tissue samples from toe of waste rock piles.<br>HHRA/ERA: Review metals chemistry from soil on recontoured bench and any remaining waste rock and update ERA. |
| Open Pit / Wall | Pit walls will be stabilized by re-sloping and using waste rock and/or fill material. Re-sloping will partially fill base of the pit to function like a French drain | No revegetation | Area will be covered with waste rock from local area | | | | | Minor change to DDRP (Prevent public access) | |
| 1408 Settling Pond | The metal contaminated soils will be either capped with a minimum 1m thick soil cover or excavated and deposited in the open ventilation shaft at the Jewelbox mine workings, and the sites will be regraded and revegetated (Section 3.7.2.5). | Area will be revegetated | Removal and dispose sediment | Assumed remediated | Planned DDRP sufficient | | Planned DDRP sufficient | DDRP adequate | N/A |
| Hydrocarbon Backfilled Area | DDRP - indicates options will be evaluated; Since the DDRP was issued, a Remediation Plan was approved and hydrocarbon contaminated soils will be capped with a soil cover in-situ | Dependent on overall remediation plan for Jewelbox area | Stockpiled soils have been backfilled and will be capped with a soil cover | Assumed hydrocarbons capped with a soil cover in HHRA; need to block soil contact | Prevent direct contact; apply a thin soil cover | Assumed hydrocarbons capped with a soil cover in ERA; need to block incidental ingestion and soil contact | Soil cover (till) of 60 cm recommended to block incidental soil ingestion and direct contact (based on hoary marmot burrow depth) | Minor change to DDRP (Risk manage hydrocarbons in-situ by applying a 60 cm soil cover) | N/A |
| Main Zone Area (AEC 9) | | | | | | | | | |
| Waste Rock Dump and Bench[2] (JBX) | Crest of the waste dump will be pulled back and rounded for aesthetics and improve stability; Revegetation will focus on relatively flat surfaces of the waste rock; Surface will be de-compacted and seeded | DDRP specifies seeding; Revegetation will focus on flat surfaces (bench) | Sampling of waste rock conducted to determine If metals concentrations pose risk to humans or to wildlife; remedial plans adapted based on findings | YES, from lead in soil, plants and small animals consumed as country foods and traditional medicines | Prevent public access and harvesting of plants and small animals from this area | YES, (Includes Jewelbox, Main Zone, 1380 Gully and 1250 Portal)<br><br>- Potential moderate or high risks to many birds and mammals from lead and zinc in soil, and ground invertebrate and small mammals tissues | Pending review of the ERA, block incidental ingestion of contaminated soil and soil to tissue exposure pathways (e.g., ground invertebrate uptake); confirmatory sampling of metals in recontoured soil benches and waste rock piles needed and then comparison to data used in Draft ERA; update food chain model. | Change to DDRP (Prevent public access; Limit consumption; Metals chemistry on recontoured benches and WRDs needed to updated ERA and assess adequacy of DDRP) | HHRA: Delineate elevated lead in soil boundary, or risk manage the entire area; Option to sample berries and medicinal plants in 2015 to establish baseline after remedial works are complete.<br>ERA: Establish local background for Jewelbox Hill/Main Zone.<br>HHRA/ERA: Review metals chemistry from soil on recontoured bench and any remaining waste rock and updated ERA. |
| Open Pit / Wall | Pit walls will be stabilized by re-sloping by dozer; waste rock from adjacent waste rock dumps used to reduce wall slope and backfill pit. Coarser rock directed to base of the fill to allow free drainage | No revegetation | N/A | | | | | Minor change to DDRP (Prevent public access and prevent harvesting) | |
| Main Zone settling pond (presume 1380) | Soils will be capped with a minimum 1-m thick soil cover or excavated and put in mine workings, regraded, revegetated | Revegetate | Remove and dispose of soil, capping with a soil cover maybe necessary if residual metals remain | Assumed remediated | Planned DDRP sufficient | | Planned DDRP sufficient | DDRP adequate | N/A |
| 1380 Gully (1380 Gully) | No reclamation is identified by the DDRP for the 1380 Gully | N/A (area is naturally vegetated) | Risks are present here, but difficult to remediate; needs discussion with stakeholders to resolve | YES, from lead in soil, plants and small animals consumed as country foods and traditional medicines | Prevent public access and harvesting of plants and small animals from this area | | TBD - Further study/delineation, other solutions, and/or risk control to block incidental soil ingestion and soil-to-tissue pathways | Change to DDRP (Prevent public access; Limit consumption; Update ERA with new data but any further action to manage ecological risks uncertain) | ERA: Delineate soils to distinguish mining from natural mineralization (sample organic and shallow inorganic soils using XRF); Expand small mammal trapping program and invertebrate and small mammal tissue collection; Review small mammal burrow depth; Update ERA. |
| 1250 Portal (1250 Portal) | No reclamation is identified by the DDRP for the 1250 portal | No revegetation planned; some of the area is naturally vegetated | N/A | Possibly from metals in soil - additional investigation required | Prevent public access? | Unlikely, but not assessed independently from 1380 Gully; 1250 Portal was not identified as an area driving risks; soil samples were fine grain HHRA soils | No remediation recommended; additional delineation and collection of bulk soil samples recommended | Minor change to DDRP (Prevent public access) | HHRA: Delineate elevated lead in soil boundary and update the HHRA for arsenic or risk manage the entire area;<br>ERA: Bulk soil samples from 1250 Portal. |
| 1250 Settling Pond | Presumed uncontaminated; Jewelbox 1250 sediment structure is small and was constructed out of natural stream channel. Water will be redirected back to natural channel, pond regarded and revegetated | Revegetate | N/A | No | No action | No | No action | DDRP adequate | N/A |

[1]References refer to sections and table/figure numbers in the DDRP.
[2]DDRP indicates that HHERA will review soil concentrations on WRDs. These areas will be designated as a "no-go" zone for human access.
N/A = not applicable
WR = Waste Rock

Color Legend:
Uncertain: Further site delineation data is required to assess risks and adequacy of DDRP
DDRP is adequate or no remedial action is recommended. The ERA and HHRA results supporting this recommendation are also shaded.
Minor change in DDRP is recommended (e.g., preventing public access, recommending a deeper soil cover depth). The ERA and/or HHRA results supporting this recommendation are also shaded.
Change to DDRP is recommended (e.g., soil cover to be placed over larger area; further investigation of relatively "high" risk areas). The ERA and/or HHRA results supporting this recommendation are also shaded.

**Figure 4-1: Conceptual decision-making framework showing a range of likely next steps for risk management depending on the outcome of the risk assessment.**

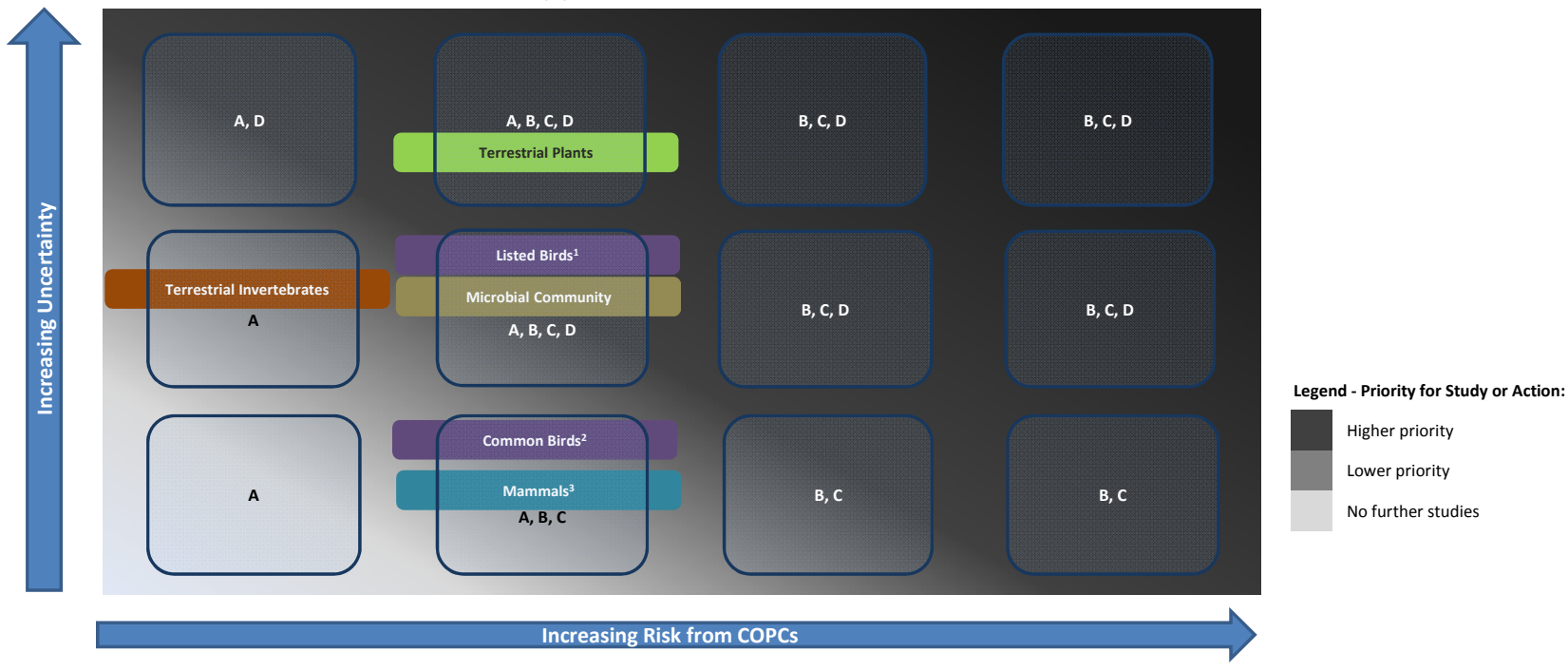



**Notes:**

1. It is important to note that the range of likely risk management options that might be considered for different risk predictions is approximate and provided for discussion purposes only. Specifically, the formal evaluation of risk management options and a decision regarding which option to adopt is not solely based on conclusions of a risk assessment. Risk managers must also consider many other types of information, such as:
   - Potential operational and environmental impacts, and potential for ongoing contaminant inputs (i.e., site-related or not);
   - Cost, benefits, and feasibility of active risk management;
   - Input from regulatory agencies and legal requirements (e.g., federal and provincial regulations, civil law requirements);
   - Teck's policies; and,
   - Input from local government, general public, and First Nations
2. These risk management options are not necessarily mutually exclusive. Depending on the size and complexity of a contaminated site, a combination of options may be relevant to address distinct exposure units.
3. Consistent with BC CSR Administrative Guidance 14, risk controls may include intrinsic controls, institutional controls, or engineered controls. These are defined in Procedure 8 as follows:
   - Institutional control: means a risk management measure for controlling risks to human health and the environment from exposure to substances at a parcel by the imposition of legal or administrative requirements (e.g., fences, signs, easements, covenant).
   - Intrinsic control: means an inherent feature at a parcel which without the use of engineering or institutional controls, controls risks to human health and the environment from exposure to substances (e.g., natural physical barrier, inherent feature that modifies properties of a substance or media).
   - Engineered controls: means a risk management measure for controlling risks to human health and the environment from exposure to substances at a parcel by the use of a technology (e.g., soil/sediment caps, solidification methodologies, water treatment systems, vapour barriers).
4. We define "source removal" as remedial actions associated with the excavation or dredging of a contaminated media (e.g., soil, sediment) to remove the source of contaminants in a given exposure unit.

Figure 4-2: Overlay of Risk Predictions and Corresponding Suitable Risk Management Options* for the Terrestrial ERA for the Sä Dena Hes Mine Site - Burnick/1300 Portal.
(A) Current Scenario - top panel, (B) Future scenario - bottom panel.

**(A) CURRENT SCENARIO**



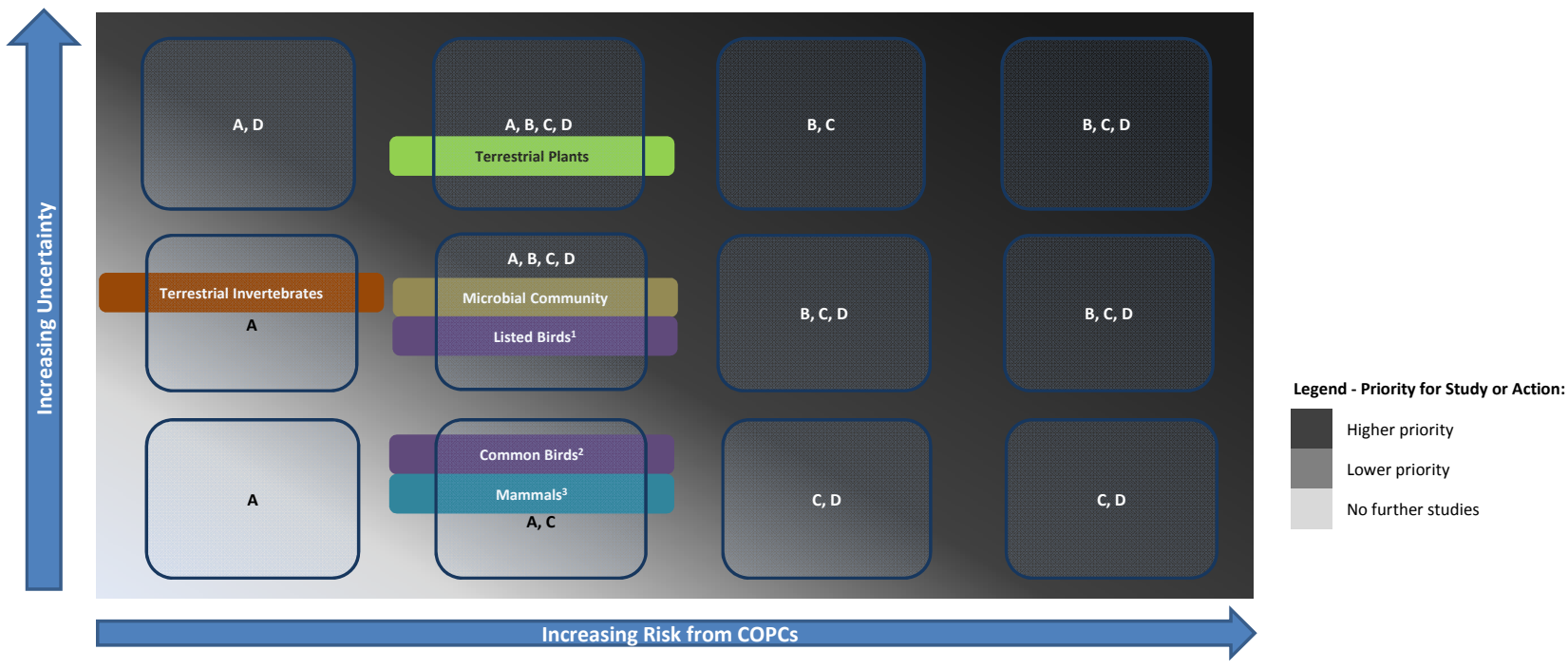

**Notes:**

[1] Listed or Listed Surrogate: C. sparrow, warbler, chickadee, y. flycatcher, w. sparrow

[2] Common: Junco, chickadee, c. sparrow, warbler

[3] Common: Vole, marmot, porcupine, shrew, mouse, squirrel, hare

**(B) FUTURE SCENARIO**




**Notes:**

[1] Listed or Listed Surrogates: C. sparrow, warbler, chickadee, y. flycatcher, w. sparrow

[2] Common: Junco, chickadee, c. sparrow, warbler

[3] Common: Vole, marmot, porcupine, shrew, mouse, squirrel, hare

* Risk Management Options (see Figure 4-1 for more details)

A = No further action

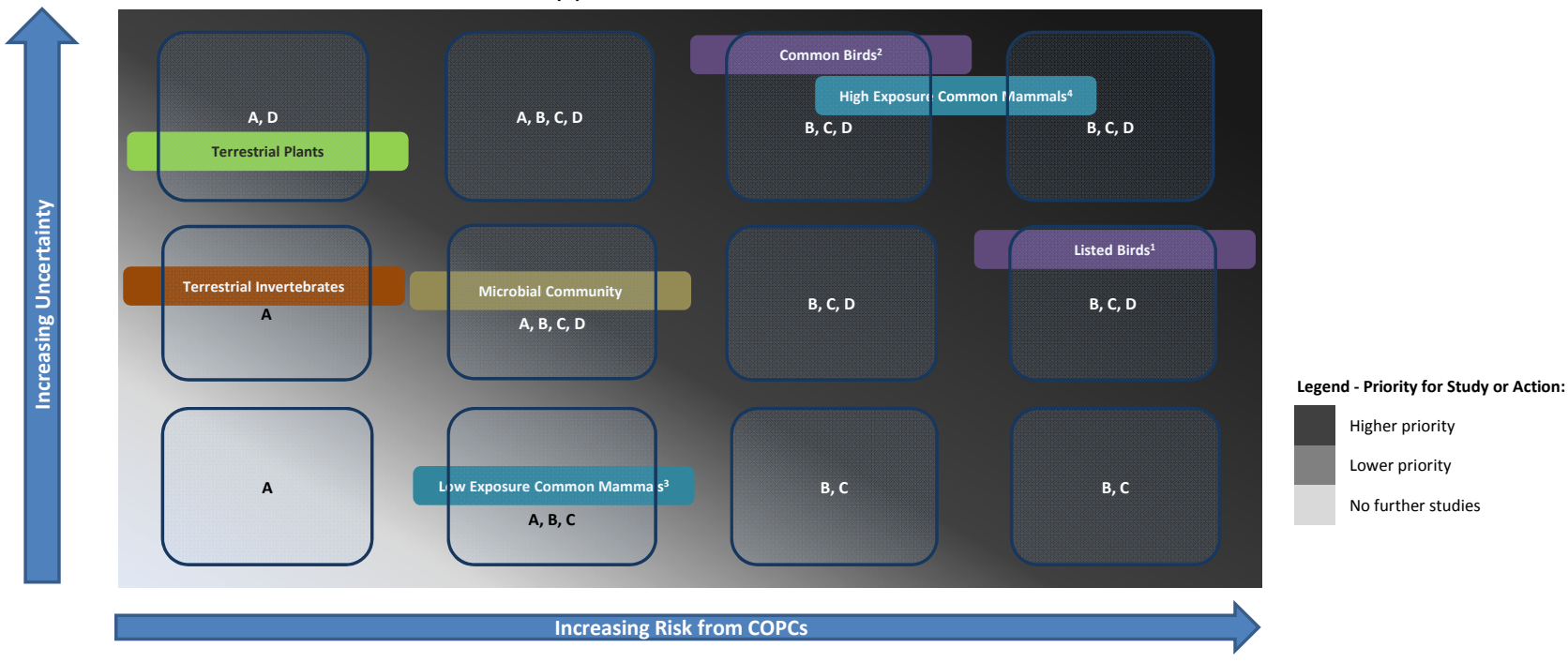
B = Risk controls/source removal

C = Other solutions

D = Further study

Figure 4-3: Overlay of Risk Predictions and Corresponding Suitable Risk Management Options* for the Terrestrial ERA for the Sä Dena Hes Mine Site - Jewelbox/Main Zone/1380 Gully/1250 Portal. (A) Current Scenario - top panel, (B) Future scenario - bottom panel.

