MEADOWBANK DIVISION

Wildlife Screening Level Risk Assessment Plan

In Accordance with NIRB Project Certificate No.004

Version 3

May, 2019

IMPLEMENTATION SCHEDULE

This Plan will be implemented immediately subject to any modifications proposed by the NIRB as a result of the review and approval process.

DISTRIBUTION LIST

AEM – Environment Superintendent

AEM – Environmental Coordinator

AEM – Environmental Technician

DOCUMENT CONTROL

Version	Date (YMD)	Section	Revision
1	2016-03-31	All	Comprehensive plan for Meadowbank Project
2	2018-06-01	2.5	ROC based on a commitment made during the Whale Tail Final Hearing through discussions with Environment and Climate Change Canada
3	2019-05-01	Throughout 3.4	Version 2 text expanded to describe assessment of risks to semi-palmated sandpiper from exposure to contaminants in the TSF. Updated time-in-area for caribou from 33% to 12% based on collaring data.

Prepared By: Meadowbank Environment Department

Approved by: Robin Allard

General Supervisor Environment

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1 INTRODUCTION

1.1 BACKGROUND

In 2006, Azimuth Consulting Group Inc. conducted a pre-construction wildlife screening level risk assessment (WSLRA) for the Meadowbank site to assess potential risks to wildlife via dietary uptake of mine-related contaminants (Azimuth, 2006). Specifically, the pre-construction SLRA focused on determining the contaminants of potential concern (COPCs) from predicted minesite activities, evaluating potential risks to wildlife from exposure to contaminants under baseline conditions, and determining the magnitude of increase in contaminant exposure required to cause concern for wildlife populations. Preliminary estimates of post-development contaminant concentrations were then obtained from models, and based on those potential future changes, expected potential risks to local wildlife were evaluated.

Under baseline conditions, negligible risks were found for all COPCs except chromium, which was determined to pose an improbable but potential risk for songbirds at baseline concentrations. COPC exposure concentrations were not expected to increase during operation, so potential risks were not expected to change from baseline conditions.

As required under the Nunavut Impact Review Board Project Certificate - Condition 67, the WSLRA is completed every 3 years during mine operation. Results to date indicate that the Meadowbank mine does not appear to be contributing significant incremental risk to wildlife from consumption of chemical contaminants.

In 2016, AEM submitted an Environmental Impact Statement (EIS) to NIRB for the Whale Tail Pit satellite deposit, located approximately 50 km north of the main Meadowbank minesite. The EIS includes an assessment of risk for wildlife in the Whale Tail Pit area under baseline conditions and the post-development scenario. Results indicated that:

> "All concentrations in soil met their respective screening values and/or baseline plus 10%; as a result, no COPCs were retained in soil and no residual impacts due to changes to soil quality were identified. Furthermore, given that no COPCs were identified for soil, no residual impacts to vegetation quality were identified. This result is consistent with the results of the conclusions of the previous risk assessments conducted at the Meadowbank Mine."
>
> "Given that no COPCs were identified in soil (Section 4.3), concentrations of chemicals in prey items (i.e., plants and animals consumed as prey) were not anticipated to change. As a result, prey items were not assessed further with respect to potential wildlife health effects and no residual health impacts due to changes to prey item quality were identified."

Nevertheless, due to stakeholder concerns with contaminant loadings due to dust, this plan presents the assessment approach and methodology that will continue to be used to assess potential risk to wildlife from chemical contaminants as a result of operations at the Meadowbank site as well as the Whale Tail Pit satellite deposit.

1.2 GENERAL APPROACH

The goal of the WSLRA is to determine whether there are potential risks to wildlife from the identified contaminants of potential concern (COPCs) under operational conditions. The general approach includes the common risk assessment components of problem formulation, exposure assessment, hazard assessment and risk characterization. In particular, assessments will aim to distinguish risk due to operation of the mine from risk due to background conditions by taking soil and vegetation samples at on-site, near-site, AWAR, Whale Tail site, Whale Tail haul road, and reference locations.

Risk assessments will follow a hazard quotient approach, and are based on food-chain modeling developed by Azimuth Consulting Group Inc. for the baseline wildlife screening level risk assessment at the Meadowbank site (Azimuth, 2006). The risk assessment framework used by Azimuth was taken from various Canadian and American sources (Environment Canada, 1994; CCME, 1996; BCE, 1998; US EPA, 1992, 1998). The exposure assessment stage will be updated with field data collected in each assessment year. Toxicity reference values (TRVs) will be continually compared to those used in similar risk assessments in the Kiggavik region and published databases.

2 PROBLEM FORMULATION

2.1 LOCATION DESCRIPTION

The main Meadowbank site is located 70 km north of the hamlet of Baker Lake, Nunavut, near the border of the Northern and Southern Arctic ecozones. Terrain in the Meadowbank area is typical barren-ground subarctic, with low-growing vegetation in poorly developed soil with continuous permafrost. The landscape is dominated by many interconnected lakes and isolated ponds with indistinct drainage patterns. Topography consists of rolling hills, boulder fields and bedrock outcrops. The main mine site is located at the headwaters of the Quioch River system, which flows southeast through Chesterfield Inlet into Hudson Bay. Lakes in this region are ultra-oligotrophic, with low productivity levels. This region supports few terrestrial mammals (15 species) and birds (62 species) (Azimuth, 2006). Migratory species (primarily caribou and Canada geese) are present.