**(A) CURRENT SCENARIO**




**Notes:**

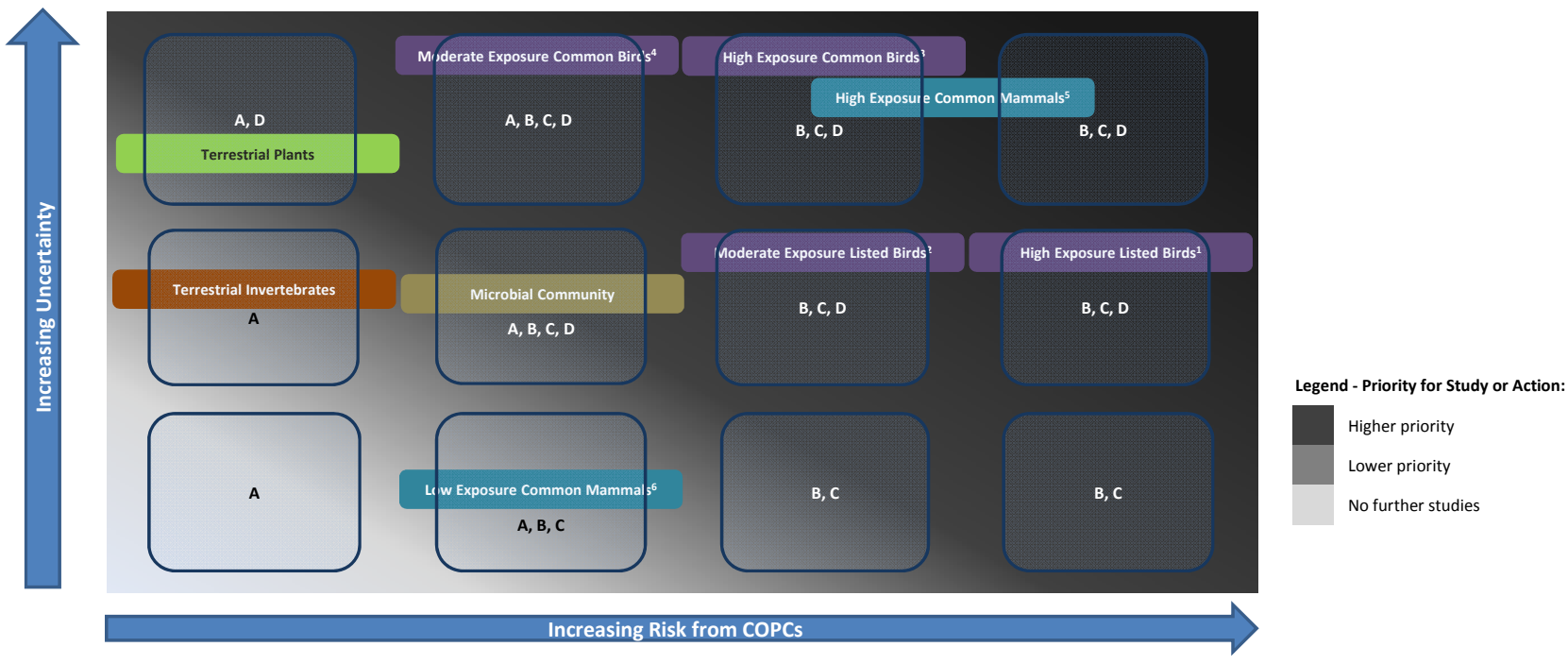
[1] Listed or Listed Surrogates: Warbler, kestrel, y. flycatcher, chickadee

[2] Common: Junco, chickadee, c. sparrow, warbler, jay

[3] Common: Vole, marmot, porcupine

[4] Common: Shrew, mouse, squirrel, hare

**(B) FUTURE SCENARIO#**




**Notes:**

[1] Listed or Listed Surrogates: Warbler, chickadee

[2] Listed or Listed Surrogates: C. sparrow, kestrel, jay, w. sparrow

[3] Common: Warbler, chickadee

[4] Common: Junco, c. sparrow, jay

[5] Common: Shrew, mouse, hare

[6] Common: Vole, marmot, porcupine, squirrel

# Future exposure and potential risks for birds and mammals are driven by the 1380 Gully

* Risk Management Options (see Figure 4-1 for more details)

A = No further action

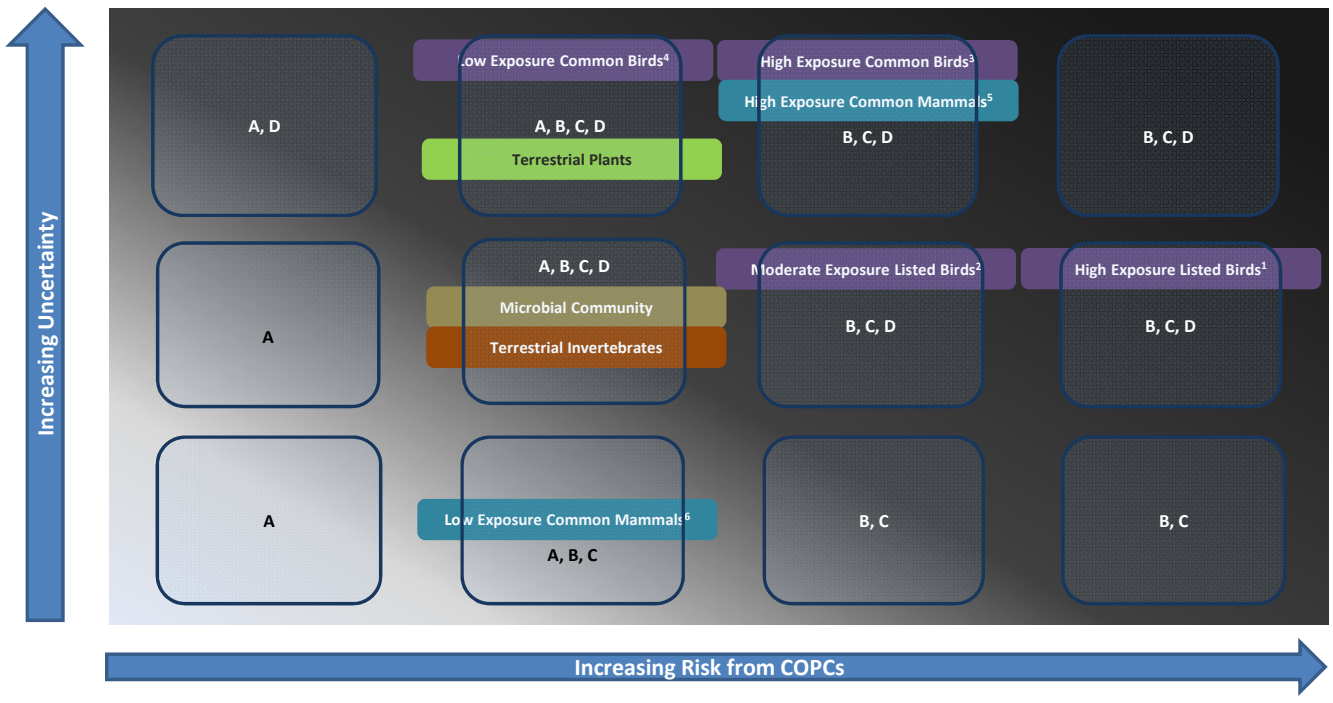
B = Risk controls/source removal

C = Other solutions

D = Further study

Figure 4-4: Overlay of Risk Predictions and Corresponding Suitable Risk Management Options* for the Terrestrial ERA for the Sä Dena Hes Mine Site - Mill Site. (A) Current Scenario - top panel, (B) Future scenario - bottom panel.

**(A) CURRENT SCENARIO**



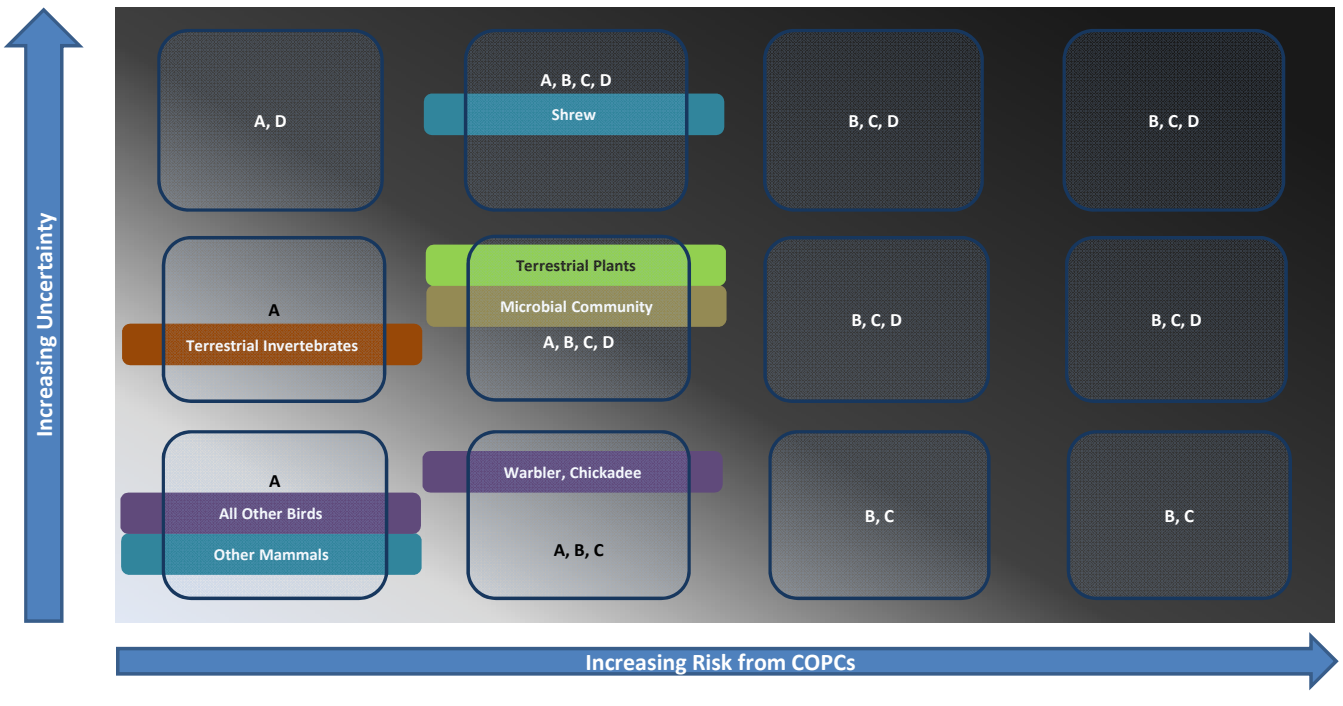

**Legend - Priority for Study or Action:**

- Higher priority
- Lower priority
- No further studies

**Notes:**

[1] Listed or Listed Surrogate: Warbler, y. flycatcher
[2] Listed or Listed Surrogate: C. sparrow, chickadee, kestrel, jay, w. sparrow
[3] Common: Warbler
[4] Common: Junco, c. sparrow, chickadee, jay
[5] Common: Shrew, mouse
[6] Common: Vole, porcupine, hare

**(B) FUTURE SCENARIO**




**Legend - Priority for Study or Action:**

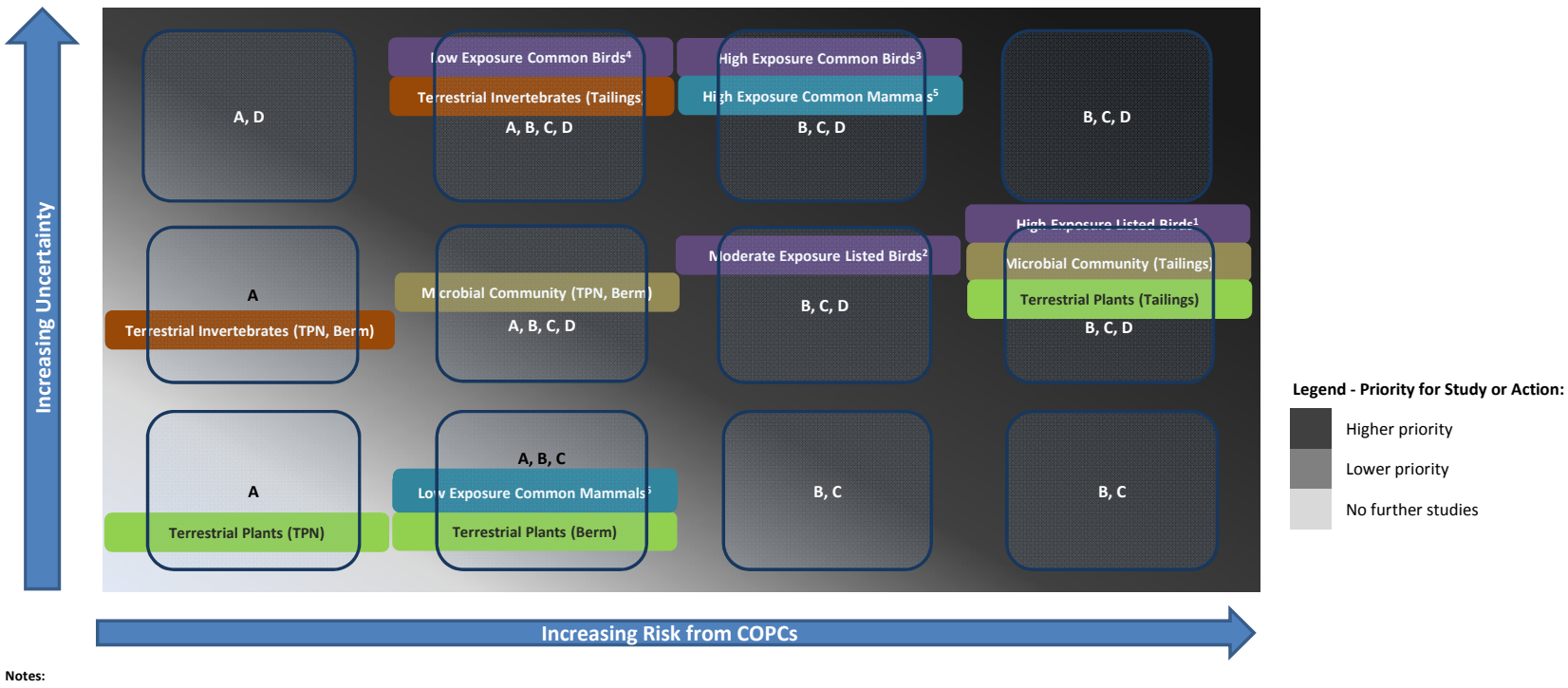
- Higher priority
- Lower priority
- No further studies

**Notes:**

* Risk Management Options (see Figure 4-1 for more details)
A = No further action
B = Risk controls/source removal
C = Other solutions
D = Further study

Figure 4-5: Overlay of Risk Predictions and Corresponding Suitable Risk Management Options* for the Terrestrial ERA for the Sä Dena Hes Mine Site - Tailings Management Facility. (A) Current Scenario - top panel, (B) Future scenario - bottom panel.

**(A) CURRENT SCENARIO**




**Notes:**

[1] Listed or Listed Surrogate: Warbler, y. flycatcher

[2] Listed or Listed Surrogate: C. sparrow, chickadee, kestrel, jay, w. sparrow

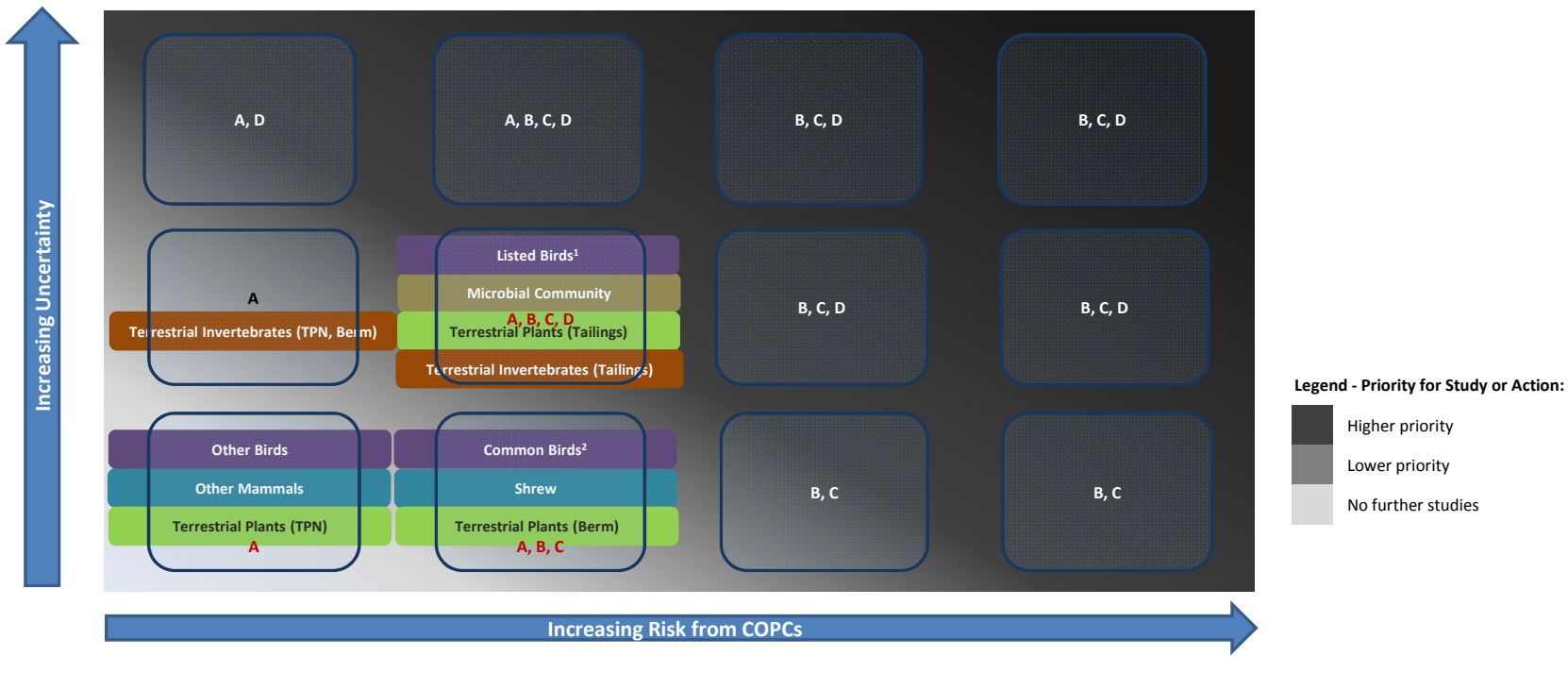
[3] Common: Warbler

[4] Common: Junco, c. sparrow, chickadee, jay

[5] Common: Shrew, mouse

[6] Common: Vole, porcupine, hare

**(B) FUTURE SCENARIO**




**Notes:**

[1] Listed or Listed Surrogate: Warbler, chickadee, jay

[2] Common: Warbler, chickadee, jay

* Risk Management Options (see Figure 4-1 for more details)

A = No further action

B = Risk controls/source removal

C = Other solutions

D = Further study

Figure 4-6: Overlay of Risk Predictions and Corresponding Suitable Risk Management Options* for the Terrestrial ERA for the Sä Dena Hes Mine Site - Overall Mine Site (Large Home Range ROCs). (A) Current Scenario - top panel, (B) Future scenario - bottom panel.