2.2 SITE FACILITIES

The Meadowbank project consists of several gold-bearing open-pit deposits (Portage, Goose, Vault, and Whale Tail). Much of the original infrastructure is located in close proximity to the mill and mine facilities, with the exception of the Vault Pit which is approximately 10 km northeast of the site. The Whale Tail Pit, which was permitted in 2018, is approximately 50 km northwest of the site.

Waste rock from the pits is stored in the Portage Waste Rock Storage Facility, Vault Waste Rock Storage Facility, and Whale Tail Waste Rock Storage Facility (RSFs). Rock Storage Facilities are constructed to minimize the disturbed area and will be capped with a layer of non-potentially acid-generating rock (NPAG). During the construction period, NPAG is also used for construction of dikes and roads. Mined ore is either processed in the mill or stockpiled for eventual processing.

Tailings are stored in the Tailings Storage Facility (TFS) adjacent to the main minesite. The TSF is defined by the series of dikes built around and across the basin of the dewatered northwest arm of Second Portage Lake. Tailings water is reclaimed for use in ore processing.

An onsite airstrip supports transportation of goods and personnel to and from the Meadowbank site by jet. A 110-km All Weather Access Road (AWAR) runs between the main minesite and the hamlet of Baker Lake, where Agnico Eagle maintains a bulk fuel storage and barge facility. The Vault Pit is connected to the main minesite by a 10-km haul road, and the Whale Tail Pit satellite deposit is connected by a 62-km haul road.

2.3 SOURCES OF CONTAMINANTS

Major mine site operations and their potential to contribute to COPCs (based on Azimuth, 2006) are summarized here.

Open pits – Along with ore, pits produce waste rock, which may contribute to COPCs through dust emissions.

Rock storage facilities – Waste rock (not containing ore) is moved to these areas. Dust may be blown from the rock piles during dumping and vehicle traffic during transport of material. Seepage from rock storage facilities is controlled in sumps and pumped back to attenuation ponds or the TSF.

Borrow pits and quarries – Borrow pits and quarries are used as necessary for the construction of mine site roads and the airstrip. The COPCs for borrow pits and quarries are similar to open pits.

Tailings Storage Facilities (TSF) – The northwest arm of Second Portage Lake was partitioned off by the East Dike and de-watered from 2009 to 2012. The northwestern portion of this area was further partitioned by the Stormwater Dike to create the North and South Cell TSF. Although permafrost is expected to freeze the tailings, the material is fine-grained and could be a source of dust emissions during dry periods.

Roads and airstrip – Frequently used gravel haul roads run throughout the mine site to connect pits, waste rock storage and processing facilities. An airstrip, receiving approximately 4 planes per week, was built at the mine site to receive deliveries and personnel. Dust from these sources could be a potential source of contaminants. A 110 km long all weather access road (AWAR) was constructed between the mine and the Hamlet of Baker Lake, using gravel from quarries along the road.

Effluent discharge – De-watering of lakes for pit development or TSF construction is considered effluent discharge and is regulated under the current NWB Water License. Lake water is treated for suspended solids removal before discharge, and since it is an existing surface water source, it is not likely to be a source of contaminants in the receiving water. Effluent is also periodically discharged from attenuation ponds into adjacent lakes, under NWB Water License and MMER requirements. As a result, metals regulated under MMER are considered as COPCs.

Diesel generating plant, mine mill plant and associated facilities – Three diesel generating plants provide power for the mine. The Air Quality Impact Assessment (2005) determined emission of PAHs was “very low” and did not require modeling. The milling of rock in the processing plant takes place under wet conditions, and is not a source of particulate emissions. All health and safety-related requirements to reduce particulate emissions during handling of the ore at the mine plant before processing are met, so these are not expected to be a significant source of contaminants.

Overall, roads, waste rock and tailings were determined to be the main sources potentially contributing to COPCs through dust emissions. Dewatering effluent discharge may potentially contribute to COPCs in water sources. In addition, risks to shorebirds from exposure to contaminants within the tailings storage facility are now considered, following discussions with Environment and Climate Change Canada during the Final Hearing for the Whale Tail Pit project.

2.4 CONTAMINANTS OF POTENTIAL CONCERN (COPCS)

In the baseline WSLRA, Azimuth (2006) identified COPCs for the main minesite area based on the chemical composition of the identified dust sources, the predicted effects of effluent on water quality in

Third Portage Lake (from Golder, 2005), and a review of metals regulated under MMER (see Azimuth, 2006, Section 2.5 for details).

Projected concentrations of metals in four dust sources (roads, waste rock and tailings) that exceeded the 90th centile of baseline soil concentrations or the CCME guidelines (CCME 1999, 2001) were included as COPCs for the main Meadowbank minesite. Five metals regulated under MMER (arsenic, copper, lead, nickel and zinc) were also included in the assessment. Although mercury was not predicted to exceed baseline soil concentrations or CCME criteria, it was included because it was found to be of concern to the general public in the Arctic.

No terrestrial wildlife COPCs were identified in the Whale Tail Pit FEIS (Golder, 2016), but those identified for the main Meadowbank site are applied to assessments for Whale Tail study locations.

In addition to the contaminants identified during baseline assessments, cyanide is now included as a COPC in the assessment of risks to shorebirds from consumption of tailings.

The COPCs for this assessment are therefore comprised of:

Antimony	Lead	Tin
Arsenic	Manganese	Uranium
Barium	Mercury	Vanadium
Beryllium	Molybdenum	Zinc
Cadmium	Nickel	Cyanide (TSF study area only)
Chromium	Selenium	
Cobalt	Strontium	
Copper	Thallium	

Certain chemicals which are controlled through best management practices and which were not addressed in the baseline SLRA include petroleum hydrocarbons, process chemicals, dioxins, nitrates, ammonia and PAHs. For each source of these chemicals, best management practices are in place and environmental exposures are not expected to occur.

2.5 RECEPTORS OF CONCERN

The WSLRA originally considered four Receptors of Concern (ROCs): ungulates, small mammals, waterfowl and songbirds. These choices were determined from the project's initial EIA, which included discussions with stakeholders, public meetings, traditional knowledge and experience from other mines. Specifically, the WSLRA focussed on caribou, Canada goose, Lapland longspur and northern red-backed vole as representative species. An ecological description of the area and detailed descriptions of the biology of each of these receptors can be found in Azimuth (2006). This updated assessment framework also includes an assessment of risks to shorebirds (as represented by semi-palmated sandpiper) from contaminants within the TSF, based on a commitment made during the Whale Tail Pit project Final Hearing, following discussions with Environment and Climate Change

Canada (ECCC). Receptor-specific values such as dietary preferences that are used in this assessment are further discussed in Section 3.1 (Table 3-1).

Separate characterizations are conducted for the main Meadowbank minesite, near-site, AWAR, Whale Tail pit, Whale Tail haul road, and external reference locations for northern red-backed vole, Lapland longspur and Canada goose, and TSF for semi-palmated sandpiper, because these species have small territories when not migrating and would not be expected to move between the sampling areas. Main minesite and near-site samples are combined for the caribou risk characterization, because it is assumed that when caribou are present they can readily move between these sampling locations. See Section 3.2 for further information on these study areas, and Section 3.4 for a discussion of how residence time in each area is handled as a dose-adjustment factor.

2.6 PROTECTION GOALS AND ENDPOINTS

Since the ROCs identified are not rare or endangered species, protection at the population level was determined to be appropriate (Azimuth, 2006). The assessment endpoint is no adverse effect of COPCs on populations of caribou, Canada goose, Lapland longspur, northern red-backed vole, and semi-palmated sandpiper.

The measurement endpoints will be calculated as exposure to the COPCs through ingestion of soil or sediment, water and food items. Ingested concentrations will be compared to literature-based ecotoxicological benchmarks equivalent to maximum acceptable exposure levels for each ROC. Specifically, the ecotoxicological benchmarks will be lowest observable adverse effect levels (LOAELs), which are generally considered to be appropriate for determining risk at the population level (Azimuth, 2006).Toxicity reference value (TRV) selection is further described in Section 4.

2.7 EXPOSURE PATHWAYS

The following exposure pathways will be investigated:

Small mammals – ingestion of plants, insects, water, soil

Ungulates – ingestion of plants, water, soil

Songbirds – ingestion of plants, insects, water, soil

Waterfowl - ingestion of plants, insects, water, soil

Shorebirds – ingestion of benthic invertebrates, water, sediment

Inhalation and dermal absorption of metals are generally considered to be insignificant in comparison to exposures through ingestion (USEPA, 2005), so they are not considered here.

3 EXPOSURE ASSESSMENT

Exposure assessment is used to calculate the dose of each COPC received by each ROC. The exposure assessment uses the food chain model developed by Azimuth (2006). The model was developed to include the influence of COPC concentrations in exposure pathways, dietary preferences, ingestion rates and dose-adjustment factors. Estimated daily intake of each COPC is calculated for each study area (main Meadowbank minesite, near-site, TSF, AWAR, Whale Tail site, Whale Tail haul road, external reference) as:

$$EDI = [\sum (I_{w,s,f} \times C_{w,s,f}) \times BF \times T]_{study\ area} + [\sum (I_{w,s,f} \times C_{w,s,f}) \times BF \times T]_{ext\ ref}$$

Where:

EDI = estimated daily intake (mg/kg body weight/day)

$I_{w,s,f}$ = intake of water, soil/sediment and food items (L/kg ww/d; kg dw/kg ww/d; kg dw/kg ww/d)

$C_{w,s,f}$ = concentration of COPC in water, soil/sediment and food items (L/kg ww/d; kg dw/kg ww/d; kg dw/kg ww/d)

BF = biotransfer factor (absorption factor)

T = proportion of time in area

Each component is described below, and an example calculation is provided in Appendix A.

3.1 INTAKE OF WATER, SOIL/SEDIMENT AND FOOD

Water, food and soil/sediment ingestion rates used in the assessments are shown in Table 3-1. All intake parameters are considered to be conservative. Water and food ingestion rates were derived from species profiles or allometric equations in USEPA (1993), as described in Table 3-1. Soil ingestion rates for Canada goose and Northern red-backed vole are also from USEPA (1993). Sediment ingestion rates for semi-palmated sandpiper are from Beyer et al. (1994). Although Beyer et al. (1994) was referenced as the source of most soil ingestion rates in the Meadowbank baseline assessment, the species chosen to represent caribou and Lapland longspur were not indicated. The soil consumption rate for caribou was increased in subsequent Meadowbank assessments and here from 2% of dry food consumption to 5%, which is the general rate for mammals in Beyer et al. (1994), as used in (Senes, 2008). The soil ingestion rate for Lapland longspur was increased from 2% to 7%, based on Hansen et al. (2011). This study identified a rate of 0.7% for Swainson's thrush, a ground-dwelling songbird that primarily feeds on flying insects and berries. A 10x safety factor was applied because Swainson's thrush is a foliage-gleaner, while Lapland longspur is considered a ground-forager (Cornell University, 2011). This factor is considered to be conservative however, because Lapland longspur does not scratch the ground to uncover food items as other ground foragers do (Harrison 1967, Greenslaw 1977).