**(A) CURRENT SCENARIO**


**Legend - Priority for Study or Action:**

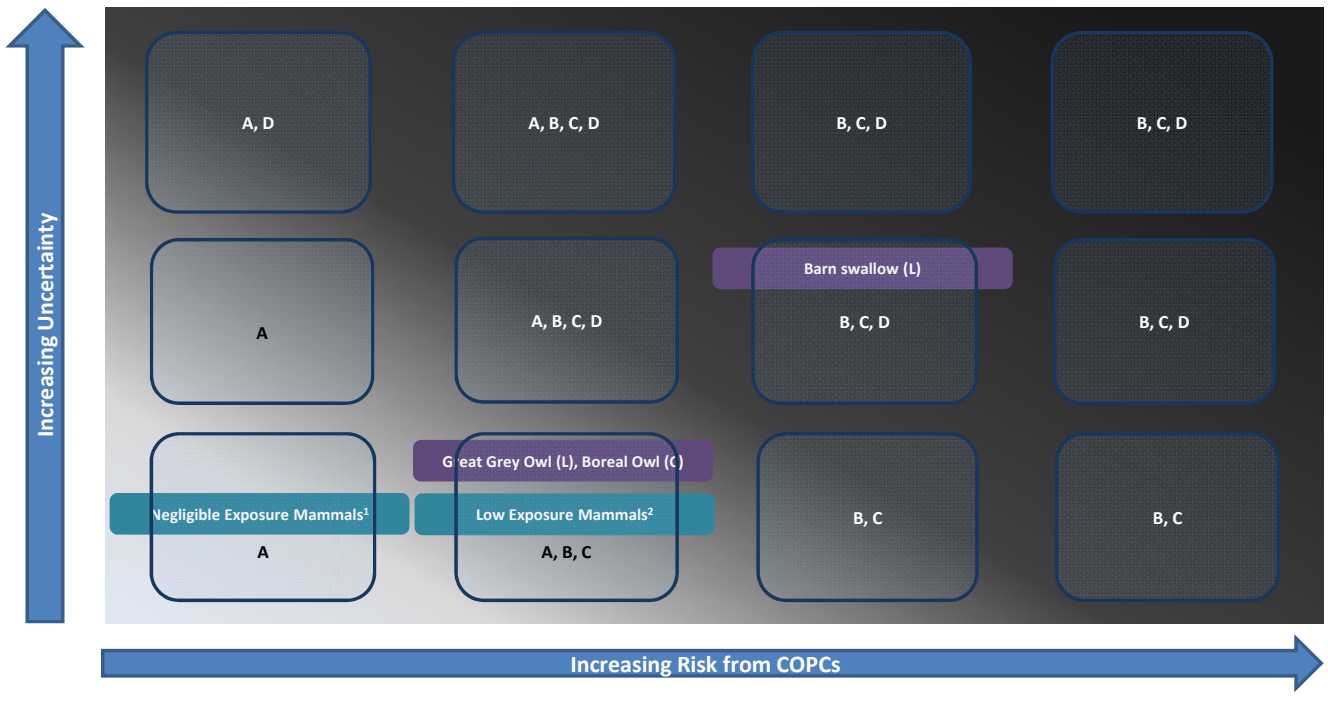
- Higher priority
- Lower priority
- No further studies

**Notes:**

[1] Moose (C), caribou (L), b. bear (C), lynx (C)

[2] Marten (L), wolverine (L), myotis (L))

**(B) FUTURE SCENARIO**




**Legend - Priority for Study or Action:**

- Higher priority
- Lower priority
- No further studies

**Notes:**

[1] Moose (C), caribou (L), b. bear (C), lynx (C), wolverine (L),

[2] Marten (L), myotis (L))

* Risk Management Options (see Figure 4-1 for more details)

A = No further action

B = Risk controls/source removal

C = Other solutions

D = Further study

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# VOLUME 2 – APPENDIX A

## Risk Analyses by Lines of Evidence for the Sä Dena Hes Terrestrial Ecological Risk Assessment

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# 1. INTRODUCTION

## 1.1. Overview

This appendix provides detailed information for each line of evidence (LOE) used in evaluating potential risks and associated uncertainties for the ecological risk assessment (ERA) of terrestrial receptors at the Sä Dena Hes Mine Site.

LOEs for this receptor group were initially identified during the Draft Problem Formulation (Azimuth 2013a) and have been slightly updated in the Updated Problem Formulation (see **Table 7-8 in Section 7 of Volume 1**). During the risk characterization process, each LOE is evaluated according to a series of attributes that represent data quality, ecological relevance, magnitude, and evidence for causality; see detailed criteria in **Tables 5-2 and 5-3 of Volume 1**. This approach to risk characterization is consistent with recent ERA guidance from Environment Canada (2012) and the Science Advisory Board for Contaminated Sites in British Columbia (SAB 2008, 2010).

Generally, each LOE used in an ERA links information or assumptions about exposure and effects, and considers causality. In some cases an LOE evaluates exposure (e.g., soil chemistry) but relies on literature studies (e.g., soil quality criteria) to assess the likely magnitude of effects instead of gathering site-specific effects data (e.g., toxicity testing or community surveys).

The detailed LOE assessment presented in this appendix "builds the case" for the weight-of-evidence (WOE) evaluation, where results of individual LOEs are integrated (in **Section 3 of the Main Report**) to reach a conclusion regarding potential risks for a specified receptor group/assessment endpoint.

In the Sä Dena Hes terrestrial ERA, we provide risk conclusions for current and future conditions to help guide risk management decision making. Current conditions and assumptions about future conditions are documented in **Sections 2.2 and 2.4 and Table 2-1 of the Main Report**.

The datasets used to support the LOE assessment are described in the LOE sections below and a review of the major supporting studies was provided in **Section 4 of Volume 1**. The data analyses conducted for each LOE are described below, but for many of the LOEs, the analysis had been reported previously in separate documents (e.g., the Data Report by Azimuth [2014a], the Interim ERA by Azimuth [2014c] including the Wildlife and Habitat Assessment by Gebauer and Associates [2014], Revegetation Test Program by Access [2008] and Detailed Decommissioning and Reclamation Plan [DDRP] by Teck [2013]). In these cases, key information is provided here, but readers are referred to these other sources for more detailed information. As well, information from **Volume 1 and Volume 2** of the ERA that is relied upon for the LOE assessment is not repeated in this appendix; readers are referred to appropriate sections, figures and tables.

## 1.2. Appendix Organization

Each of the following sections describes LOEs used in the terrestrial ERA for the Sä Dena Hes ERA. The general LOE categories include:

- Soil chemistry for plants and invertebrates
- Tissue chemistry (plants, invertebrates and small mammals) and hare and moose fecal pellet chemistry as measures of exposure to the ROC groups themselves (relative to background)
- Field surveys for plants and catch rates for invertebrates and small mammals
- A plant colonization study and revegetation test plots
- Food chain modeling

For each LOE, we describe specifically how the exposure and effects information is used to inform the LOE, the data analysis that underpins the LOE, and the risk characterization stage attributes.

# 2. SOIL CHEMISTRY

## 2.1. LOE Description

Compare soil chemistry to Yukon CSR soil standards used for COPC screening (i.e., generic or matrix-specific standards for toxicity to soil invertebrates and plants, using the Wildlands (PL) use category). Evaluate spatial gradients and extent of contamination patterns.

This LOE is used for plants and invertebrate communities.

## 2.2. Data Analysis

**Section 7.2** of **Volume 1** includes an Updated PF and describes the screening process and benchmarks used to identify contaminants of potential concern (COPCs) for the terrestrial environment. In this section, we rely on the same approach to use soil chemistry data from 2012-2013 as a LOE in the ERA.

Briefly, soils were screened against the following Yukon CSR soil standards for Wildlands (PL) (Yukon Environment, 2002):

- Matrix numerical soil standards (toxicity to soil invertebrates and plants [Yukon CSR Schedule 2]). The 'Contact' guideline, derived from toxicity studies in the literature that defines the lowest soil concentration where direct toxicity to rooting plants and/or soil dwelling invertebrates have been demonstrated. Contact standards have been determined for antimony, cadmium, chromium, copper, lead, mercury and zinc.
- Where toxicity-derived guidelines have not been determined, we applied 'Generic' parkland soil quality guidelines for antimony, barium, beryllium, cobalt, molybdenum, nickel, selenium, silver, tin and vanadium (Yukon CSR Schedule 1).
- Local Background – Defined as the 95th percentile of the mean of metals concentrations from all inorganic reference soils. Reference areas included two far-field reference stations (FF-Ref1, FF-Ref2) up to 3 km away within the native forest accessed from the mine road, and an on-site reference (NC-Ref). In nearly all cases, background metals concentrations were lower than the contact or generic guideline concentrations. Zinc was the only metal where the background concentration (685 mg/kg) exceeded the screening standard (450 mg/kg) (for the terrestrial screen), indicating that regional soils are naturally elevated in zinc.

**Figures 7-1 to 7-6 of Volume 1** show the COPC concentrations in soils throughout the site. Samples shown in green meet the CSR PL standard, samples shown in orange exceed the CSR standard by 1 to 10 times, and samples shown in red exceed the CSR standard by more than 10 times. **Table A-1 of Volume 1** summarized the screening quotients (i.e., soil concentration divided by standard "SQs") for all metals by AEC and **Table A-1** below summarizes this information for the 10 COPCs. Note that for this table (and soil COPC screening only) AEC 1 (Jewelbox) and AEC 9 (Main Zone, 1380 Gully) are presented separately. This was done to be consistent with Golder's ESA and AEC groupings. However, Golder has

inferred a connection between AEC 1 and AEC 9 (see **Figure 4-1 of Volume 1**); thus, these areas are grouped in the Drat TERA[1].

Overall, the data show high SQs particularly for lead, zinc, selenium and molybdenum. The Jewelbox AEC appears the most contaminated followed by Main Zone, Mill Site and the Tailings Facility. The Burnick area is the least contaminated, with only two COPCs being identified in this area.

[1] Note that further evaluation of the separate contribution of various management units in AEC 1/9 (e.g., waste rock piles, benches, 1380 Gully, 1250 Portal) to exposure to various ROCs will be conducted in the Updated TERA.

**Table A-1: Summary of COPC concentration by AEC (mg/kg dw) and degree of exceedance of relevant CSR standards (Screening Quotient [SQ]).**

| | Maximum and 95% UCLM Concentration of COPC by AEC (mg/kg dw) (SQ vs. Standard), Spatial Extent[1] | | | | |
|---|---|---|---|---|---|
| **COPC and Guidelines (mg/kg dw)** | **AEC 2 Burnick Zone** | **AEC 1 Jewelbox** | **AEC 9 Main Zone, 1380 Gully, 1250 Portal** | **AEC 3 Mill Site** | **AEC 8 Tailings Management Facility** |
| *n* | *12* | *17* | *15-29* | *38-41* | *47* |
| **Antimony 20 (PL Generic)** | Not a COPC | Not a COPC | Max = 80 (4)<br>95% = 32 (1.6) | Not a COPC | Not a COPC |
| **Arsenic 50 (PL Plant Invert)** | Not a COPC<br>Limited | Max = 373 (7.5)<br>95% = 111 (2.2)<br>Moderate | Max = 357 (7.1)<br>95% = 110 (2.2)<br>Moderate | Max = 334 (6.7)<br>95% = 66 (1.3)<br>Moderate | Max = 68.7 (1.4)<br>95% = 33 (0.7)<br>Limited |
| **Cadmium 70 (PL Plant Invert)** | Not a COPC<br>Widespread[2] | Max = 934 (13)<br>95% = 243 (3.5)<br>Moderate | Max = 450 (6.4)<br>95% = 199 (2.8)<br>Moderate | Max = 617 (8.8)<br>95% = 71 (1.0)<br>Limited | Not a COPC<br>Limited |
| **Copper 150 (PL Plant Invert)** | Not a COPC | Max = 523 (3.5)<br>95% = 181 (1.2) | Not a COPC | Not a COPC | Not a COPC |
| **Lead 1000 (PL Plant Invert)** | Not a COPC<br>Moderate* | Max = 30,300 (30)<br>95% = 9,489 (9.5)<br>Widespread | Max = 45,700 (46)<br>95% = 13,443 (13)<br>Widespread | Max = 34,300 (34)<br>95% = 4,902 (4.9)<br>Widespread | Max = 14,800 (15)<br>95% = 5,119 (5.1)<br>Widespread |
| **Molybdenum 10 (PL Generic)** | Not a COPC<br>Limited | Max = 98.6 (10)<br>95% = 24 (2.4)<br>Widespread | Not a COPC<br>Localized | Max = 80.1 (8.0)<br>95% = 14 (1.4)<br>Moderate | Max = 17.7 (1.8)<br>95% = 8 (0.8)<br>Moderate |
| **Selenium 3 (PL Generic)** | Max = 9.3 (3.1)<br>95% = 5 (1.7)<br>Widespread | Max = 57.2 (19)<br>95% = 17 (5.7)<br>Widespread | Max = 32 (11)<br>95% = 12 (3.9)<br>Moderate | Max = 29 (10)<br>95% = 4 (1.5)<br>Moderate | Max = 15.2 (5.1)<br>95% = 4 (1.2)<br>Widespread |
| **Silver 20 (PL Generic)** | Not a COPC | Max = 47.7 (2.4)<br>95% = 18 (0.9) | Max = 64.7 (3.2)<br>95% = 26 (1.3) | Not a COPC | Not a COPC |

| | Maximum and 95% UCLM Concentration of COPC by AEC (mg/kg dw) (SQ vs. Standard), Spatial Extent[1] | | | | |
|---|---|---|---|---|---|
| **COPC and Guidelines (mg/kg dw)** | **AEC 2 Burnick Zone** | **AEC 1 Jewelbox** | **AEC 9 Main Zone, 1380 Gully, 1250 Portal** | **AEC 3 Mill Site** | **AEC 8 Tailings Management Facility** |
| *n* | *12* | *17* | *15-29* | *38-41* | *47* |
| **Vanadium 200 (PL Generic)** | Not a COPC | Max = 1,030 (5.2)<br>95% = 241 (1.2) | Not a COPC | Not a COPC | Not a COPC |
| **Zinc 450 (PL Plant Invert)** | Max = 17,100 (25)<br>95% = 7,104 (11)<br>Widespread | Max = 160,000 (238)<br>95% = 29,797 (44)<br>Widespread | Max = 70,800 (104)<br>95% = 20,467 (30)<br>Widespread | Max = 105,000 (155)<br>95% = 11,659 (17)<br>Widespread | Max = 18,500 (27)<br>95% = 6,404 (9.4)<br>Widespread |

COPCs by AEC are highlighted according to the SQ based on the *maximum* concentration:

Blue highlighted cells = Not a COPC

Yellow highlighted cells = Low SQ of (1 to 3)

Orange highlighted cells = Moderate SQ of 3 to 10

Red highlighted cells = High SQ of > 10

Max = Maximum

95% = 95% UCLM (upper confidence limit of the mean)

CSR Standards are:

PL = Wildlands/Park Land – Generic or Matrix Specific for Toxicity to Plants and Soil Invertebrates

Notes:

1 – Spatial extent was determined based on the number of samples exceeding the PL standards, for the primary COPCs that were mapped (arsenic, cadmium, lead, molybdenum, selenium, zinc). Ratings are: localized = small area exceeds criteria; limited = few samples exceed criteria but not in a localized area; moderate = several samples exceed criteria; widespread = most samples exceed criteria

2 – Locations where HHRA samples exceed guidelines, but HHRA samples were not included in the COPC screening

## 2.3. LOE Attributes

### 2.3.1. Data Quality

**Acceptable** – Soil data used for soil screening were provided by Golder (2013, 2014a). Data quality was considered acceptable based on QA/QC measures that were in place during site characterization. Samples for which data quality was questionable were excluded from the data set (i.e., 2012 XRF data and 2012 duplicate data for the NC-Ref sample; see Data Report Azimuth 2014a).

### 2.3.2. Ecological Relevance

**Low** – Comparisons of soil chemistry data to various benchmarks are considered to have low ecological relevance for predicting risks to plants and ground invertebrates. The LOE does not incorporate any site-specific information on local soil characteristics or the plant and invertebrate communities themselves (e.g., abundance, richness, and biomass). Furthermore, the CSR PL standards are either generic or based on pooled effects data for plants and soil invertebrates for the matrix-specific standards (CSST 1996); matrix specific standards (i.e., for antimony, cadmium, chromium, copper, lead, mercury and zinc) are considered more relevant for assessing risks to plants and invertebrates (but pooled and not as separate ROC groups) than generic standards. The soil chemistry information does provide important context (i.e., contaminant exposure) for establishing exposure levels and interpreting other LOEs.

### 2.3.3. Magnitude

*Degree of Contamination and Spatial/Temporal Scale*

Ratings are provided by area:

- **Burnick/1300 Portal (AEC 2)**
  - **Current: Above Benchmarks, High Degree of Exceedance** – While most COPCs were not elevated at Burnick, concentrations of zinc were high (up to 25 times above standard). Selenium was elevated to a moderate degree (up to 3 fold above standard). Spatial extent is considered widespread within the AEC for zinc, selenium and cadmium. In the absence of remediation, temporal extent is considered long-term based on inferred stable conditions in the terrestrial environment.
  - **Future: Above Benchmarks, High Degree of Exceedance** – The future scenario assumes that remediation occurs in the Burnick 1200 bench area (e.g., soil cover), which would address the samples/areas with elevated zinc, selenium, cadmium and other sporadic

COPC exceedances on the 1200 bench[2]. It was assumed that no remediation would occur for the 1300 Portal bench[3], so future soil chemistry is predicted to remain high at the 1300 Portal. Overall, uncertainty in future soil chemistry in this AEC, as a consequence of actual closure activities, remains high.

- **Jewelbox (AEC 1)**
  - **Current: Above Benchmarks, High Degree of Exceedance** – This AEC was the most contaminated on-Site with some of the highest COPC concentrations in soil and the most COPCs identified (arsenic, cadmium, copper, lead, molybdenum, selenium, silver, vanadium, and zinc). Zinc, lead, selenium and cadmium had the highest SQs (e.g., 19 for selenium, 30 for lead, and 238 for zinc, based on maximum concentrations). Spatial extent is considered widespread within the AEC for several COPCs. In the absence of remediation, temporal extent is considered long-term based on inferred stable conditions in the terrestrial environment.

> **Note:** In Tables 3-1 and 3-2, AEC 1 and AEC 9 are presented together and future ratings (Table 3-2) are based on AEC 9, since concentrations are predicted to remain higher in AEC 9 (because of the 1380 gully) relative to AEC 1.

  - **Future: Above Benchmarks, Moderate Degree of Exceedance** – It was assumed that and Jewelbox bench areas above the Jewelbox Pit, Jewelbox North and 1408 waste rock piles would be remediated (e.g., soil removal or capping), which would address the elevated COPCs in these areas, but might not address elevated COPCs around the periphery[4]. Overall, future soil chemistry is predicted to be moderate, but uncertainty remains high as post-reclamation re-contoured soil and waste-rock metals chemistry is unknown.

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[2] As part of reclamation, Teck has re-contoured both the 1200 and 1300 bench areas at the Burnick AEC in 2014 using uncharacterized nearby soils. As well, the upper portions of the 1200 and 1300 waste rock piles have been disturbed and re-sloped with a mixture of waste rock and underlying till, with unknown metals composition. The lower portions of the 1200 and 1300 waste rock piles have been left undisturbed. All of these features (re-contoured benches and waste rock piles and undisturbed waste rock piles) are currently being characterized and will be re-evaluated in the Updated TERA. See **Section 2.2 in the Main Report** for more details.