Table 3-1. Body weight (BW), water intake (I_{water}), soil intake (I_{soil}), and wet and dry (I_{food}; FI) food intake for the identified ROCs.

Parameter	Units	Value	Reference	Notes
Northern Red-backed Vole				
BW	kg wet	0.02	Nagorsen (2005)	Smallest body weight used
I_{water}	L/kg wet/day	0.253	USEPA (1993)	Species profile data for the Prairie Vole
I_{soil}	kg dry/kg wet/day	0.0008	USEPA (1993)	Assumed 2.4% of dry food ingestion

Parameter	Units	Value	Reference	Notes
				rate (similar to Meadow Vole)
I_{food}	kg wet/kg wet/day	0.135	USEPA (1993)	Species profile data for the Prairie Vole
FI	kg dry/kg wet/day	0.049	Not available	Moisture in food assumed to be 64% as per diet moisture calculation
Caribou				
BW	kg wet	75	Dauphine (1976)	Smallest body weight used
I_{water}	L/kg wet/day	0.064	USEPA (1993)	Based on allometric equation for all mammals (L/day) $(0.099*(BW)^{0.90})$
I_{soil}	kg dry/kg wet/day	0.0013	Beyer et al. (1994)	Assumed 5% of dry food ingestion rate (general rate for mammals)
I_{food}	kg wet/kg wet/day	0.047	Not available	Moisture in food assumed to be 43% as per diet moisture calculation
FI	kg dry/kg wet/day	0.027	USEPA (1993)	Based on total dry food intake for herbivorous mammals (g/day) $(0.577*(BW)^{0.727})$
Lapland Longspur				
BW	kg wet	0.023	Cornell University (2011)	Smallest body weight used
I_{water}	L/kg wet/day	0.205	USEPA (1993)	Based on allometric equation for all birds (L/day) $(0.059*(BW)^{0.67})$
I_{soil}	kg dry/kg wet/day	0.0174	Hansen et al. (2011)	Assumed 7% of dry food ingestion rate (rate of Swainson's thrush +10x safety factor)
I_{food}	kg wet/kg wet/day	0.656	USEPA (1993)	Moisture in food of insectivorous birds; assumed 62% as per diet moisture calculation
FI	kg dry/kg wet/day	0.249	USEPA (1993)	Based on total dry food intake for passerine birds (g/day) $(0.398*(BW)^{0.850})$
Canada Goose				
BW	kg wet	2.000	Mowbray et al. (2002)	Smallest body weight used
I_{water}	L/kg wet/day	0.044	USEPA (1993)	Species profile data for Canada Goose
I_{soil}	kg dry/kg wet/day	0.0006	USEPA (1993)	Assumed 8.2% of dry food ingestion rate
I_{food}	kg wet/kg wet/day	0.032	USEPA (1993)	Species profile data for Canada Goose
FI	kg dry/kg wet/day	0.011	Not available	Moisture in food assumed to be 66% as per diet moisture calculation
Semi-palmated Sandpiper				
BW	kg wet	0.030	CWS (2001)	-
I_{water}	L/kg wet/day	0.188	USEPA (1993)	Allometric scaling for birds (L/day) = $0.059\ Wt^{0.67}$ (kg)
$I_{sediment}$	kg dry/kg wet/day	0.059	Beyer et al. (1994)	30% of dry food ingestion rate
I_{food}	kg wet/kg wet/day	1.0	USEPA (1993)	Allometric scaling for birds (g (dw)/day) = $0.648\ Wt^{0.651}$ (g); assumed moisture content of 80%

Parameter	Units	Value	Reference	Notes
				per Senes (2008)
FI	kg dry/kg wet/day	0.197	USEPA (1993)	Allometric scaling for birds (g (dw)/day) = 0.648 $Wt^{0.651}$ (g); assumed moisture content of 80% per Senes (2008)

3.2 DIETARY CONCENTRATIONS OF COPCS

Concentrations of COPCs will be measured in and around the Meadowbank site in water, soil and plant tissue (food items: sedges, lichens, berries) in assessment years. This includes five samples of each media type from four Meadowbank minesite (onsite) locations, three near-site locations, one AWAR location, two Whale Tail Pit locations, one Whale Tail Haul Road location, one TSF location and three external reference locations. Sample locations are shown in Figure 3-1. An SOP for methods of collection along with UTM coordinates is provided in Appendix C.

Water and sediment grab samples from the Core Receiving Environment Monitoring Program (CREMP) data collection will be used in the WSLRA analyses (Figure 3-1). Onsite (main Meadowbank minesite) concentrations will be from samples collected in Second Portage Lake (SPL) and the east and north basins of Third Portage Lake (TPE, TPN). AWAR concentrations will be from samples collected in TPN. Near-site concentrations will be from samples collected in Tehek Lake (TE). Whale Tail Pit concentrations will be from samples collected in Whale Tail Lake South. Whale Tail Haul Road concentrations will be from samples collected in Pipedream Lake (PDL). External reference samples are from Inuggugayualik Lake (INUG) and PDL. Exact coordinates are subject to slight changes each year – see CREMP Plan (Azimuth, 2015) for details.

Specific locations for the Whale Tail site will be determined following ground-truthing, but will target locations up to 5 km downwind (to the south/southeast) of site activity, and will include one location on the downwind side of the haul road. The general approach for selecting these sites will be consistent with a near-field/far-field method used for the main Meadowbank minesite since 2008, as illustrated in Figure 3-1.

Concentrations in soil and plant tissue used for food chain modeling will be the upper 95% confidence limit of the mean (UCLM). If values are below the detection limit, a value of ½ the detection limit will be used. Based on published literature, methyl mercury is assumed to comprise 1% of total mercury in water and soil, and 34% of total mercury in plant tissue, and inorganic mercury = total – methyl mercury (Azimuth, 2006).

Concentrations of COPCs in insects are not measured, but are modeled from soil concentrations using published bioaccumulation models for arsenic, cadmium, copper, lead, and zinc (Sample and Arenal, 2001; as described in Azimuth, 2006):

$$\ln[insect] = B0 + B1(\ln[soil])$$; concentrations are expressed in mg/kg dry weight

This method is particularly conservative, because the modeled factors are for ground insects whereas the songbird population in this assessment consumes primarily flying insects. A bioaccumulation factor (BAF) of 1 is assumed for all remaining COPCs, which is also considered to be very conservative.

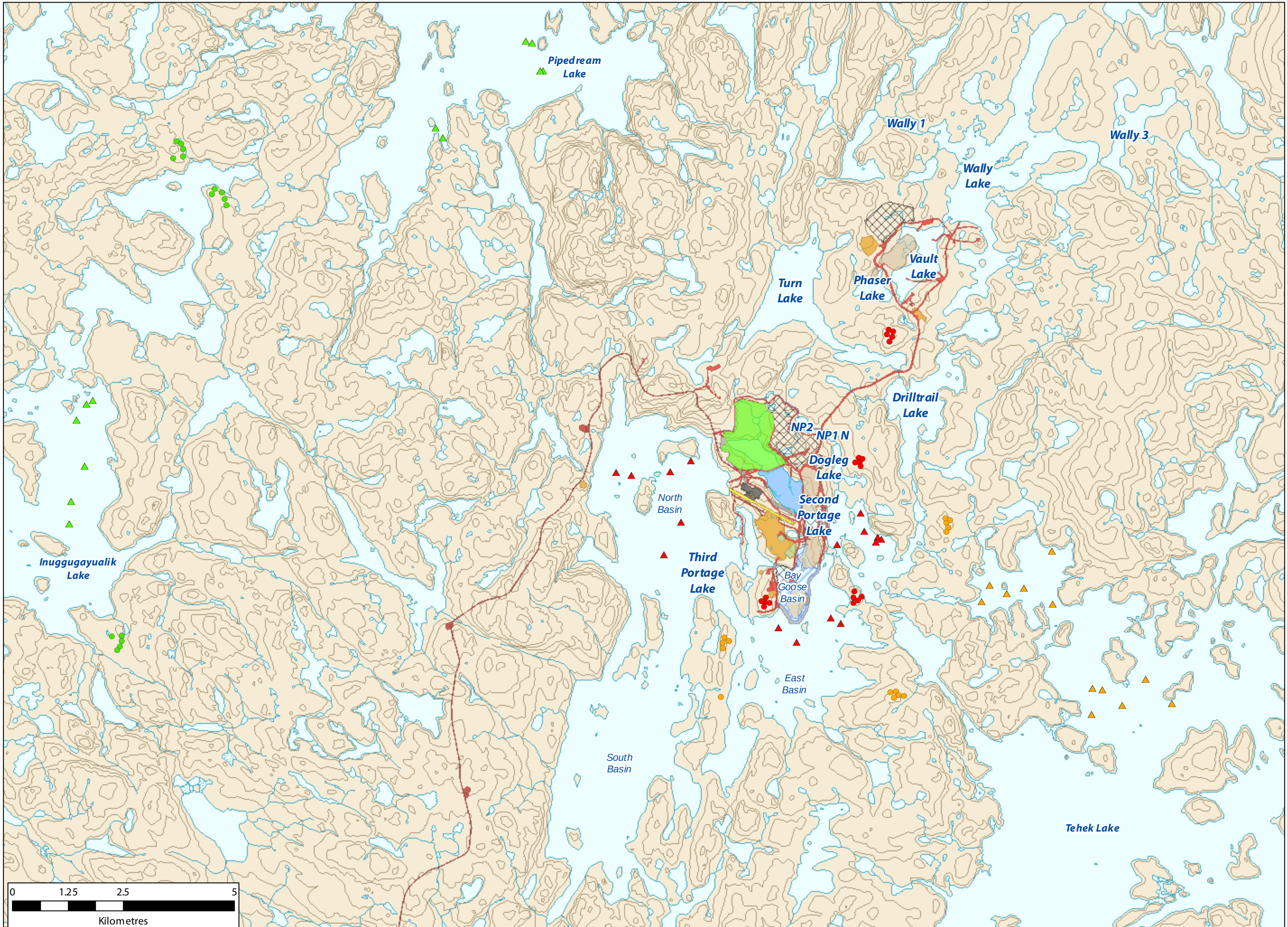
For benthic invertebrates, BAFs from USEPA (1999) will be used to estimate whole-body tissue concentrations based on measured sediment concentrations as:

[benthic invertebrate] = BAF x [sediment]; concentrations are expressed in mg/kg dry weightAvailable BAFs are shown in Table 3-2. For all other COPCs, a BAF of 1 is assumed.