[3] See footnote 2.

[4] As part of reclamation, Teck has re-contoured the Pit, North and 1408 bench areas at the Jewelbox AEC in 2014 using uncharacterized nearby soils. As well, we understand that the upper portions of the Pit, North and 1408 waste rock piles have been disturbed and re-sloped with a mixture of waste rock and underlying till, with unknown metals composition. The lower portions of these waste rock piles remain undisturbed. All of these features (re-contoured benches and waste rock piles and undisturbed waste rock piles) are currently being characterized and will be re-evaluated in the Updated TERA. Golder is also characterizing 'background' soil quality in the Jewelbox Hill (naturally mineralized) area. See **Section 2.2 in the Main Report** for more details.

- **Main Zone/1380 Gully/1250 Portal (AEC 9)**
  - **Current: Above Benchmarks, High Degree of Exceedance** – This AEC was the second most contaminated area on-Site and had the highest concentrations of lead in soil. Several COPCs were identified (antimony, arsenic, cadmium, lead, selenium, silver, and zinc) with SQs up to 104 for zinc, and 46 for lead (based on maximum concentrations). Spatial extent is considered widespread within the AEC for several COPCs. In the absence of remediation, temporal extent is considered long-term based on inferred stable conditions in the terrestrial environment.
  - **Future: Above Benchmarks, High Degree of Exceedance** – The ERA assumed that the Main Zone[5] bench area would be remediated (i.e., soil cover), which would address elevated COPCs on the bench. However, it was assumed that there would be no remediation of the 1380 Gully and 1250 Portal. Consequently, future soil chemistry overall in AEC 9 is still rated as high. Note that uncertainty remains high as a result of uncertainty in post-reclamation soil chemistry in reclaimed areas and uncertainty with respect to actual (if any) remedial measures in the 1380 Gully and 1250 Portal.
- **Mill Site (AEC 3)**
  - **Current: Above Benchmarks, High Degree of Exceedance** – This AEC had high concentrations of lead (up to 34 fold above standard), selenium (up to 10 fold above standard) and zinc (up to 155 fold above standard), and moderate concentrations of arsenic, cadmium, and molybdenum. Spatial extent ranged from **limited** for cadmium to **widespread** for zinc and lead, and was **moderate** for other COPCs. In the absence of remediation, temporal extent is considered **long-term** based on inferred stable conditions in the terrestrial environment.
  - **Future: Mostly Below Benchmarks, Low Degree of Exceedance** – For the ERA, we have **assumed** that the entire disturbed footprint of the Mill Site AEC is to be covered with clean soil. Assuming this occurs, most of the elevated COPCs would be addressed and only some lower exceedances on the border of the AEC in vegetated habitat would remain. Some additional characterization is planned in the Mill Site area by Golder in 2014; however, overall, future soil chemistry is rated as having a low degree of exceedance.

[5] As part of reclamation, Teck has re-contoured the Main Zone pit and waste rock bench area in AEC 9 in 2014 using uncharacterized nearby soils. As well, we understand that the upper portions of the Main Zone waste rock pile has been disturbed and re-sloped with a mixture of waste rock and underlying till, with unknown metals composition. We understand, the lower portion of the waste rock pile remains undisturbed. All of these features (re-contoured pit, bench and waste rock pile, and undisturbed waste rock pile) are currently being characterized and will be re-evaluated in the Updated TERA. Golder is also characterizing 'background' soil quality in the 1380 Gully, which may be a naturally mineralized area. See Section 2.2 in the Main Report for more details.

- **Tailings Management Facility (AEC 8)**
  - **Current: Above Benchmarks, High Degree of Exceedance** – This AEC had high concentrations of lead (up to 15 fold above standard), and zinc (up to 27 fold above standard), and moderate concentrations of selenium. Overall, there were fewer COPCs identified within this AEC. Notwithstanding, spatial extent is considered **widespread** within this AEC for lead, selenium and zinc. In the absence of remediation, temporal extent is considered **long-term** based on inferred stable conditions in the terrestrial environment.
  - **Future: Mostly Below Benchmarks (except periphery), Moderate Degree of Exceedance** – For the ERA, we have assumed that the majority of the TMF is to be covered with clean soil (except TPN, TPN-West Berm and the marsh area; see **Section 2.2 in the Main Report** for details). Assuming this occurs, most of the elevated COPCs would be addressed, except for in the TPN, and TPN-West berm areas and a couple other exceedances on the border of the AEC in vegetated habitat. Further delineation of soils along the perimeter of the TMF and ponds (and possibly in the marsh habitat) is planned for 2014. Overall, however, future soil chemistry is rated as having a low degree of exceedance.

These ratings apply equally to plants and invertebrates.

**Overall mine site trends:**

- **Spatial extent of contamination is widespread** – Overall, COPC exceedances are widespread within the disturbed AECs, but contamination does not appear to have migrated into the adjacent forested lands, with the exception of the 1380 Gully, 1250 Portal, and TPN (north of the north Tailings).
- **Temporal extent of contamination is long-term** – While soil data were collected only in 2012 and 2013, close to 20 years after the mine entered a state of temporary closure, the terrestrial environment is considered fairly stable and soil data are expected to represent long-term trends (without active remediation). Post-closure soil chemistry in the AECs is anticipated to improve where remedial works are planned, according to the information and assumptions provided in **Section 2.2** of the main report. Soil and waste rock chemistry in the reclaimed AECs described above are currently being characterized and will be re-evaluated in the Updated TERA.

### *Uncertainty About Magnitude*

**Moderate for Exposure; High for Effects** – For this LOE we consider uncertainty related to the magnitude of exposure to be moderate. While we expect the data collected to date provides a fairly solid foundation, there are some remaining data gaps for site characterization (see **Section 4.6 of Volume 1**), and uncertainty in actual post-closure conditions remains high. In addition, the DDRP is adapting to results of the HHRA and ERA, so final remedial measures and post-closure conditions may change.

Uncertainty related to extrapolating this LOE to effects to plant and invertebrate communities is considered high because it does not incorporate any site-specific information on local soil characteristics

or the plant and invertebrate communities themselves. Note, uncertainty related to effects is provided in **Tables 3-1** and **3-2**.

For plants and invertebrates, according to CSST (1996), the CSR standards for the protection of soil invertebrates and plants were derived using a dataset of draft unpublished CCME Ecological Health Substance Assessment documents, which include mortality, reproduction, and growth endpoints. All appropriate invertebrate and plant data were first pooled, then separated into discrete lethal and sublethal distributions to derive LC20[6] and EC50[7] values, respectively. The PL standards represent the lowest of either the LC20 or the EC50. Given this derivation process, there is uncertainty when attempting to understand the likely magnitude of effects to plant communities versus invertebrates. Furthermore, no differentiation between soil textural types is recognized when deriving the CSR soil matrix standards for the protection of soil invertebrates and plants. While soil properties undoubtedly influence contaminant partitioning as well as bioavailability, the science is not yet sufficiently developed to allow simple soil textural cut-offs to serve as a generically applicable differentiator of bioavailability or toxicity (SAB 2009). Independent of soil properties, the form of the metal will also play a role in its bioavailability (Allen 2002). We note that based on PBET testing conducted to support the HHRA, bioaccessibility of lead in the soils at the Sä Dena Hes site is considered high (around 80%).

### *2.3.4. Causality*

*Strength of Correlation and Supporting Evidence*

**Correlation (N/A); Supporting Evidence (Plausible) –** This LOE identifies elevated exposure relative to effects-based benchmarks/standards. Because the standards are effects-based, they provide plausible supporting evidence for potential toxicity. However, because standards are usually derived to be conservative for multiple sites/environments, exceedance of a standard only indicates the possibility for an effect. This LOE does not provide evidence of causality for actual effects.

*Uncertainty Related to Causality*

**High –** While the mechanism of action is supported by the data underlying the soil standards, this LOE does not incorporate site-specific information on effects to assess strength of relationships/causality.

[6] Contaminant concentration resulting in mortality in 20% of the exposed organisms.

[7] Contaminant concentration resulting in 50% impairment in an endpoint for the exposed organisms.

# 3. PLANT AND BERRY TISSUE CHEMISTRY

## 3.1. LOE Description

Comparison of plant and berry tissue chemistry across a gradient of on-Site COPC exposure in soil and in relation to background plant tissue chemistry from reference areas.

This LOE is used for plants communities only.

## 3.2. Data Analysis

This LOE relies on plant data collected from the Sä Dena Hes mine site in 2012 and 2013, which has been reported in the Data Report (Azimuth 2014a). Concentrations of metals in willow twigs from 2013 (Table 6-1), alder twigs from 2013 (Table 6-2), willow and alder leaves and twigs from the Tailings Pond in 2012 are reported in Section 6 of the Data Report. Concentrations of metals in crowberry, huckleberry, and lingonberry are reported in Section 9 of the Data Report (including Figure 9-1). Locations of tissue sampling areas are shown in **Figure 4-9** of the **Main Report**. Readers are referred to the Data Report for further details.

Briefly, plant tissues from on-Site areas were compared to the maximum concentration from the three reference areas, for each species. Samples that were more than **two fold above the maximum are bolded**, and samples exceeding **ten times the reference concentration are shaded** in the Data Report and in the summary below. The data show (results here focus on COPCs that exceed the maximum reference area concentration):

Willow twigs:

- Cadmium exceeded the maximum reference concentration (5.26 mg/kg ww) in one of three samples from the 1250 Portal (**10.9** mg/kg ww), and one of three samples from the 1300 Portal (**11.9** mg/kg ww). Cadmium concentrations in willow leaves and twigs collected in 2012 from the North Tailings were up to **19** mg/kg ww.
- Lead exceeded the maximum reference concentration (0.257 mg/kg ww) in samples from JBX (**4.9** mg/kg ww), 1380 Gully (**61.4** mg/kg ww), 1250 Portal (up to **5.89** mg/kg ww), and MS (**0.911** mg/kg ww). Lead concentrations in willow leaves and twigs collected in 2012 from the North Tailings were up to **13** mg/kg ww.
- Zinc exceeded the maximum reference concentration (82.5 mg/kg ww) in samples from the 1300 Portal (up to **200** mg/kg ww). Zinc concentrations in willow leaves and twigs collected in 2012 from the North Tailings were up to **459** mg/kg ww.

Alder twigs:

- Cadmium exceeded the maximum reference concentration (0.0751 mg/kg ww) in one of three samples from the 1250 Portal (**5.7** mg/kg ww), the 1300 Portal (**0.27** mg/kg ww).

- Lead exceeded the maximum reference concentration (2.26 mg/kg ww) in samples from the 1380 Gully (**5.35** mg/kg ww). Lead concentrations in alder leaves and twigs collected in 2012 from the North Tailings were up to **128** mg/kg ww (ten times higher than willow). Note this data show that lead in alder from the reference areas and from North Tailings was about ten times higher than lead in willow from these areas. However, lead in alder from the 1380 Gully was to times lower than willow.
- Zinc exceeded the maximum reference concentration (64.7 mg/kg ww) in leaves and twigs collected in 2012 from the North Tailings area (**240** mg/kg ww).

Crowberry

- Arsenic exceeded the maximum reference concentration (0.004 mg/kg ww) in one of three samples from BRK (**0.1** mg/kg ww).
- Lead exceeded the maximum reference concentration (0.004-0.013 mg/kg ww) in samples from JBX (**1.84** mg/kg ww), 1380 Gully (up to **0.57** mg/kg ww), MS (**0.69** mg/kg ww), TPN (**0.12** mg/kg ww), and BRK (**0.04** mg/kg ww).
- Some other metals were two fold higher the maximum reference concentration, including chromium from 1380 Gully, zinc from JBX and molybdenum from BRK.

Huckleberry

- Lead exceeded the maximum reference concentration (0.0044 mg/kg ww) in samples from JBX (**0.06** mg/kg ww), 1380 Gully (up to **0.04** mg/kg ww), and MS (**0.65** mg/kg ww).
- Few other metals from exposure areas were at least two times higher than maximum reference areas, including molybdenum from BRK.

Lingonberry

- Lead exceeded the maximum reference concentration (0.01 mg/kg ww) in samples from 1380 Gully (up to **0.13** mg/kg ww), MS (up to **1.08** mg/kg ww), and TPN (**0.06** mg/kg ww).
- Few other metals from exposure areas were at least two times higher than maximum reference areas, including chromium at 1380 Gully and REC-S.

## 3.3. LOE Attributes

### *3.3.1. Data Quality*

**Acceptable** – Data quality of vegetation data used for the ERA was considered acceptable based on standard field and laboratory QA/QC measures that were used. No data quality issues have been identified in the Data Report (Azimuth 2014a).

### 3.3.2. Ecological Relevance

**Low** – Tissue samples collected from the site represent site-specific exposures relative to the reference area, but effects are not directly assessed. As a result, this LOE is considered to have low ecological relevance for predicting risks to plants.

### 3.3.3. Magnitude

*Degree of Contamination and Spatial/Temporal Scale*

Degree of contamination ratings for tissue concentrations, relative to background, were based generally on the following categories:

- Negligible = the same or lower than background
- Low = 1 to 3 times above background
- Moderate = 3 to 10 times above background
- High = Greater than 10 times above background

The magnitude of exceedance, but also the number of samples exceeding and spatial extent were considered in the degree of contamination ratings.

Ratings are provided by area:

- **Burnick/1300 Portal – Current and Future: Moderate Degree of Exceedance** – Cadmium concentrations in willow and alder from the 1300 Portal were two to five fold above background. Arsenic and molybdenum in berries from BRK exceeded background by up to 25 fold. Spatial extent is considered **localized** (small areas of the 1300 Portal and Burnick Zone) and only some of the samples exceeded. Temporal extent is considered **long-term** based on inferred stable conditions. It is possible, but uncertain whether reclamation/remediation of the 1200 and 1300 Burnick disturbed areas would result in lower metals concentrations in berries collected from nearby tissue sampling areas. Consequently, future concentrations are rated the same as current.
- **Jewelbox/1380 Gully/1250 Portal – Current and Future: High Degree of Exceedance** – Lead in willow, alder and berries from these areas consistently exceeded background by more than ten fold, and up to 200 times in some cases. Chromium exceeded background in berries from the 1380 Gully by more than two fold. Spatial extent is considered **widespread** throughout this AEC grouping; the AEC is relatively large and most samples exceeded. Temporal extent is considered **long-term** based on inferred stable conditions of the terrestrial environment and because no remedial action is planned in the 1380 Gully or 1250 Portal.
- **Mill Site – Current and Future: High Degree of Exceedance** – Lead in berries from MS were consistently above background by approximately 60-100 times. Willow and alder did not exceed background. Spatial extent is considered **moderate** (collected from several areas from

around the Mill Site) and only some of the samples exceeded. Temporal extent is considered **long-term** based on inferred stable conditions. Remediation in this area may address elevated metals in berries in this area, but again this is uncertain as they were collected outside the disturbed footprint. Additional berry samples were collected in 2014 to reduce uncertainty.

- **Tailings Management Facility – Current and Future: High Degree of Exceedance** – Lead and zinc were elevated in willow and alder on the North Tailings by up to 50 fold. Berries from TPN were six to nine fold above background. Spatial extent is considered **moderate** on the north tailings and to the north in the forested area and not all vegetation types exceeded in TPN. Temporal extent is considered **long-term** based on inferred stable conditions. Remediation of this AEC is expected to address elevated metals in plants growing on the tailings. There is uncertainty for the TPN area, however, which may be elevated due to historical dusting and where there are no plans for remediation.

Overall, the above plant concentrations and ratings are used for both the current and future scenarios because most of the plants were collected outside the disturbed footprints of the AECs, and there is uncertainty whether remedial plans will address elevated COPCs in plants. For tissue areas located within AECs (i.e., 1380 Gully, 1250 Portal and TPN) no remedial activities are planned, except in the South Tailings area of AEC 8.

*Uncertainty About Magnitude*

**Moderate for Exposure; High for Effects** – For this LOE we consider uncertainty related to the magnitude of exposure to be moderate because of the expected spatial and species-specific variability in metal uptake. Uncertainty related to extrapolating this LOE to effects to plants is considered high because it is a measure of exposure only and effects information is not considered. Note, uncertainty related to effects is provided in **Tables 3-1** and **3-2**.

### 3.3.4. Causality

*Strength of Correlation and Supporting Evidence*

**N/A –** This LOE is a measure of exposure in plants on-Site relative to background and does not assess actual toxicological effects. However, there is an implicit assumption that background plant concentrations represent "safe" exposure levels. If on-Site concentrations are equivalent or lower than background, this LOE can be effective in ruling out potential contaminant-related effects. However, if on-Site concentrations exceed background, then exposure is confirmed to be elevated and there is the potential for toxicological effects.

*Uncertainty Related to Causality*

**N/A –** Causality not assessed.

# 4. INVERTEBRATE TISSUE CHEMISTRY

## 4.1. LOE Description

Comparison of ground and flying invertebrate tissue chemistry across a gradient of on-Site COPC exposure in soil and in relation to background invertebrate chemistry from reference areas.

This LOE is used for invertebrate communities only.

## 4.2. Data Analysis

This LOE relies on ground and flying invertebrate data collected from the Sä Dena Hes mine site in 2013, which has been reported in Section 7 of the Data Report (Azimuth 2014a). Locations of tissue sampling areas are shown in **Figure 4-9** of the **Main Report**. Readers are referred to the Data Report for further details.

Briefly, invertebrates from on-Site areas were compared to the maximum concentration from the three reference areas. Samples that were more than **two fold above the maximum are bolded**, and samples exceeding **ten times the reference concentration are shaded** in the Data Report and in the summary below. The data show (results here focus on COPCs that exceed the maximum reference area concentration):

**Ground invertebrates**

- Antimony exceeded the maximum reference concentration (0.006 mg/kg ww) in the 1380 Gully (**0.14** mg/kg ww), TPN (**0.02** mg/kg ww), North Tailings (**0.03** mg/kg ww) and TPN-West berm (**0.02** mg/kg ww).
- Arsenic exceeded the maximum reference concentration (0.05 mg/kg ww) in the 1380 Gully (**0.29** mg/kg ww), JBX (**0.22** mg/kg ww), TPN (**0.31** mg/kg ww), and TPN-West berm (**0.13** mg/kg ww).
- Cadmium exceeded the maximum reference concentration (3.7 mg/kg ww) in the 1380 Gully (6.1 mg/kg ww).
- Lead exceeded the maximum reference concentration (<2 mg/kg ww) in the 1380 Gully (**72** mg/kg ww), and TPN-West berm (**19** mg/kg ww).
- Selenium exceeded the maximum reference concentration (0.40 mg/kg ww) in the North Tailings (**0.85** mg/kg ww), and TPN-West berm (**1.45** mg/kg ww).
- Vanadium exceeded the maximum reference concentration (0.10 mg/kg ww) in the 1380 Gully (**0.77** mg/kg ww), JBX (**0.52** mg/kg ww), North Tailings (**1.1** mg/kg ww), TPN (**0.51** mg/kg ww), TPN-West berm (**0.57** mg/kg ww), BRK (**0.30** mg/kg ww), TPW (**0.21** mg/kg ww).
- Zinc exceeded the maximum reference concentration (72mg/kg ww) in the 1380 Gully (**145** mg/kg ww).