Table 3-2. Bioaccumulation factors (BAFs) from USEPA (1999) used for estimating whole-body concentrations of COPCs in benthic invertebrates.

Parameter	BAF
Aluminum	0.90
Arsenic	0.90
Barium	0.90
Chromium	0.39
Copper	0.30
Lead	0.63
Mercury	0.068
Nickel	0.90
Selenium	0.90
Silver	0.90
Thallium	0.90
Zinc	0.57
Cyanide	0.90

Prior to the initial assessment of risk for semi-palmated sandpiper (2020), sampling for benthic invertebrates will be conducted within the TSF to determine whether any significant populations are established in this area. Since the TSF is not intended as aquatic habitat, it is unlikely that any resident populations of invertebrates are substantial enough to fulfill the dietary needs of shorebirds. If insignificant numbers of invertebrates are found, dietary exposure for semi-palmated sandpiper will be calculated from onsite sediment monitoring locations (SPL, TPE, TPN). In this case, a comparative study will be conducted to determine any significant differences in COPC concentrations between the deeper-water CREMP sediment collection locations (typically ~ 3 m) and shoreline sediment samples. If differences are not significant, CREMP sediment samples will be considered appropriate for the purposes of the SLRA moving forward.



Legend

Soil/Veg Sampling Location

- Onsite
- Near Site
- External Reference

Water Sampling Locations

- Onsite
- Near Site
- External Reference

2014 Mine Plan

- Quarry
- AWPAR Quarry
- Dewatered Lake
- Portage Attenuation Facility
- Tailings Storage Facility
- Roads
- AWPAR
- Dikes
- Diversion Ditch
- Stockpiles
- Pits
- Facility
- Airstrip
- Waste Dump

Wildlife Screening Level Risk Assessment

DOUGAN & ASSOCIATES
ECOLOGICAL CONSULTING & DESIGN
77 Wyndham Street South • Guelph ON N1E 5R3
T 519.822.1609 • F 519.822.5389 • www.dougan.ca

PROJECT: DA11-062-03

CLIENT: Agnico-Eagle Mines Ltd., Meadowbank Div.

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DATE: MARCH 2015

SCALE: 1:80,000

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CHECKED BY: MAY

FIGURE:

3-1

The information displayed on this map has been compiled from various sources. While every effort has been made to accurately depict the information, this map should not be relied on as being a precise indicator of locations, features, or roads, nor as a guide to navigation. MNR data provided by Queen's Printer of Ontario. Use of the data in any derivative product does not constitute an endorsement by the MNR or the Ontario Government of such products.

3.2.1 Dietary Preferences

The proportions of food items (sedge, lichen, berries, insects, benthic invertebrates) that comprise each diet (Table 3-3) were determined using the literature reviews referred to in Section 2.6. Similar values have been used in another recent risk assessment (Senes, 2008). Consistent with Azimuth (2006), sedges, lichens and berries will be considered surrogates for all plant matter ingested by the ROCs.

Table 3-3. Estimated dietary preferences for the receptors of concern at the Meadowbank site.

Dietary Item	Northern red-backed vole	Caribou	Lapland longspur	Canada goose	Semi-palmated sandpiper
Sedges	55%	30%	25%	50%	0%
Lichens	0%	65%	0%	0%	0%
Berries	40%	5%	5%	45%	0%
Insects	5%	0%	70%	5%	0%
Benthic Invertebrates	0%	0%	0%	0%	100%
Total	100%	100%	100%	100%	100%

3.3 BIOTRANSFER FACTOR

The uptake efficiency factor (biotransfer or absorption factor) describes the proportion of the COPC that is absorbed into the animal from any ingested sources. Uptake efficiency was conservatively assumed to be 100% for all COPC/receptor combinations. This is likely an extremely conservative assumption; for example, chromium compounds were found to have a maximum absorption efficiency of 10% in the GI tract (Outridge and Scheuhammer, 1993).

3.4 TIME IN AREA

Territory size (foraging range) affects the proportion of an animal's diet that could be affected by mine-related contaminants. In the baseline assessment for Meadowbank (Azimuth, 2006), an adjustment factor for foraging range was not applied (animals were assumed to spend 100% of time in the study area). For subsequent assessments, the only ROC assumed to spend 100% of its time in any study area is the northern red-backed vole, because of its small territory size. Canada geese, and Lapland longspur are migratory species, and the fraction of time spent in any study area for those species (main minesite, near-site, AWAR, Whale Tail site, Whale Tail Haul Road) is estimated at 33%, based on the 2008 Screening Level Environmental Effects Assessment for the Kiggavik Project (Senes, 2008).

While semi-palmated sandpiper are similarly migratory and estimated to spend 33% of the year in the minesite area (Senes, 2008), they are not expected to obtain 100% of their food and water from the TSF, since best management practices are in place to actively discourage wildlife from this area. During breeding season, inspections are performed at least once per day, and birds are deterred from the open-water areas of the TSF through the use of personnel presence, decoys, noise cannons, and flares. While bird presence around the TSF occurs for up to 2 weeks in the very early spring, prior to ice-off on natural lakes, very few birds are observed in this area after that time. Therefore, the proportion of semi-palmated sandpiper exposure to COPCs originating from the TSF is nominally estimated at 4% (i.e. 2 weeks per year), with the remainder of exposure during their time onsite (29%) estimated from the onsite sample locations. This value may be refined in future years based on results of TSF wildlife surveys.