**Flying invertebrates**

- Note that data for flying insects are more limited than ground invertebrates. Concentrations of lead in flying insects from the Mill Site (**4.88** mg/kg ww) were more than 10-fold above background (0.47 mg/kg ww). Some of the samples located around the periphery of the Tailings facility had slightly elevated metals relative to background, such as arsenic, lead, and selenium; but no other patterns of exceedance were observed

## 4.3. LOE Attributes

### 4.3.1. Data Quality

**Acceptable** – Data quality of invertebrate tissue data used for the ERA was considered acceptable based on standard field and laboratory QA/QC measures that were used. No data quality issues have been identified in the Data Report (Azimuth 2014a).

### 4.3.2. Ecological Relevance

**Low** – Tissue samples collected from the site represent site-specific exposures relative to the reference area, but effects are not directly assessed. As a result, this LOE is considered to have low ecological relevance for predicting risks to invertebrates.

### 4.3.3. Magnitude

*Degree of Contamination and Spatial/Temporal Scale*

Degree of contamination ratings for tissue concentrations, relative to background, were based generally on the following categories:

- Negligible = the same or lower than background
- Low = 1 to 3 times above background
- Moderate = 3 to 10 times above background
- High = Greater than 10 times above background

The magnitude of exceedance, but also the number of samples exceeding and spatial extent were considered in the degree of contamination ratings.

Ratings are provided by area:

- **Burnick/1300 Portal – Current and Future: Negligible Degree of Exceedance** – Metal COPC concentrations in invertebrates did not exceed background.
- **Jewelbox/Main Zone/1380 Gully/1250 Portal – Current and Future: High Degree of Exceedance** – Concentrations of some metals such as antimony, arsenic, lead, vanadium and zinc in ground invertebrates from the 1380 Gully and JBX exceeded background. The 1380 Gully

had SQs of 36 to 50 for antimony and lead, respectively. While only two tissue areas were sampled, they both generally exceeded reference area concentrations of metals, so spatial extent is considered **widespread** throughout this AEC grouping. Temporal extent is considered **long-term** based on inferred stable conditions. Reclamation of the Jewelbox and Main Zone bench areas may address elevated concentrations in ground invertebrates in the JBX station; but no remedial action is planned in the 1380 Gully.

- **Mill Site**
  - **Current: Moderate Degree of Exceedance** – Metals in ground invertebrates were not elevated at MS, but lead in flying invertebrates was 10-fold higher than background. Spatial extent is estimated to be **moderate**, but is not well defined. Temporal extent is considered **long-term** based on inferred stable conditions.
  - **Future: Low Degree of Exceedance** – Remediation of the Mill Site and TMF is expected to address elevated lead in flying invertebrates in this area. (Metals in ground invertebrates were not elevated under current conditions).
- **Tailings Management Facility**
  - **Current: High Degree of Exceedance** – Several metals exceeded background in invertebrates from this AEC (North Tailings, TPN, TPN-West berm). SQs were up to 10-fold, but were typically less than this. Spatial extent is considered **widespread** on this AEC, and invertebrates would be expected to be elevated the southern portion of the AEC as well. Temporal extent is considered **long-term** based on inferred stable conditions.
  - **Future: Moderate Degree of Exceedance** – Remediation of this AEC is expected to address elevated invertebrate tissue on the disturbed area, but there is uncertainty for the TPN and TPN-West Berm areas, which may be elevated due to historical dusting and there are no plans for remediation. Spatial extent is predicted to be more **localized** in the future scenario (compared to current conditions).

### *Uncertainty About Magnitude*

**Moderate for Exposure; High for Effects** – For this LOE we consider uncertainty related to the magnitude of exposure to be moderate because of the expected spatial variability in data. Uncertainty related to extrapolating this LOE to effects to invertebrates is considered high because it is a measure of exposure only and effects information is not directly assessed. Note, uncertainty related to effects is provided in **Tables 3-1 and 3-2**.

#### 4.3.4. Causality

*Strength of Correlation and Supporting Evidence*

**N/A –** This LOE is a measure of exposure in invertebrates on-Site relative to background and does not assess actual toxicological effects. However, there is an implicit assumption that background tissue/feces concentrations represent "safe" exposure levels. If on-Site concentrations are equivalent or lower than background, this LOE can be effective in ruling out potential contaminant-related effects. However, if on-Site concentrations exceed background, then exposure is confirmed to be elevated and there is the potential for toxicological effects.

*Uncertainty Related to Causality*

**N/A –** Causality not assessed.

# 5. SMALL MAMMAL & BIRD[8] TISSUE CHEMISTRY & HARE AND MOOSE PELLET CHEMISTRY

## 5.1. LOE Description

Comparison of small mammal or bird tissue chemistry across a gradient of on-Site COPC exposure in soil and in relation to background tissue chemistry from reference areas.

Comparison of hare and moose fecal pellet chemistry across a gradient of on-Site COPC exposure in soil and in relation to background hare and moose fecal pellet chemistry from reference areas.

This LOE is used for bird ROCs (i.e., incidental bird tissue) and small mammal ROCs (i.e., shrew, vole and mouse tissue data). The pellet data is used specifically for snowshoe hare (i.e., hare pellet data) and moose (i.e., moose pellet data).

## 5.2. Data Analysis

This LOE relies on small mammal/bird and fecal pellet data collected from the Sä Dena Hes mine site in 2013, which has been reported in Section 8 (small mammals) and Section 6 (pellet) of the Data Report (Azimuth 2014a). Locations of tissue sampling areas are shown in **Figure 4-9 of the Main Report**. Readers are referred to the Data Report for further details.

Briefly, small mammal (and bird) tissues and hare and moose pellets from on-Site areas were compared to the maximum concentration from the three reference areas. Samples that were more than **two fold above the maximum are bolded**, and samples exceeding **ten times the reference concentration are shaded** in the Data Report and in the summary below. The data show (results here focus on COPCs that exceed the maximum reference area concentration):

Shrews:

- Antimony exceeded the maximum reference concentration (0.006 mg/kg ww) in one-of-seven shrews from JBX (**0.0135** mg/kg ww).
- Lead exceeded the maximum reference concentration (1.78 mg/kg ww) in two-of-seven shrews from JBX (**9.6, 13.3** mg/kg ww).
- Selenium exceeded the maximum reference concentration (0.73 mg/kg ww) in two-of-six shrews from STP (**2.98, 1.61** mg/kg ww).

[8] Two birds were incidentally caught in traps in the program and are included in the data set.

Red-backed moles and meadow voles:

- Antimony exceeded the maximum reference concentration (0.013 mg/kg ww) in five-of-seven voles from MS (up to **0.24** mg/kg ww).
- Arsenic exceeded the maximum reference concentration (0.05 mg/kg ww) in one-of –six voles at BRK (**0.17** mg/kg ww) and one-of-seven voles at MS (**0.16** mg/kg ww).
- Lead exceeded the maximum reference concentration (1.28 mg/kg ww) in one-of-six voles from BRK (**3.1** mg/kg ww), and seven-of-seven voles from MS (up to **21.9** mg/kg ww) and the single vole that was analyzed from TPN (**7.5 mg/kg** ww).
- Selenium exceeded the maximum reference concentration (0.25 mg/kg ww) in two-of-six voles from BRK (**0.66** mg/kg ww), one-of-seven voles from MS (**0.66** mg/kg ww) and a single vole from STP (**0.64** mg/kg ww).
- Vanadium exceeded the maximum reference concentration (0.16 mg/kg ww) in one-of-seven voles from MS (**1.03** mg/kg ww).

Birds:

- Lead in the North Tailings Savannah sparrow (**3.46** mg/kg ww) exceeded the FF-Ref1 dark-eyed junco (0.853 mg/kg ww) as well as the maximum reference shrew and vole concentrations (1.78 and 1.28 mg/kg ww, respectively)
- Selenium in the North Tailings Savannah sparrow (**1.81** mg/kg ww) exceeded the FF-Ref1 dark-eyed junco (0.432 mg/kg ww) as well as the maximum reference shrew and vole concentrations (0.73 and 0.25 mg/kg ww, respectively)

Hare pellets:

- Metals concentrations in hare feces collected from Burnick zone and TPN-West berm in particular were between 2x and 10x or higher than reference area feces for several COPC metals including antimony, arsenic, copper, lead, selenium, and vanadium. Zinc from the TPN West Berm was just over twice the reference concentration, but this was the only location that zinc was elevated in hare fecal pellets.
- Lead exceeded the maximum reference concentration (13.7 mg/kg dw) at BRK (**53.6** mg/kg ww), MS (**31** mg/kg ww), TPN (**34** mg/kg ww) and TPN-West berm (**607** mg/kg ww).
- A large number of other non-COPC metals were elevated in hare feces at BRK and TPN-West berm but are not evaluated further.

Moose[9] pellets:

- Metals concentrations in moose feces collected from on-Site were elevated above reference area feces for several COPC metals including antimony, arsenic, cadmium, copper, lead, and selenium.
- Cadmium exceeded the maximum reference concentration (4.3 mg/kg dw) throughout the site by 2 – 4 times.
- Lead exceeded the maximum reference concentration (2.4 mg/kg dw) at 1380 Gully (**117** mg/kg ww) and TPN (**34.2** mg/kg ww) and REC-W (**7.9** mg/kg ww), and TPW (**5.9** mg/kg ww).
- Mercury, a non-COPC, in moose feces was consistently higher at most of the on-Site areas than in reference areas.

## 5.3. LOE Attributes

### *5.3.1. Data Quality*

**Acceptable** – Data quality of small mammal and bird tissue data and fecal pellet data used for the ERA was considered acceptable based on standard field and laboratory QA/QC measures that were used. No data quality issues have been identified in the Data Report (Azimuth 2014a).

### *5.3.2. Ecological Relevance*

**Low** – Tissue samples collected from the site represent site-specific exposures relative to the reference area, but effects are not directly assessed. As a result, this LOE is considered to have low ecological relevance for predicting risks to mammals and birds.

### *5.3.3. Magnitude*

*Degree of Contamination and Spatial/Temporal Scale*

Degree of contamination ratings for tissue concentrations, relative to background, were based generally on the following categories:

- Negligible = the same or lower than background
- Low = 1 to 3 times above background
- Moderate = 3 to 10 times above background

[9] For this LOE, moose pellets are used to support the mammal risk ratings by AEC (for animals with small home ranges). We note that the data suggest elevated cadmium, lead and mercury (a non-COPC) either throughout the site or near specific AECs. While we would expect that exposure for individual moose foraging in or near AECs would be elevated, this does necessarily translate to risks for individuals foraging throughout their entire foraging range, or for populations. The food chain model for moose estimated the on-Site lead dose to be 2.6 times higher than background; but both predicted doses were below the TRV.

- High = Greater than 10 times above background

The magnitude of exceedance, but also the number of samples exceeding and spatial extent were considered in the degree of contamination ratings.

Ratings are provided by area:

- **Burnick/1300 Portal – Current and Future: Low Degree of Exceedance**
  - Concentrations of arsenic, lead and selenium in BRK voles were elevated by 2-3 fold over background.
  - Hare feces also had 3-fold higher lead in the BRK sample, relative to the background.
  - Spatial extent may extend throughout this AEC, but the size of the AEC is small, so elevated exposure is expected to be localized. Temporal extent is considered **long-term** based on inferred stable conditions. It is possible that reclamation in the Burnick area may address elevated metals exposure in small mammals under future conditions.
- **Jewelbox/1380 Gully/1250 Portal – Current and Future: Moderate (small mammal tissue) or High (moose feces) Degree of Exceedance**
  - Concentrations of lead in JBX shrews were elevated by up to 7.5 fold. (Note that small mammals were not captured in the 1380 Gully, despite trapping efforts).
  - Moose feces from the 1380 Gully was 50 times higher in lead than background.
  - Spatial extent of elevated exposure is considered **widespread** throughout this AEC grouping. Temporal extent is considered **long-term** based on inferred stable conditions. Reclamation/remediation of the benches and waste rock piles may reduce metals exposure to small mammals and other species in these areas; but no remedial action is planned in the 1380 Gully.
- **Mill Site**
  - **Current: High (small mammal tissue) or low (hare feces) Degree of Exceedance**
    - Several metals in voles were elevated at MS; lead was elevated in all seven voles, and was up to 20-fold higher than background.
    - As well, hare feces were elevated about 2.5 fold from the MS relative to background.
    - Spatial extent is estimated to be **widespread** throughout the AEC, but is not well defined. Temporal extent is considered **long-term** based on inferred stable conditions.
  - **Future: Low Degree of Exceedance –** Remediation of the Mill Site is expected to address elevated metals in small mammals and snowshoe hare in this area.
- **Tailings Management Facility**

- **Current: Moderate (bird, small mammal tissues) or High (hare and moose feces) Degree of Exceedance**
  - Lead in the single vole was 4-6 times higher from the TPN area compared to background.
  - Lead and selenium in the single bird were 4-6 times higher from the TPN and North Tailings area compared to background.
  - Hare and moose feces from TPN and TPN-West Berm had up to 44 times more lead than feces collected from the reference areas.
  - Spatial extent is considered **widespread** on this AEC, and wildlife foraging from the southern portion of the AEC would be expected to have elevated metals concentrations as well. Temporal extent is considered **long-term** based on inferred stable conditions.
- **Future: Moderate Degree of Exceedance –** Remediation of this AEC is expected to address elevated metals exposure to wildlife on the disturbed area, but there is uncertainty for the TPN and TPN-West Berm areas, which may be elevated due to historical dusting and there are no plans for remediation. Spatial extent is predicted to be more **localized** in the future scenario (compared to current conditions).

*Uncertainty About Magnitude*

**Moderate for Exposure; High for Effects** – For this LOE we consider uncertainty related to the magnitude of exposure to be moderate because of the expected spatial variability in data and the limited sample sizes in some areas. Uncertainty related to extrapolating this LOE to effects to mammals is considered high because it is a measure of exposure only and effects information is not considered. Note, uncertainty related to effects is provided in **Tables 3-1 and 3-2**.

### 5.3.4. Causality

*Strength of Correlation and Supporting Evidence*

**N/A –** This LOE is a measure of exposure in mammals/birds on-Site relative to background and does not assess actual toxicological effects. However, there is an implicit assumption that background tissue/feces concentrations represent "safe" exposure levels. If on-Site concentrations are equivalent or lower than background, this LOE can be effective in ruling out potential contaminant-related effects. However, if on-Site concentrations exceed background, then exposure is confirmed to be elevated and there is the potential for toxicological effects.

*Uncertainty Related to Causality*

**N/A –** Causality not assessed.

# 6. QUALITATIVE FIELD SURVEY OF PLANTS & PLANT COLONIZATION STUDIES

## 6.1. LOE Description

Qualitative evaluation of native vegetation community across a gradient of on-site COPC exposure in soil (i.e., plant/habitat survey information compared to soil COPC concentration maps and vegetation tissue concentrations).

Evaluation of colonization and growth of planted species in vegetation test plots at COPC contaminated areas on-Site (e.g., Tailings Management Facility)

This LOE is used for plants communities.

## 6.2. Data Analysis

### *6.2.1. Overview*

This LOE synthesizes information on:

- concentrations of metals in soils (**Section 7.2 of Volume 1 and Section 2 of this appendix**),
- concentrations of metals in plant tissues (reported in the Data Report [Azimuth 2014a] and summarized in **Section 3 of this appendix**),
- vegetation composition and percent cover in tissue sampling areas from the wildlife and habitat assessment (Gebauer & Associates, 2014 reported as Appendix B of the Interim ERA [Azimuth 2014c]), as well as
- information on plant colonization/revegetation and alder test trials at the Sä Dena Hes site (Teck 2013, Access 2008).

Highlights of the above pieces of information are documented below; readers are referred to the above sources for additional information. The above information is also combined in a summary table to assess potential risks to plants by AEC (**Table A-2**).

### *6.2.2. Metals in Soils*

Patterns of COPC exceedances in soil were described in **Section 7.2 of Volume 1 and Section 2 of this appendix** (soil chemistry LOE). COPC concentrations in soil samples throughout the site were also shown in **Figures 7-1 to 7-6 of Volume 1**, relative to underlying areas of disturbance. Overall, exceedances of lead, zinc and other COPCs were widespread within the AECs, and for the most part, the areas of contamination overlap with areas of physical disturbance. The exceptions are for soils in the 1380 Gully, 1250 Portal and TPN, where metals are elevated, but habitat is not disturbed.

### 6.2.3. Metals in Plant Tissues

Concentrations of COPCs in vegetation and/or berries were elevated in several tissue sampling areas that were located beyond the disturbed footprint of the collective AECs (i.e., 1300 Portal, BRK, JBX, 1380 Gulley, 1250 Portal, MS, TPN, tissue sampling areas; see **Section 3** of this appendix for concentration summaries and **Figure 4-9 of Volume 1** for sampling area locations).

### 6.2.4. Habitat Assessment (Gebauer 2014)

Section 3.2.1 of Gebauer & Associates (2014) provides a brief habitat description of some of the main types of AECs within the Site:

***"Mill Site, Roads, Waste Rock Piles and Mine Pits***

*The Site is characterized by numerous roads, landings, parking areas, and other bare, open areas, including waste rock piles and mine pits. Vegetation in these areas is sparse and generally dominated by grasses and invasive herbaceous species (see Appendix III, Photos 1, 2 and 3).*

***Landfill***

*The Landfill consists of mostly bare ground, some patchy regeneration of herb and shrub species, including species such as willows and Balsam Poplar, and a pond (see Appendix III, Photo #4).*

***Tailings and Reclaim Ponds***

*The Tailings Facility is characterized by mostly bare ground with some regrowth in areas where revegetation efforts have been successful (i.e., willow, herbs, grasses) (Appendix III, Photo #5), near the water's edge (i.e., sedges) (Appendix III, Photo #6) and along the impoundment edge (i.e., willows). Vegetation along the edges of the Reclaim Pond is dominated by willows, bog birch, and other shrub species (Appendix III, Photo #7). A boggy area between the northern and southern Tailings Facilities is dominated by plant species such as Sphagnum, Labrador-Tea, Scrub Birch and Shrubby Cinquefoil (Appendix III, Photo #8)."*

Composition of plant species in tissue sampling areas and the photos referred to in the above text are provided in Appendix II of Gebauer (2014), which is provided as Appendix B of the Interim ERA (Azimuth 2014c). Plant composition information is summarized by AEC according to habitat type of the sampling unit and relative to reference or selected on-Site uncontaminated habitats in **Table A-2**.

### 6.2.5. Plant Colonization Studies (Teck 2013, Access 2008)

Teck and Access have been conducting work to support reclamation objectives at the site (Teck 2013, and Access 2008). The DDRP states that:

*"The objectives of the land reclamation and revegetation initiatives at the Sä Dena Hes mine site are to provide short and long term erosion control, to ensure a final land use compatible with the surrounding lands and to leave the area as a self-sustaining ecosystem."*

Revegetation efforts at the mine site will focus on restoring natural vegetation communities and native species, although some agronomic species will be used in high erosion areas near water courses. To this end, Teck has been monitoring natural revegetation and, in 2001, established test plots to determine optimum soil treatments and seed mixtures for reclamation. Key observations reported in Teck 2013, and Access 2008 are provided below:

- **Revegetation (Teck 2013):**
  - The only active revegetation initiative was conducted in 1992 by the former mine owners on disturbed land around the freshwater pumphouse and its access route. Activities included clearing debris, decompacting the soil, and adding seed with fertilizer. In July 1999 the area was inspected and showed robust growth of graminoids (e.g., fescues), legumes (e.g., clover), and other species such as willow were colonizing the area.
  - It has also been observed that natural revegetation has been occurring since the mine has closed in areas around the TMF, borrow areas, explorations trails, and mine roads. Species such as willows, alder, and graminoids are early colonizers and revegetation is reportedly more extensive in areas that have not been disturbed in recent years (Teck 2013).
- **Vegetation test plots (Access 2008):** Starting in 2001, several test plots were established to determine the optimum soil treatments and seed mixtures for reclamation. Multiple plots were set up in each test area to measure relative success of various soil, seeding and fertilizer applications, as well as monitor natural colonization in control plots (with no treatment). Test plots were located near the Main Access road, the Jewelbox Hill haul road, the Landfill, and several were on the TMF. The 2007 monitoring results show that revegetation was more rapid in all areas with the seeding and fertilizer applications, relative to control (no application) (Access, 2008). Measured in 2007, plant cover was usually around 30-80% in the treated test plots and about 10% in the control plots (all sites overall). At the TMF, different till cover depths (200 mm, 300 mm, and 500 mm rock with 300 mm soil) were applied overtop of tailings where the test plots were established. The treated test plots in the 200 mm site actually performed better (i.e., 50-80% plant cover) than the 300 mm site (30-50% plant cover), with control plots showing less than 5% cover under both species. However, at TMF Site 5C (500 mm rock and 300 mm soil cover), plant cover was close to 100% on the treated test plots and 10% on the control (Access 2008). Natural revegetation of "volunteer" species was occurring throughout all test plot areas. For example, at the Jewelbox Hill haul road, alpine bluegrass, spike trisetum, and subalpine fir were some of the dominant native species.
- **Alder test plot on the Tailings Management Facility (Teck 2013):** Teck has done some sampling of metal concentrations in plants to assess relative uptake of metals (lead) in different species. Based on concentrations in leaves and twigs, it was shown that uptake of lead in willow

is greater than uptake in alder[10]. Thus, for the Tailings Management Facility, the plan documented in the DDRP is to plant a higher proportion of alder than willow in this area, because the concentration of lead is expected to be lower in alder, and it is less preferable to moose than willow (moose may be attracted to this area for forage). As well, capping of the tailings is planned to reduce metal uptake by plants. In 2009, alder test plot were established on the Tailings Management Facility. A total of 1200 alder plants were planted on the Tailings Management Facility under various treatments ranging from planting in a soil cover of 300 mm to planting directly on tailings up to the edge of the ponded water. After three growing seasons, plant survival in all treatments remains high at 95%. Based on observations in 2012, plants growing on the till cover exhibited significant growth (were 2 feet tall) and appear healthy with no sign of stress. However, alder plants growing directly on the tailings had impaired growth (were stunted relative to those on the till cover) and showed definite signs of stress.

A summary table linking exposure and effects information for plants by AEC (i.e., incorporating soil chemistry [**Section 2**], plant tissue chemistry [**Section 3**], this LOE, and the plant colonization studies [**Section 6**]) is provided below.

[10] This is consistent with Azimuth's results from the 1380 Gully, but not from the North Tailings and reference areas based on the 2012 and 2013 sampling in support of the ERA (see **Section 5** of this appendix). Likely, spatial variability of COPC concentrations in soils on small scales will influence the overall patterns observed in plant tissues.

**Table A-2: Summary of plant exposure and effects results by AEC for the ERA.**

| AEC [Tissue Sampling Area] | Exposure | | | Effects | |
|---|---|---|---|---|---|
| | Soil[1] (within AEC) | Soil[2] (within tissue sampling area) | Plant Tissues[3] (within tissue sampling area) | Qualitative Survey[4] (within tissue sampling area) | Reference/Selected Habitats[4] (within reference/selected vegetation sampling areas) |
| **AEC 2** | | | | | |
| 1200 Burnick Bench and WRD [BRK] | High | Low | Moderate | Negligible effects (Current and Future Conditions) - similar to reference habitat<br>Coniferous Habitat: 15,50% dominant and subdominant trees, respectively (subalpine fir); 30,20% tall and short shrubs (fir, blueberry); 12% alfalfa, twinflower; 90% moss; 10% CWD | Coniferous Habitat (Reference[6]): 12-75% dominant trees (subalpine fir mostly, lodgepole pine and white spruce), 2-60% subdominant trees (subalpine fir mostly); 5-100% tall shrubs (fir, alder); 15-37% low shrubs (alder, fir, clubmoss); limited herbs (up to 8% bunchberry); 75-95% moss; 1-5% CWD |
| 1300 Portal [1300 Portal] | High | N/A (vegetation only) | Moderate | N/A | N/A |
| **AEC 1/9** | | | | | |
| Jewelbox Bench and WRD (including 1408) [JBX] | High | Moderate | High | Negligible effects (Current and Future Conditions) - similar to reference habitat<br>Alpine Habitat: No trees; 25% tall shrubs (subalpine fir, willow); 95% low shrubs (willow, blueberry, heather, fir); limited herbs, moss, lichen 2% CWD | Avalanche Chute Habitat (Selected[7]): No trees; 25% tall shrubs (subalpine fir); 100+% low shrubs (fir, bunchberry, blueberry, crowberry, alder); limited herbs, 75% moss, 2% lichen, 10% CWD |
| Main Zone Bench and WRD | High | N/A | N/A | N/A | N/A |
| 1380 Gully [1380 Gully] | High | High | High | Negligible effects (Current and Future Conditions) - different than alpine chute - 1380 Gully has trees (station lower in Alpine, near Subalpine), but not considered a negative effect<br>Alpine Habitat: 10,25% dominant and subdominant trees (subalpine fir); 30,87% tall and low shrubs (subalpine fir, willow); 95% low shrubs (willow, blueberry, heather, fir); limited herbs, moss, lichen 2% CWD | Avalanche Chute Habitat (Selected[7]): No trees; 25% tall shrubs (subalpine fir); 100+% low shrubs (fir, bunchberry, blueberry, crowberry, alder); limited herbs, 75% moss, 2% lichen, 10% CWD |
| 1250 Portal [1250 Portal] | Moderate | Moderate | High | N/A | N/A |
| **AEC 3** | | | | | |
| Mill Site Disturbed Area [MS] | High | Moderate | High | Negligible effects (Current and Future Conditions) - similar to reference habitat<br>Coniferous Habitat: 50,65% dominant and subdominant trees, respectively (subalpine fir, lodgepole pine, white spruce); 37% tall shrubs (alder, fir); 48% short shrubs (fir, clubmoss, currant); limited herbs, 80% moss, 5% CWD | Coniferous Habitat (Reference[6]): 12-75% dominant trees (subalpine fir mostly, lodgepole pine and white spruce), 2-60% subdominant trees (subalpine fir mostly); 5-100% tall shrubs (fir, alder); 15-37% low shrubs (alder, fir, clubmoss); limited herbs (up to 8% bunchberry); 75-95% moss; 1-5% CWD |

**Table A-2: Summary of plant exposure and effects results by AEC for the ERA.**

| AEC [Tissue Sampling Area] | Effects | |
|---|---|---|
| | **Revegetation Plots**[5] (North Tailings) | **Alder Trial**[5] (North Tailings) |
| **AEC 2** | | |
| 1200 Burnick Bench and WRD [BRK] | N/A<br>General Mine Site: Natural recolonization occurring in less disturbed areas of the Mine Site, generally. Volunteer colonizers and plant cover 10% in untreated plots; plant cover of 30-80% in seeded and fertilized plots (plots located on Main Access road, the Jewelbox Hill haul road, the Landfill). | N/A |
| 1300 Portal [1300 Portal] | N/A<br>(see General Mine Site information under Burnick above) | N/A |
| **AEC 1/9** | | |
| Jewelbox Bench and WRD (including 1408) [JBX] | N/A<br>(see General Mine Site information under Burnick above) | N/A |
| Main Zone Bench and WRD | N/A<br>(see General Mine Site information under Burnick above) | N/A |
| 1380 Gully [1380 Gully] | N/A | N/A |
| 1250 Portal [1250 Portal] | N/A<br>(see General Mine Site information under Burnick above) | N/A |
| **AEC 3** | | |
| Mill Site Disturbed Area [MS] | N/A<br>(see General Mine Site information under Burnick above) | N/A |

**Table A-2: Summary of plant exposure and effects results by AEC for the ERA.**

| AEC [Tissue Sampling Area] | Exposure | | | Effects | |
|---|---|---|---|---|---|
| | Soil[1] (within AEC) | Soil[2] (within tissue sampling area) | Plant Tissues[3] (within tissue sampling area) | Qualitative Survey[4] (within tissue sampling area) | Reference/Selected Habitats[4] (within reference/selected vegetation sampling areas) |
| **AEC 8** | | | | | |
| North and South Tailings [North Tailings] | High | High | High | High Effects (Current Conditions) - disturbed habitat<br>Disturbed Habitat: No trees or tall shrubs; 5% low shrubs (willow); 50% grass<br><br>N/A (Future Conditions) | N/A |
| TPN [TPN] | Moderate | Moderate | Moderate | Negligible effects (Current and Future Conditions) - similar to reference habitat<br>Coniferous Habitat: 35,15% dominant and subdominant trees, respectively (subalpine fir, white spruce); 10,50% tall and short shrubs (fir); 90% moss | Coniferous Habitat (Reference[6]): 12-75% dominant trees (subalpine fir mostly, lodgepole pine and white spruce), 2-60% subdominant trees (subalpine fir mostly); 5-100% tall shrubs (fir, alder); 15-37% low shrubs (alder, fir, clubmoss); limited herbs (up to 8% bunchberry); 75-95% moss; 1-5% CWD |
| TPN-West berm | Moderate | Moderate | N/A (no vegetation collected) | Low effects (Current and Future Conditions) - similar to reference habitat, except limited moss at TPN-West berm (ground covered by leaf litter), which could be due to previous disturbance or microclimate/habitat<br>Upland Shrubland Habitat: No trees; 100% tall shrubs (willow, aspen); 65% low shrubs (subalpine fir, currant); limited herbs, moss | Upland Shrubland Habitat (Selected[8]): No trees; 85-100% tall shrubs (alder, willow, fir); 45-82% low shrubs (alder, fir, willow, bunchberry, fireweed); limited herbs; 5-75% moss; <1% CWD |

[1] Section 2 of this appendix; see also Data Report (Azimuth 2014a)
[2] Based on visual inspection of Figures 7-1 to 7-6 in Volume 1; see also Data Report (Azimuth 2014a)
[3] Section 3 of this appendix; see also Data Report (Azimuth 2014a)
[4] This section; see Gebauer (2014) in Appendix B of Interim ERA (Azimuth 2014c)
[5] This section; see also Teck (2013) and Access (2008).
[6] Range of three reference stations in Coniferous habitat (NC-Ref, FF-Ref1, FF-Ref2)
[7] One selected uncontaminated habitat stations in Avalanche Chute habitat (which is in the alpine, but slightly different than Alpine habitat) (Veg #1)
[8] Range of three selected uncontaminated habitat stations in Upland Shrubland habitat (Veg #3, #4, #5)
N/A = Not applicable
CWD = Coarse woody debris

| | **Exposure ratings (see text in LOE sections for details):** | **Effects ratings (see text in LOE sections for details):** |
|---|---|---|
| Negligible: | AEC is the same or less than background | See above |
| Low: | AEC is 1 to 3 fold higher than background | See above |
| Moderate: | AEC is 3 to 10 fold higher than background | See above |
| High: | AEC is more than 10 fold higher than background | See above |

**Table A-2: Summary of plant exposure and effects results by AEC for the ERA.**

| AEC<br>[Tissue Sampling Area] | Effects<br>**Revegetation Plots**[5]<br>(North Tailings) | <br>**Alder Trial**[5]<br>(North Tailings) |
|---|---|---|
| **AEC 8** | | |
| North and South Tailings<br>[North Tailings] | N/A (Current Conditions)<br>No test plots without a soil/till cover<br><br>Negligible Effects (Future Conditions)<br>Test plots with at least 200 mm soil cover had volunteer colonizers and 10% plant cover in unfertilized plots; and 30-100% plant cover in seeded and fertilized plots. | High Effects (Current Conditions)<br>Alder plants growing directly on the tailings had impaired growth relative to those on the till cover and showed definite signs of stress.<br><br>Low Effects (Future Conditions)<br>Alder plants growing on the till cover exhibited significant growth (were 2 feet tall) and appear healthy with no sign of stress. (A low rating is provided because there is no control off-Site of the tailings) |
| TPN [TPN] | N/A | N/A |
| TPN-West berm | N/A | N/A |

[1] Section 2 of this appendix; see also Data Report (Azimuth 2014a)
[2] Based on visual inspection of Figures 7-1 to 7-6 in Volume 1; see also Data Report (Azimuth 2014a)
[3] Section 3 of this appendix; see also Data Report (Azimuth 2014a)
[4] This section; see Gebauer (2014) in Appendix B of Interim ERA (Azimuth 2014c)
[5] Section 6 of this appendix; see also Teck (2013) and Access (2008).
[6] Range of three reference stations in Coniferous habitat (NC-Ref, FF-Ref1, FF-Ref2)
[7] One selected uncontaminated habitat stations in Avalanche Chute habitat (which is in the alpine, but slightly different than Alpine habitat) (Veg #1)
[8] Range of three selected uncontaminated habitat stations in Upland Shrubland habitat (Veg #3, #4, #5)
N/A = Not applicable
CWD = Coarse woody debris

| | **Exposure ratings (see text in LOE sections for details):** | **Effects ratings:** |
|---|---|---|
| Negligible: | AEC is the same or less than background | See above |
| Low: | AEC is 1 to 3 fold higher than background | See above |
| Moderate: | AEC is 3 to 10 fold higher than background | See above |
| High: | AEC is more than 10 fold higher than background | See above |

## 6.3. LOE Attributes

### 6.3.1. Data Quality

**Acceptable** – Underlying soil data were provided by Golder (2013, 2014a) and data quality was considered acceptable based on QA/QC measures that were in place during site characterization. Soil samples for which data quality was questionable were excluded from the data set (2012 XRF data and 2012 duplicate data for the NC-Ref sample; see Data Report, Azimuth 2014a). Standard field and laboratory QA/QC measures were used for vegetation and berry collection and chemical analysis. No data quality issues have been identified in the Data Report (Azimuth 2014a). Vegetation and habitat information was provided by Gebauer & Associates (2013, 2014) over the course of three site visits. The plant colonization component is based on information reported by Teck (2013) and Access (2008). While this information is considered qualitative, it is considered acceptable to support qualitative risk ratings for plants.

### 6.3.2. Ecological Relevance

**High** – The field measurement targeted site-specific plant samples and their communities. Although the level of quantification is low, this LOE does inform on the assessment endpoint for plants – structure and ecological function of native plant communities.

### 6.3.3. Magnitude

*Effect Size and Spatial/Temporal Scale*

The effect size rating provided here considers whether there are effects to plants at the Site from contaminants, specifically (i.e., effects from physical disturbance are considered an inherent part of the mining operation that will be addressed by revegetation efforts as per the DDRP). Ratings are qualitative and based on the degree of similarity in species composition and plant cover, relative to reference habitats, as well as differences noted in the colonization studies. Overall at the mine site, the information above suggests that:

1. Bare areas where plant growth/habitat recolonization is limited correspond with mine site disturbance areas (i.e., AECs), where both soil contamination and physical disturbance occur (see COPC maps **Figures 7-1 to 7-6 of the Volume 1** showing high soil concentrations overlapping with areas of physical disturbance).
2. On a broad scale, recolonization of plants appears to be occurring in disturbed areas/edges of disturbed areas, but vegetation in these areas is sparse and generally dominated by grasses, invasive herbaceous species, Sitka alder and willow. Teck also notes that natural revegetation is occurring on-Site, and more so in areas that have not been disturbed recently. Native colonizers were observed in test plots set up in different areas throughout the site (mine access road, Jewelbox Hill haul road, landfill, and Tailings Management Facility (test plots had a soil till cover);

although recolonization was occurring much more slowly in untreated plots, relative to seeded and fertilized plots). Based on the test plots, Teck's reclamation activities as specified in the DDRP are expected to be sufficient to revegetate the Mine Site generally.

3. Based on the habitat evaluation by the wildlife biologist, plant communities in ecological tissue sampling stations located outside disturbed area footprints, but where COPC metals concentration(s) were elevated in soils and/or plant tissues (i.e., BRK, JBX, 1380 Gulley, 1250 Portal, MS and TPN) did not appear to be impacted by contaminants.

More specific information is synthesized in **Table A-2** and used to inform risk ratings by area:

- **Burnick/1300 Portal – Current and Future: Low Effects –** Although soil exposure is considered high in disturbed areas, and plant exposure in the BRK and 1300 Portal tissue sampling areas was moderate, effects to plants are considered low. This is based on the points listed above (i.e., undisturbed areas with elevated contamination did not show effects to plants) and the qualitative habitat survey in the BRK tissue sampling area downgradient from the Burnick waste rock dump that showed no impairment in the plant community composition and percent cover, relative to reference areas, even though plant tissues were moderately elevated (**Table A-2**). Because the BRK tissue station was located outside the AEC and soil concentrations were low, risks to plants within the disturbed AEC are rated as low (rather than negligible).
- **Jewelbox/Main Zone/1380 Gully/1250 Portal – Current and Future: Negligible Effects –** Soil exposure is considered high in disturbed areas, as well as in the 1380 Gully and JBX (moderate) tissue sampling areas. Plant exposure in the JBX and 1380 Gully tissue sampling areas was moderate or high, respectively. However, effects to plants are considered negligible based on the qualitative habitat survey conducted in the JBX and 1380 Gully (which are located within the AEC), which documented no negative impairment of the plant communities, relative to the uncontaminated Avalanche Chute reference vegetation unit (**Table A-2**).
- **Mill Site – Current and Future: Low Effects –** Although soil exposure is considered high in disturbed areas and the MS tissue station, and plant exposure in MS was moderate, effects to plants are considered low. This is based on the points listed above (i.e., undisturbed areas with elevated contamination did not show effects to plants) and the qualitative survey in the MS tissue sampling area that showed no impairment in the plant community composition and percent cover, relative to reference areas, even though plant tissues were moderately elevated at MS (**Table A-2**). Because the MS tissue station was located outside the AEC, risks to plants within the disturbed AEC are rated as low (rather than negligible).
- **Tailings Management Facility** –
    - **North and South Tailings**: The risk rating for the TMF was based primarily on the alder trials on the TMF, but also on the qualitative habitat survey. Exposure to metals in soils and plant tissues in these portions of the AEC were considered high.

- **Current: High Effect** –Alder planted directly on tailings had stunted growth and were stressed compared to those planted on a 300 mm soil cover (overtop of tailings). The habitat survey documented disturbed habitat with only some will shrubs, grasses and bare ground.
- **Future: Low Effect** – Alder planted on a 300 mm soil cover appeared healthy and were growing vigorously. (A control off-Site of the Tailings was not included, so effects are rated as low rather than negligible). As well, test plots grown with at least 200 mm of soil cover overtop tailings showed rapid recolonization with seeding and fertilizer applications, as well as recolonization by native "volunteer" species; although this was occurring much more slowly.