The time caribou spend in any study area (12%) was determined through an examination of collared caribou from the Meadowbank region, which found that any one animal spent no more than a maximum of 12% of the year within 25 km of the minesite (Martin Gebauer and Jason Shaw, personal communication, March 2012). This is similar to the estimate of 10% used in the 2004 assessment of the Lupin minesite (Golder, 2004).

The remaining fraction of exposure doses for each ROC will be calculated based on external reference samples.

Risk will be characterized for small-territory ROCs (Northern red-backed vole, Canada geese and Lapland longspur) for main Meadowbank minesite (onsite), near-site, AWAR, Whale Tail Pit, Whale Tail Haul Road, and external reference locations separately, in order to determine whether those animals choosing territories at any mine-related location are at increased risk compared to those choosing territories at nearby reference locations. Exposure data for main minesite and near-site locations will be combined for caribou because caribou can readily roam between the onsite and near-site locations in the course of a day. Risk for semi-palmated sandpiper is determined due to exposure to contaminants in the TSF only, based on recommendations from ECCC and commitments made during the 2018 Whale Tail Final Hearings.

Time-in-area adjustment factors are summarized in Table 3-3.

Table 3-4. Time-in-area assumption for each study area and ROC. In each case, the remainder of exposure is calculated from COPC concentrations at external reference sites.

Study Area	Northern red-backed vole	Caribou	Lapland longspur	Canada goose	Semi-palmated sandpiper
Onsite	100%	12%	33%	33%	-
Near-site	100%		33%	33%	-
AWAR	100%	12%	33%	33%	-
Whale Tail Pit area	100%	12%	33%	33%	-
Whale Tail haul road	100%	12%	33%	33%	-
TSF & Onsite	-	-	-	-	4% & 29%

4 TOXICITY ASSESSMENT

The toxicity reference values (TRVs) used in the Meadowbank assessments (Appendix B) were collated from a review of the literature; mainly from Sample et al. (1996). This represents one of the most comprehensive and commonly used sources available for wildlife toxicity reference values and has been used in other similar assessments for this region (e.g. Senes, 2008). In order to ensure the selected TRVs were relevant to the Meadowbank site and the conditions of that risk assessment, several criteria were used in the baseline assessment in screening toxicity studies. These included selecting values from studies conducted on species of similar phylogeny (i.e. bird or mammal), and selecting studies that examined individual or population-level effects over chronic time periods. The following describes TRV selection, as performed by Azimuth (2006):

> The TRVs chosen for use in the risk characterization include both no observable adverse effect levels (NOAELs) and lowest observable adverse effect levels (LOAELs) when available. If effects concentrations were reported in terms of food concentrations, these were converted to dose. If a LOAEL was reported but no NOAEL could be determined, it was estimated as 1% of the LOAEL (as in Sample et al. 1996, Chapman et al. 1998). LOAELs cannot be estimated if only a NOAEL is available. Since the protection goal of this risk assessment no adverse effect of COPCs on populations of the ROCs, LOAELs are the most relevant TRV, and are used in the final risk estimate.
>
> Instead of species-to-species uncertainty factors, the baseline assessment used allometric scaling factors (Sample et al. 1996) to adjust mammalian TRVs from the test species (typically mouse or rat) to the ROC. A scaling factor of 1 was used for birds (Mineau et al. 1996).
>
> Where toxicity information was found for multiple forms of a contaminant, the one with the greatest toxic potency was chosen. TRVs for chromium-VI were available for mammals, but only chromium-III was available for birds. No NOAELs or LOAELs were available for total mercury. Mammalian LOAELs were not available for inorganic mercury or beryllium. Avian LOAELs were not available for uranium or vanadium. Avian NOAELs were not available for antimony and beryllium and were extrapolated from the mammalian values. The avian LOAEL for antimony was extrapolated from the mammalian value.

The TRV for cyanide in the assessment of risks to semi-palmated sandpiper was obtained from Ma and Pritsos (1997), as applied for another Northern shorebird, the common snipe, in Golder (2004).

5 RISK CHARACTERIZATION

5.1 HAZARD QUOTIENTS

Risk characterization compares predicted exposure concentrations with the toxicity reference values from the literature, using the hazard quotient approach. Hazard quotients for all study areas (main Meadowbank minesite (onsite), near-site, AWAR, Whale Tail Pit, Whale Tail Haul Road, TSF, and external reference) will be calculated as:

$$HQ = EDI / TRV$$

Where:

EDI = estimated daily intake (ug/kg body weight/day)

TRV = toxicity reference value (ug/kg body weight/day)

See Appendix A for an example calculation and Appendix B for all TRVs used in assessments for Meadowbank. As discussed above, the TRV to be used is represented by the LOAEL, unless only a NOAEL was available (indicated).

Because of the conservative assumptions included at this level of assessment, there is generally considered to be a high degree of certainty associated with results indicating negligible risk. A hazard quotient > 1 indicates the possible need for more in-depth assessment, including analysis of assumptions used. However, when HQ values exceed 1 for both the baseline (or external reference) and the study areas, and are of similar magnitude, it may be assumed that the receptor is adapted to the measured exposure level, or that the assumptions used in calculating the HQ have resulted in an over-estimation of risk (Dominion Diamond, 2015).

HQ values and a characterization of risk for each ROC will be provided in the assessment report.