- **TPN – Current and Future: Negligible Effects**: Effects at TPN are considered negligible based on the comparison of plant composition and percent cover at TPN to the three reference areas, even though soil and plant tissue concentrations of metals in the area were considered moderately elevated.
- **TPN-West berm – Current and Future: Low Effects**: Effects at TPN-West berm are considered low based on the comparison of plant composition and percent cover at TPN-West berm to the three reference areas, even though soil and plant tissue concentrations of metals in the area were considered moderately elevated. A low rating (rather than negligible) was applied because although the majority of plant community components were similar at TPN-West berm to the Upland Shrubland reference habitat, there was no moss at TPN-West berm (but this could be related to previous disturbance or microclimate/habitat conditions).

*Uncertainty About Magnitude*

**North and South Tailings – Current and Future: Moderate Uncertainty** – The magnitude rating relied mostly on the alder trial and revegetation plots. The main uncertainty is that these studies were qualitative/semi-quantitative and provides only high level information, so only major effects may be detectable (i.e., there was no quantification of growth in the alder trial, or evaluation of specific sensitive native species).

**Ecological Tissue Stations (BRK, 1380 Gully, JBX, MS, TPN, TPN-West berm) – Current and Future: Low Uncertainty** – Based on the species composition and percent cover information from the habitat survey in these specific areas, uncertainty is considered low.

**Other areas (e.g., disturbed areas within AECs) – Current and Future: High Uncertainty (except Mill Site, future uncertainty considered moderate)** – The magnitude ratings for the other disturbed areas were based more on the habitat survey information, which provided qualitative/semi-quantitative information and low stressor specificity (prone to variability and confounding variables such as physical disturbance). In some cases, inferences are made based on general site patterns and information from other AECs/tissue sampling areas, so spatial resolution is considered low. As with the recolonization studies, the habitat survey provides information at a low resolution (i.e., no evaluation of

specific native or sensitive species). For the Mill Site, application of a clean soil cover over the disturbed portion of the AEC is expected to address any factors limiting plant growth within this AEC, with a moderate degree of uncertainty.

### 6.3.4. Causality

*Strength of Correlation and Supporting Evidence*

**North and South Tailings - Current: Correlation (Moderate, Positive); Supporting Evidence (N/A)** – It was shown that the tailings deposits are impairing the growth of alder planted directly in tailings; however, this could be contaminant-related and/or result from the physical and nutrient characteristics of the tails. Notwithstanding, this LOE provides some evidence of effects to plants from the tailings.

**North and South Tailings - Future: Correlation (None); Supporting Evidence (N/A)** – Based on the alder trial and revegetation test plots, a till cover of at least 200 mm has been sufficient to support plant growth and recolonization by seeded and native "volunteer" species.

**All other areas - Current and Future: Correlation (Negative); Supporting Evidence (Plausible) –** While it is possible that the bare areas, where plant growth and/or habitat recolonization are limited, could be impacted by physical disturbance, contaminants, or a combination of both, recolonization of plants throughout the site and the apparent lack of effects to plants in tissue sampling areas (e.g., BRK, JBX, 1380 Gulley, 1250 Portal, MS and TPN) where concentrations of metals in soils and/or plants were elevated above standards and/or reference areas, suggests that contamination is not limiting plant recolonization on a coarse scale.

*Uncertainty About Causality*

**Moderate** – The co-occurrence of high metals concentrations in soils and physical disturbance of the mine site are confounding factors that lead to moderate uncertainty in causality. As well, although the plant colonization studies were qualitative/semi-quantitative, they provided evidence of effects to plants grown on tailings, and, conversely, ample growth on a till cover (which was higher in fertilized and seeded treatments than in the controls). Whether this is related to COPCs is, however, uncertain.

# 7. GROUND AND FLYING INVERTEBRATE FIELD SURVEY

## 7.1. LOE Description

Semi-quantitative comparison of catch-per-unit-effort (CPUE, based on mass and abundance) and richness from pitfall traps across a gradient of on-Site COPC exposure in soil and tissues and relative to off-Site reference areas. Emphasis was placed on biomass to target the assessment endpoint for terrestrial invertebrates

Information on catch-per-unit-effort (CPUE, based on mass) of flying invertebrates from malaise traps was added as a secondary point of comparison for this LOE (available for some areas only). Flying invertebrates may be less tied to specific soil areas at the Site, so less weight is placed on flying invertebrate data relative to ground invertebrates.

This LOE is used for invertebrate communities.

## 7.2. Data Analysis

This LOE relies on ground and flying invertebrate catch data collected from the Sä Dena Hes mine site in 2013, which has been reported in Section 7 of the Data Report (including Tables 7-1, 7-3 and E1 in Appendix E) (Azimuth 2014a). For ground invertebrates, each organism was identified and enumerated in the field (to determine abundance and richness), and daily and total biomass were recorded. More emphasis was placed on the biomass measurement endpoint, as an indication of function of the invertebrate community (i.e., providing food for birds and mammals). For flying invertebrates, only daily biomass was recorded. While it is difficult to tease out differences in habitat features and quality, weather conditions, or effects of predation by mammals and birds on local invertebrate populations among locations (e.g., reference versus exposure; alpine versus lowland), these data can provide perspective on the general health of an area. Readers are referred to the Data Report for further details.

The three reference stations represented background and were used for comparisons to invertebrate catch from the AECs. Information on ground and flying invertebrate tissue chemistry and effects data based in the catch data (listed below) is combined in a summary table to assess potential risks to invertebrates by AEC (**Table A-3**). Ground and flying invertebrate results were:

- Burnick Zone
  - BRK ground invertebrates – Biomass was slightly higher than background (<2 fold); abundance was within the range of background; taxa richness was the same as background.
  - BRK flying invertebrates – Biomass was reduced relative to background (2 to 7 fold lower). Flying invertebrates are less exposed to soils, and less associated with specific areas, relative to ground invertebrates, so this endpoint was given lower emphasis than the ground invertebrate data. As well, there was no difference between BRK flying invertebrate tissue

chemistry relative to background (i.e., no evidence of elevated exposure for flying invertebrates captured from BRK) (see **Section 4** of this appendix).

- Jewelbox and 1380 Gully
  - JBX and 1380 Gully ground invertebrates – Biomass was higher than background (3 to 4 times); abundance was higher than background (>1 to 2 fold); slightly fewer taxonomic groups were captured here (7 and 8 taxa groups) than from reference areas (9 and 10 taxa groups). There were large numbers of spiders (>260), mites (>50) and few beetles (<35). Other taxa such as springtails and sowbugs were rare, possibly due to poorly developed organic soils and/or the alpine elevation.
  - JBX and 1380 Gully flying invertebrates – no malaise trapping was conducted at these stations.
- Mill Site
  - MS ground invertebrates – Biomass was within the range of background; abundance was within the range of background; taxa richness was higher than background (12 taxa groups for MS versus 9 or 10 taxa groups for reference areas).
  - MS flying invertebrates – Biomass was reduced relative to background (2 to 8 fold lower), but could possibly be the result of the relatively small area of undisturbed forest that comprised the area where the MS station was located. Flying invertebrates are less exposed to soils, and less associated with specific areas, relative to ground invertebrates, so the flying invertebrate measurement endpoint was considered secondary.
- Tailings Management Facility (ground invertebrates only; no malaise traps were set at these stations)
  - TPN – Biomass was higher than background (2 to 4 times); abundance was within the range of background; richness was the same as background.
  - TPN-West Berm – Biomass was higher than background (2 to 3 times); abundance was within the range of background; richness was lower than background (6 for TN-West Berm versus 9 or 10 for reference areas). This area was dominated by beetles (280) and spiders (102) with a few springtails with few other taxa (n=6).
  - North Tailings – This sample was from the open/grass area overtop the tailings deposit. Biomass was much lower than background (0.04 g ww/day at North Tailings versus 0.25 to 0.44 g ww/day from reference areas in the GIFP traps); abundance was much lower than background (7 invertebrates/day at North Tailings versus 26 to 51 invertebrates/day at the reference areas; richness was lower than background (5 at North Tailings versus 9 or 10 from reference areas). This area clearly had a depauperate ground invertebrate community, but based on information from the other areas that had high COPC concentrations in soils and invertebrates, the cause of the impairment here is likely habitat related.

**Table A-3: Summary of invertebrate exposure and effects results by AEC for the ERA.**

| AEC [Tissue Sampling Area] | Exposure | | | | Effects | |
|---|---|---|---|---|---|---|
| | Soil[1] (within AEC) | Soil[2] (within tissue sampling area) | Flying Invertebrate Tissues[3] (within tissue sampling area) | Ground Invertebrate Tissues[3] (within tissue sampling area) | Flying Invertebrate Biomass[4] (within tissue sampling area) | Ground Invertebrate Biomass, Abundance, Richness[5] (within tissue sampling area) |
| **AEC 2** | | | | | | |
| 1200 Burnick Bench and WRD [BRK] | High | Low | Negligible | Negligible | Moderate effects: Biomass 2 to 7 fold lower than background | Negligible effects: Biomass greater than background; abundance and richness similar to background |
| 1300 Portal [1300 Portal] | High | N/A (not sampled) | N/A (not sampled) | N/A (not sampled) | N/A (not sampled) | N/A (not sampled) |
| **AEC 1/9** | | | | | | |
| Jewelbox Bench and WRD (including 1408) [JBX] | High | Moderate | N/A (not sampled) | Moderate | N/A (not sampled) | Negligible effects: Biomass and abundance greater than background; richness slightly lower than background |
| Main Zone Bench and WRD | High | N/A | N/A (not sampled) | N/A (not sampled) | N/A (not sampled) | N/A (not sampled) |
| 1380 Gully [1380 Gully] | High | High | N/A (not sampled) | High | N/A (not sampled) | Negligible effects: Biomass and abundance greater than background; richness slightly lower than background |
| 1250 Portal [1250 Portal] | Moderate | Moderate | N/A (not sampled) | N/A (not sampled) | N/A (not sampled) | N/A (not sampled) |

**Table A-3: Summary of invertebrate exposure and effects results by AEC for the ERA.**

| AEC [Tissue Sampling Area] | Exposure | | | | Effects | |
|---|---|---|---|---|---|---|
| | Soil[1] (within AEC) | Soil[2] (within tissue sampling area) | Flying Invertebrate Tissues[3] (within tissue sampling area) | Ground Invertebrate Tissues[3] (within tissue sampling area) | Flying Invertebrate Biomass[4] (within tissue sampling area) | Ground Invertebrate Biomass, Abundance, Richness[5] (within tissue sampling area) |
| **AEC 3** | | | | | | |
| Mill Site Disturbed Area [MS] | High | Moderate | High | Negligible | Moderate effects: Biomass 2 to 8 fold lower than background | Negligible effects: Biomass and abundance similar to background; richness higher than background |
| **AEC 8** | | | | | | |
| North and South Tailings [North Tailings] | High | High | N/A (not sampled) | High | N/A (not sampled) | High effects: Biomass 5 to 10 fold lower than background; abundance and richness lower than background. Sample collected in bare/disturbed area; cause of impaired community is likely habitat related. |
| TPN [TPN] | Moderate | Moderate | N/A (not sampled) | Moderate | N/A (not sampled) | Negligible effects: Biomass greater than background; abundance and richness similar to background |
| TPN-West berm [TPN West-berm] | Moderate | Moderate | N/A (not sampled) | Moderate | N/A (not sampled) | Negligible effects: Biomass greater than background; abundance similar to background; richness lower than background |

[1] Section 2 of this appendix; see also Data Report (Azimuth 2014a)

[2] Based on visual inspection of Figures 7-1 to 7-6 in Volume 1; see also Data Report (Azimuth 2014a)

[3] Section 4 of this appendix; see also Data Report (Azimuth 2014a)

[4] This section; see also Data Report (Azimuth 2014a). Flying invertebrates are less exposed to soils, and less associated with specific areas, relative to ground invertebrates, so the flying invertebrate endpoint was given lower emphasis than the ground invertebrate data (see text for details).

[5] This section; see also Data Report (Azimuth 2014a)

N/A = Not applicable

| | **Exposure ratings (see text in LOE sections for details):** | **Effects ratings (see text in LOE sections for details):** |
|---|---|---|
| Negligible: | AEC is the same or less than background | AEC is the same or less than background |
| Low: | AEC is 1 to 3 fold higher than background | AEC is 1 to 3 fold lower than background |
| Moderate: | AEC is 3 to 10 fold higher than background | AEC is 3 to 10 fold lower than background |
| High: | AEC is more than 10 fold higher than background | AEC is more than 10 fold lower than background |

## 7.3. LOE Attributes

### 7.3.1. Data Quality

**Acceptable** – This was a field based measure and standard procedures were applied to the degree possible to ensure consistency when counting and weighing organisms, including reviewing taxonomy relative to invertebrate guide books and having two staff involved with taking measurements as a QA check. No data quality issues were identified.

### 7.3.2. Ecological Relevance

**High** – The field measurements specifically target the assessment endpoint for terrestrial invertebrates – presence and ecological function of the invertebrate community.

### 7.3.3. Magnitude

*Degree of Effect and Spatial/Temporal Scale*

Effect size ratings for the invertebrate survey, consider community indices (biomass, abundance and richness), relative to background. They were based generally on the following categories:

- Negligible = ground and flying invertebrate community indices are the same or higher than background
- Low = ground invertebrate community indices are 1 to 3 times lower than background OR there is no effect to ground invertebrate indices, but flying invertebrate indices are lower than background (any magnitude)
- Moderate = ground invertebrate community indices are 3 to 10 times lower than background
- High = ground invertebrate community indices are more than 10 times lower than background

The effect size rating generally relies on any index that shows an effect (is different), but incorporates information from the various measurement endpoints.

Ratings are provided by area (see also **Table A-3**):

- **Burnick/1300 Portal – Current and Future: Negligible Effect** – Ground invertebrate indices were the same or higher than background. Although flying invertebrate biomass was lower than background, flying invertebrates are less associated with soil related contaminants, so this was considered a secondary endpoint. As well, there was no difference between BRK flying invertebrate tissue chemistry and background.
- **Jewelbox/1380 Gully/1250 Portal – Current and Future: Negligible Effect** – Ground invertebrate indices were the same or higher than background.

- **Mill Site**
  - **Current: Low Effect** – Ground invertebrate indices were the same or higher than background. Flying invertebrate biomass was lower than background here, but could in part be due to the relatively smaller forested area around the MS sample area. As well, flying invertebrates are less associated with soil related contaminants, so this endpoint was considered secondary. A low rating was provided for this area, because flying invertebrate tissue concentrations were higher here for lead and some other COPCs than at the reference areas.
  - **Future: Negligible Effect** – Remediation of the Mill Site and TMF AECs is expected to reduce COPC concentrations in flying invertebrate from MS. While the link between elevated lead and reduced biomass in flying invertebrates from MS is unlikely causal; expected improvements in site conditions resulted in a lower (negligible) risk rating for this area in the future.
- **Tailings Management Facility**
  - **Current: Negligible (TPN, TPN-West berm) or High (North Tailings) Effect** – Ground invertebrate indices were the same or higher than background, except at North Tailings, where differences are attributed to habitat.
  - **Future: Negligible Effect (TPN, TPN-West berm) or Low (North Tailings)** – Remediation of the TMF AEC is expected to reduce COPC concentrations in soils over the disturbed area, and reclamation is expected to improve habitat. While the link between elevated metal COPCs and reduced biomass in ground invertebrates from North Tailings is unlikely causal (i.e., likely habitat-related); expected improvements in site conditions resulted in a lower (low) risk rating for this area in the future.

*Uncertainty About Magnitude*

**Moderate for Effects** – While this LOE was quantitative, it was conducted at a low resolution:

- Major taxanomic group;
- Spatial coverage of traps was roughly consistent between areas;
- Differences in microhabitats, weather and environmental factors are likely to influence invertebrate community overall and between sampling days; and
- Measurement indices were conducted at high level (not looking for sensitive species or species-specific changes in community).

Therefore, only major effects would be detectable. Despite these uncertainties and confounding factors, the LOE is considered sufficient to assess the assessment endpoint of structure and ecological function (food source) for higher trophic organisms. Data represent one-year only, but the general lack of effects throughout the mine site, still supports moderate uncertainty.

### 7.3.4. Causality

*Strength of Correlation and Supporting Evidence*

**Ground invertebrates: Correlation (Negative); Supporting Evidence (N/A)** – The North Tailings area clearly had a depauperate ground invertebrate community, and could potentially be the results of contaminants and/or physical disturbance. However, because this was the only sample collected within a physically disturbed habitat (open grass area overtop of tailing deposits), and no other contaminated areas showed an impaired ground invertebrate community, causation is likely due to habitat and physical disturbance. All other areas, including those with high COPC concentrations in soils and invertebrates, did not show impaired ground invertebrate metrics (i.e., negative relationship between soils concentrations and invertebrate indices).

**Flying invertebrates: Correlation (Weak, Positive); Supporting Evidence (N/A)** – While both AEC samples had lower biomass than background, only the MS area also had elevated COPCs in flying invertebrate tissues. Generally, flying invertebrates are less associated with soil contamination, so this information was considered secondary, and the causality rating for ground invertebrates is used in the overall WOE assessment (**Table 3-1 of the Main Report**).

*Uncertainty About Causality*

**High (North Tailings) Moderate (all other areas)** – Uncertainty related to causality is considered moderate at most areas because of:

- Confounding factors - microhabitats, weather and environmental factors are likely to influence the invertebrate community, and
- Low resolution of the tool and low stressor specificity, but
- There was an overall lack of pattern between high COPC concentrations in soils and ground invertebrate metrics, particularly when emphasizing biomass for the invertebrate assessment endpoint of ecological function.

The high rating at North Tailings is because of the physical disturbance, although likely the cause of the impaired invertebrate community, represents a major confounding factor.

# 8. SMALL MAMMAL FIELD SURVEY (TRAPPING)

## 8.1. LOE Description

Semi-quantitative comparison of catch from pitfall traps (e.g., for shrews), and small mammal snap traps (e.g., for mice and voles) across a gradient of on-Site COPC exposure in soil and tissues and in relation to background catch rates from reference areas.

This LOE is used for small mammals.

## 8.2. Data Analysis

This LOE relies on small mammal catch data collected from the Sä Dena Hes mine site in 2013, which has been reported in Section 8 of the Data Report (Azimuth 2014a) (a revised small mammal catch table is provided as **Table A-4** below). Two different trapping methods were used: snap traps and pit fall traps, and five individual voles or shrews were targeted from each sampling area. Two sampling programs were conducted: one in June and one in August. The June program began shortly after snow-melt and prior to dispersal of young-of-the-year juvenile mice and it was anticipated that few animals would be captured. If five individuals of each species were not captured in the June survey, small mammal trapping was re-initiated during August.

This LOE is considered semi-quantitative at best because trapping occurring during two different time periods and different levels-of-effort were needed at different tissue sampling areas to capture targeted numbers of small mammals. Because the primary goal of the small mammal collection was for tissue chemistry to support the food chain model, information collected to support this LOE was considered secondary. Overall, this LOE informs mainly on presence/absence; general information on abundance at each area is provided but with variability in catch effort and timing, direct quantitative comparisons are not appropriate. General findings were:

- Sixty-six (66) small mammals were captured during the June and August 2013 field surveys consisting of 33 dusky shrew, 22 red-backed vole, 3 deer mouse, 5 meadow vole, 2 long tail vole and 1 jumping mouse. Overall, fewer animals were captured than anticipated during both June and August field programs.
- Overall, at least one individual from both target species was captured from most areas that traps were set. The exceptions were:
    - 1380 Gully – No small mammals were captured from this location in either June or August, despite what appeared to be presence of reasonable habitat and a food source. The reasons for their absence in the gully are uncertain, but the role of contaminants in this area cannot be ruled out. A more focused study of local small mammal populations in this area may be required to resolve this question. The data to-date represents one year of information.

  - North Tailings – This sample was from the open grass area overtop the tailings deposit, and only a limited sampling effort (five snap traps) was applied at this station. A Savannah sparrow was collected incidentally in a snap trap. In this area, the lack of small mammals is considered habitat related.

- Jewelbox, Mill Site, Burnick Zone – Small mammal catches (8 to 13) were the same or higher than at the reference stations (5 to 8).
- TPN and the periphery of the Tailings Pond (Outside-AEC areas) – Small mammal catches (2 to 4) were generally lower than at the reference stations (5 to 8); except for STP (7), which was in the range of reference areas.

**Table A-4: Summary of small mammal catch results from the June and August surveys at Sä Dena Hes, 2013[1]**

| Site Code | Dusky shrew | Red-backed vole | Meadow vole | Long-tail vole | Deer mouse | Jumping mouse | *Total Small Mammals* | Birds[2] |
|---|---|---|---|---|---|---|---|---|
| FF-Ref1 | 3 | 2 | | | | | *5* | 1 |
| FF-Ref2 | 5 | 2 | 1 | | | | *8* | |
| NC-Ref | 1 | 3 | 1 | | | 1 | *6* | |
| 1380 Gully | | | | | | | *0* | |
| JBX | 7 | | | 2 | | | *9* | |
| MS | 2 | 7 | | | 4 | | *13* | |
| BRK | 2 | 6 | | | | | *8* | |
| North Tailings[3] | | | | | | | *0* | 1 |
| TPN | | | 3 | | | | *3* | |
| TPN-West berm[3] | | | | | | | *0* | |
| TPW | 1 | | | | 3 | | *4* | |
| TPE | 1 | 1 | | | | | *2* | |
| STP | 6 | 1 | | | | | *7* | |
| REC-S | 3 | | | | | | *3* | |
| REC-W | 2 | | | | | | *2* | |

Notes:

[1] Revised Table 8-1 from Data Report, Azimuth 2014a.

[2] Two birds captured as by-catch in the snap traps during the June, 2013 field survey.

[3] Limited trapping effort in these areas; only five snap traps were deployed for 3 days.

## 8.3. LOE Attributes

### 8.3.1. Data Quality

**Acceptable** – Level of quantification is considered low, but data is considered acceptable as a measure of presence/absence. Small mammal traps were set and small mammals were identified by an experienced wildlife biologist.

### 8.3.2. Ecological Relevance

**Moderate** – The field measurement targeted Site-specific small mammal populations; however, the level of quantification really only informed on presence/absence, which provides some indication whether species are on-Site and reproducing, but may not be able to directly assess population viability.

### 8.3.3. Magnitude

*Degree of Effect and Spatial/Temporal Scale*

Effect size ratings for the small mammal survey were qualitative based solely on total catch, relative to background. They were based generally on the following categories:

- Negligible = small mammal catch was the same or higher than background
- Low = fewer small mammals were captured compared to background
- High = no small mammals were captured

Ratings are provided by area:

- **Burnick – Negligible Effect** – Small mammals were caught here; the number caught was the same as the reference stations.
- **Jewelbox – Negligible Effect** – Small mammals were caught here; the number caught was slightly more than the reference stations.
- **1380 Gully – High Effect** – No small mammals were captured here, despite what appeared to be presence of reasonable habitat and a food source. Data represent one-year only; it is possible that this was an anomaly, but the potential role of contaminants cannot be ruled out.
- **Mill Site – Negligible Effect** – Small mammals were caught here; the number caught was more than the reference stations.
- **Tailings Management Facility – Low Effect** – No small mammals were caught from North Tailings, but this is attributed to habitat. The number of small mammals captured from TPN and the periphery of the tailings was lower than the reference stations.

These effect levels represent current and future conditions (as no effects were observed at some locations; and no remedial plans are proposed for the 1380 Gully).

*Uncertainty About Magnitude*

**High for Effects** – This LOE was semi-quantitative, and mostly informed on presence/absence as there was variability in catch effort and time period. The final measurement index (total catch) provided only general high level information, so only major effects may be detectable (i.e., there was no evaluation of specific species abundance or keying in on sensitive species). As well, natural variability due to habitats, weather, and environmental factors are likely to influence small mammal catch rates and species composition overall and between sampling days and time periods. The cause of the lack of small mammals at the 1380 Gully is uncertain, and data represent one year only.

### 8.3.4. Causality

*Strength of Correlation and Supporting Evidence*

- **Correlation (Moderate, Positive); Supporting Evidence (Plausible) (1380 Gully station in AEC 1/9)** – It is plausible that the lack of small mammals could be related to elevated contaminants in the 1380 gully, as habitat and food did not appear to be limiting factors in this area. Literature information reviewed to develop a TRV for the food chain model provides supporting evidence on effects to survival for mammals exposed to lead. Lead in soil, willow, berries and ground invertebrates were, in many cases, the highest on-Site, so there is a link between elevated chemistry and the lack of small mammals in the gully.
- **Correlation (None); Supporting Evidence (N/A) (TMF (AEC 8) and Outside AEC on the periphery of the TMF) –** No small mammals were collected from a limited effort at the North Tailings, but this was the only effort within a physically disturbed habitat (open grass area overtop of tailing deposits) where habitat is insufficient to support small mammals (e.g., lack of food and protection from predators). Thus, the cause of the impairment at North Tailings is attributed to habitat and physical disturbance. For TPN and the other areas on the periphery of the Tailings, while small mammal captures were lower than at reference areas, there was no concurrent finding of elevated metals in soils and/or small mammal tissues in all of these areas. As well, the catch rates should only be relied on for presence/absence.
- **Correlation (Negative); Supporting Evidence (N/A) (Mill Site, Burnick, JBX station in AEC 1/9)** – More or the same number of small mammals were captured from these other AECs (which had high COPC concentrations in soils, plants and invertebrates) relative to reference areas.

*Uncertainty About Causality*

**High (1380 Gully station in AEC 1/9)** – Specific cause and effect relationships between elevated lead in soils and tissues from the 1380 Gully and the lack of small mammals have not been verified; the effects and causality ratings are based on inferences made from available information.

**Low (all other areas)** – There were either no effects, or potential effects were linked to habitat or not related to elevated tissue concentrations. Although microhabitats, weather and environmental factors are likely to influence the small mammal catches (i.e., confounding factors), the overall lack of pattern between high COPC concentrations in soils and tissues, and the presence of small mammals did not lead to the detection of effects (but uncertainty in magnitude was considered high).

# 9. FOOD CHAIN MODEL

## 9.1. LOE Description

Comparison of an estimated total dose for bird and mammal ROCs from a food chain model using measured contaminant concentrations in dietary items to available TRVs relevant for effects on survival, reproduction, and growth. The model was run at the AEC-scale for ROCs with small home ranges (≤ 25 ha) and at the mine site-scale for ROCs with large home ranges (>25 ha) and for current and future (post-closure) scenarios. Additional scenarios were run to guide remediation planning, but are not reported here (see Interim ERA, Azimuth 2014c).

This LOE is used for species-specific risks to birds and mammals.

## 9.2. Data Analysis

The food chain model was the main subject of the Interim ERA (Azimuth 2014c); readers are referred to this report for information. The final risk ratings for birds and mammals reported in the Interim ERA, based on the food chain model, are presented below under "Magnitude".

Interpretation of the model results involved a three-step process:

- **Step 1 (hazard evaluation)** – Comparison of predicted COPC doses for each ROC to the TRVs selected for listed and common species using hazard quotients (HQs). HQs < 1 or Background HQs indicate that risks are negligible and warrant no further assessment and HQs ≥ 1 indicate the possibility of adverse effects, warranting further risk characterization using dose-response datasets (if available). This was done for the 12 ROCs that generally had the highest HQs (i.e., proceed to Step 2).
- **Step 2 (organism-level risk evaluation)** – Visual inspection of where predicted doses fall on dose-response data plots (based on organism-level endpoints) using the number of studies showing effects, the magnitude of these responses and the steepness of the dose-response relationship as guides to characterize risk. The following four effect size categories were used as guides for this step:
    - Negligible (<10% sublethal effect size)
    - Low (10-20% sublethal effect size)
    - Moderate (20-50% sublethal effect size)
    - High (>50% sublethal effect size or >20% lethal effect size).
    - For any cases where risk levels for any ROC under the background scenario are equivalent to those predicted for an AEC/the overall mine site scenario, then risks are considered negligible.

- **Step 3 (population-level risk evaluation)** – Risk and uncertainty ratings from Step 2 (above) were qualitatively adjusted to extrapolate from organism-level risks to likely local population-level risks, for common species only. The extrapolation is based on the assumption that there is inherent conservatism when protecting populations using organism-level endpoints.

## 9.3. LOE Attributes

### 9.3.1. Data Quality

**Acceptable** – The food chain model relied on soil, water and tissue data, as well as a number of model input parameters provided by the wildlife biologist. The model received a QA/QC review by separate modelers at Azimuth (see documentation in the Interim ERA). The Interim ERA is currently a draft version and is undergoing regulatory review. Results reported herein have not been modified based on initial feedback from the regulatory review process. It is anticipated that a separate response to comments on the Interim ERA will be provided and any modifications to the food chain model will be made in an Updated TERA.

### 9.3.2. Ecological Relevance

**Moderate** – Ecological relevance of the food chain model was rated as moderate[11], because it is a desktop analysis (not a direct measure of the assessment endpoint for birds and mammals in the field) but uses site exposure data. In this ERA, TRVs are based on dose-response relationships for organism-level endpoints and so the food chain model is considered to have higher ecological relevance for listed species (i.e., measurement endpoints match assessment endpoints), compared to common species, where measurement endpoints do not match assessment endpoints, but risk ratings have been qualitatively adjusted to represent the population-level.

### 9.3.3. Magnitude

*Effect Size and Spatial/Temporal Scale and Uncertainty Ratings*

Final risk conclusions for the ten small-home ranged receptors that generally had the highest exposure to COPCs with dose-response datasets are the focus of the risk conclusions reported below. HQ information is not repeated (see Interim ERA); rather, findings reported here focus on the appropriate assessment endpoint (i.e., organism-level for listed species and population-level for common species) based on the Step 2/3 interpretive process. Risk and uncertainty ratings are species-specific, so in some cases ranges are reported below. Ratings are provided by area:

[11] Rating changed from low-moderate in PF to reflect use of dose-response TRV datasets for several COPCs.

**Burnick/1300 Portal –**

- **Current and Future: Low or Negligible Effects with Low Uncertainty (Common Species) and Low Effects with Moderate Uncertainty (Listed Birds) –** Risks were considered low with low or moderate uncertainty (ROC-specific), but were not completely ruled out for all COPC-ROC combinations (including some listed birds) for both current and future scenarios at the Burnick area. Because the Burnick area (1200 and 1300) is very small relative to other AECs, contamination here is unlikely to affect populations of common species, or provide food and habitat to many individuals of listed species. As well, residual risks in the future scenario were driven by HHRA (fine grain) soils from the 1300 Portal, which may overestimate exposure to bulk soil from incidental soil ingestion[12]. Specific risks were rated as:
    - Birds (current and future):
        - Low with moderate uncertainty for listed birds (chipping sparrow (L*)[13], Wilson's warbler (L*), boreal chickadee (L*), yellow-bellied flycatcher (L), white-throated sparrow (L))
        - Low with low uncertainty for common (C) birds (dark-eyed junco, boreal chickadee, chipping sparrow, Wilson's warbler).
    - Mammals:
        - Current: Low with low uncertainty for common shrew, deer mouse, northern red-backed vole, hoary marmot, porcupine, Arctic ground squirrel, snowshoe hare, which are all common species.
        - Future: Negligible with low uncertainty for common shrew, deer mouse, northern red-backed vole, hoary marmot, porcupine, Arctic ground squirrel, snowshoe hare, which are all common species.

**Jewelbox/Main Zone/1380 Gully/1250 Portal –**

- **Current: Moderate-to-High Effects with Moderate-to-High Uncertainty –** Specifically, risks were rated as:
    - High with moderate uncertainty for listed birds (e.g., Wilson's warbler (L*), American kestrel (L), yellow-bellied flycatcher (L), and boreal chickadee (L*))

[12] The Burnick AEC is currently being sampled to characterize conditions since reclamation activities have proceeded; see footnote 2 for further details.

[13] Species status is noted according to the labels used in the Interim ERA, i.e., C = common species, L = listed species, and L* = common species that is a surrogate for one or more listed species. For surrogate species, risk ratings are provided for these species as surrogates for listed ROCs, and for these species themselves as common ROCs.

  - Moderate with high uncertainty for common birds (e.g., dark-eyed junco (C), chipping sparrow (C), Wilson's warbler (C), boreal chickadee (C), and gray jay (C))
  - Moderate[14] with high uncertainty for deer mouse, common shrew, Arctic ground squirrel, and snowshoe hare, which are all common species.
  - Low with low uncertainty for the northern red-backed vole, hoary marmot, and porcupine, which are all common species.
- **Future: Moderate-to-High Risks with Moderate-to-High Uncertainty –** Specifically, risks were rated as:
  - High with moderate uncertainty for listed birds (e.g., Wilson's warbler (L*), and boreal chickadee (L*))
  - Moderate with moderate uncertainty for listed birds (e.g., chipping sparrow (L*) American kestrel (L), gray jay (L*), and white-throated sparrow (L))
  - Moderate with high uncertainty for common birds (e.g., Wilson's warbler (C), boreal chickadee (C),
  - Low with moderate uncertainty for common birds (e.g., dark-eyed junco (C), chipping sparrow (C), and gray jay (C))
  - Moderate15 with high uncertainty for deer mouse, common shrew, and snowshoe hare, which are all common species.
  - Low with low uncertainty for the Arctic ground squirrel, northern red-backed vole, hoary marmot, and porcupine, which are all common species.
- Residual risks are due to high metals concentrations within the 1380 Gully that is captured within the Jewelbox AEC, but where no remedial works are planned[16].

**Mill Site and Tailings Area -**

- **Current: Low-to-High Effects with Moderate-to-High Uncertainty –** Specifically, risks were rated as:

[14] A "moderate-high" risk rating with "moderate-high" uncertainty was documented in the Interim ERA (Azimuth 2014c); but this incorporated consideration of the small mammal trapping data, and specifically the lack of small mammals captured at the 1380 Gully. These LOEs (and risk ratings) have been separated in this report.

[15] See footnote 8.

[16] AECs 1 and 9 are currently being sampled to characterize conditions since reclamation activities have proceeded; see footnotes 4 and 5 for further details.

- High with moderate uncertainty for listed birds (e.g., Wilson's warbler (L*), and yellow-bellied flycatcher (L))
- Moderate with moderate uncertainty for listed birds (chipping sparrow (L*) American kestrel (L), boreal chickadee (L*), gray jay (L*), and white-throated sparrow (L))
- Moderate with high uncertainty for common birds and mammals (e.g., Wilson's warbler (C), and common shrew (C))
- Low with high uncertainty for common birds and mammals (e.g., dark-eyed junco (C), chipping sparrow (C), boreal chickadee (C), gray jay (C), and deer mouse (C))
- Low with low uncertainty for the northern red-backed vole, snowshoe hare, and porcupine, which are all common species.

- **Future: Negligible-to-Low Risks with Low-to-High Uncertainty to Most ROCs, –** Specifically, risks were rated as:
  - Low with high uncertainty for common shrew (C, Mill Site)
  - Low with low uncertainty for Wilson's warbler (L*), and boreal chickadee (L*) (Mill Site)
  - Although residual risks were identified for the TMF, post-closure exposure was likely overestimated because of conservative assumptions in the model. Therefore, future risks were considered:
    - Low with moderate uncertainty for listed birds (e.g., Wilson's warbler (L*), boreal chickadee (L*), and gray jay (L*)), and
    - Low with low uncertainty for common birds (e.g., shrew (C), Wilson's warbler (C), boreal chickadee (C), and gray jay (C)).
    - Low with low uncertainty for the common shrew (C).
  - Risks were considered negligible with low uncertainty for all other ROCs.

**Overall Mine Site**

- **Current: Low-to-High Effects with Low-to-Moderate Uncertainty –** Specifically, risks were rated as:
  - High with moderate uncertainty for barn swallow (L*)
  - Low with low uncertainty for great gray owl (L*), boreal owl (C), moose (C), caribou (L), black bear (C), marten (L), lynx (C), wolverine (L), and myotis (L).
- **Future: Negligible-to-Low Risks with Low-to-High Uncertainty to Most ROCs, –** Specifically, risks were rated as:
  - Moderate with moderate uncertainty for barn swallow (L*)

- Low with low uncertainty for great gray owl (L*), boreal owl (C), marten (L), wolverine (L), and myotis (L).
- Negligible with low uncertainty for moose (C), caribou (L), black bear (C), and lynx (C).

The temporal extent of the LOE is limited and is based on one to two years of field data. However, given the stability of the terrestrial environment, this is not expected to limit the applicability of the results. The future scenario was based on expected improvements in soil and tissue chemistry following site reclamation, but actual future conditions are uncertain. Post-reclamation soil/waste rock chemistry in reclaimed AECs is being characterized and future conditions will be re-evaluated in the Updated TERA.

*Uncertainty About Magnitude*

Uncertainty ratings were provided above with risk ratings by ROC group and AEC (and were explained in the Interim ERA).

*"In general, for cases where risks are considered negligible (e.g. HQs<1 or risks equivalent to background), uncertainty is considered low because there is some conservatism in the food chain model approach and assumptions and so there is a high level of confidence (low uncertainty) that potential risks are negligible or low. For listed species, in cases where risks are rated as low, moderate or high, uncertainty is generally considered moderate, because of general uncertainties in the desk-top approach, model assumptions, dose-response relationships and categorization of risks (see Section 3.4.2). For common species, in cases where risks are rated as low, moderate or high, uncertainty is generally considered high, because of the uncertainties identified for listed species in addition to having to extrapolate from organism-level endpoints (model results) to population-level endpoints (protection level/assessment endpoint for common species). There were exceptions to these general uncertainty rating categories, for various reasons related to the ROC or AEC, for example. Specific reasons for applying an uncertainty rating that differs from these general categories for any AEC/ROC combination are provided in the results section (Section 3.4.1) and/or in the detailed risk narrative (Appendix E) [of the Draft Interim ERA, Azimuth 2014c]."*

### 9.3.4. Causality

*Strength of Correlation and Supporting Evidence*

**Correlation (N/A); Supporting Evidence (Plausible) –** This LOE identifies elevated exposure relative to effects-based TRVs and, where possible, relative to dose-response data sets. Because the dose-response data sets are based on ecologically relevant effects, they provide plausible supporting evidence for potential toxicity. However, this LOE does not provide field-based evidence of causality for actual effects.

*Uncertainty Related to Causality*

**High –** While the mechanism of toxicological effect is supported by the data underlying the TRVs and dose-response data sets, this LOE does not incorporate site-specific information on effects to assess strength of relationships/causality.

# 10. REFERENCES

See **Main Report (Volume 2)**.