5.2 UNCERTAINTY ASSESSMENT

The assumptions included in each section of the assessment are discussed here, along with implications for over- or under-estimating risk.

5.2.1 Uncertainty in Exposure Assessment

ROCs used in the assessment are assumed to represent categories of species (e.g. ungulates, small mammals, waterfowl, shorebirds, song birds) that are found around the Meadowbank site. Exposure is assumed to be similar for other species in these categories. Compared to other Arctic animals, the exposure for the species chosen is expected to be realistic to conservative, because they all are assumed to forage in or on the soil.

Exposure concentrations in environmental media are assumed to be represented by the 95% UCLM of the measured concentrations. Since animals would be more likely to ingest food sources with a range of COPC concentrations, this is a conservative assumption.

Ingestion rates are applied using published values for similar but not identical species. Based on biological factors, these rates were chosen to be conservative.

Dietary preferences are from studies on the same or similar species, but are not from populations specifically inhabiting the study region.

It is assumed that flying insects accumulate the same proportion of metals from soil as ground-dwelling insects, because no flying insect BAFs were available. This assumption likely results in an over-estimation of risk for ROCs who primarily consume flying insects (Lapland longspur).

Absorption of COPCs in the gastrointestinal tract was assumed to be 100%. This assumption likely results in an over-estimation of risk for all COPCs/ROC combinations.

Methyl mercury proportions of total mercury concentrations are estimated from the available literature using the UCLM from two studies (Azimuth, 2006). While there is an unknown degree of uncertainty in the extrapolation of this data for use at the Meadowbank site, the fractions chosen were at the highest end of the published range, and are therefore designed to be conservative. Furthermore, mercury was included as a COPC because it was found to be of concern to the general public in the Arctic, and no source of elevated mercury was identified at the mine.

Ingestion of COPCs was the only route of exposure considered in this assessment. While this assumption may slightly under-estimate actual exposure, inhalation and dermal absorption of metals are generally considered to be insignificant in comparison to exposures through ingestion (USEPA, 2005).

5.2.2 Uncertainty in Toxicity Assessment

TRVs are not available for the ROCs considered in this assessment and species-to-species extrapolations are necessary. This includes allometric scaling for mammals, 1:1 scaling for birds, and the application of uncertainty factors in mammal-to-avian extrapolation. Food intake-to-body weight ratios are well studied and uncertainty factors are designed to be protective, so these extrapolations are likely to be realistic or conservative.

As is common in screening level risk assessments, the estimation of risk is for each COPC in isolation, and does not consider potential additive, synergistic or antagonistic reactions. Models for determining mixture toxicity of a large suite of metals are not yet widely available, and guideline values are for single compounds only. This factor may lead to under-estimation of actual risk from metals overall, but the otherwise conservative nature of an SLRA is assumed to compensate for this issue.

6 REPORTING AND ADAPTIVE MANAGEMENT

The SLRA for the Meadowbank site (including the Whale Tail Pit and Haul Road) will evaluate risks to wildlife from contaminant exposure in and around the mine site every three years during operation, and results will be reported to NIRB in the context of AEM's Annual Report for the Meadowbank site.

Because of the conservative assumptions included at this level of assessment, there is generally considered to be a high degree of certainty associated with results indicating negligible risk (HQ <1). In the case that hazard quotients exceed 1 and differ substantially (generally, by more than an order of magnitude) between mine-related and reference and/or baseline sites for a certain COPC, incremental risk due to mine operation will be classified as potentially unacceptable and more detailed investigations will be initiated. This may include a desk-top review and refining of the assessment parameters, and/or additional sampling in the subsequent year to confirm results. In the case that results of refined assessments continue to indicate unacceptable risk, adaptive management may include such interventions as capping of dust sources, increased road watering, delineation of contaminated areas, and deterrence methods pending reclamation.

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Appendix A

Example Calculation

Exposure of Lapland longspur to Pb (main minesite area)

Exposure Assessment

$$EDI = T_{onsite}(DS_{onsite} + DW_{onsite} + DF_{onsite}) + T_{ref}(DS_{ref} + DW_{ref} + DF_{ref})$$

Where:

EDI = estimated daily intake of COPC

T_{onsite} = fraction of time in study area (i.e. onsite) = 33%

T_{ref} = remaining fraction of time = 67% (remainder of exposure based on external reference concentrations)

DS = dose from incidental soil ingestion

I_{soil} = intake of soil

DW = dose from drinking water

I_{water} = intake of water

DF = dose from food

I_{food} = intake of food

$Pb_{(media)}$ = measured concentration of lead in media (95% UCLM of onsite or external reference values, accordingly)

Example:

DS_{onsite} (mg/kg ww/d) = Pb_{soil}* (mg/kg dw) * I_{soil} (mg dw/kg ww/d)

= 11.23 * 0.0174

= 0.195

DW_{onsite} (mg/kg ww/d) = Pb_{water} (mg/L) * I_{water} (L/kg ww/d)

= 0.00 * 0.205

= 0.00

DF_{onsite} (mg/kg ww/d) = Pb_{sedge} (mg/kg ww)*25% + Pb_{lichen} (mg/kg ww)*0% + $Pb_{berries}$ (mg/kg ww)*5% + $Pb_{insects}$ (mg/kg ww)*70% * I_{food} (kg ww/kg ww/d)

= 0.35*25% + 1.68*0% + 0.03*5% + 0.37*70% * 0.656

= 0.228

DS_{ref} (mg/kg ww/d) = Pb_{soil} (mg/kg dw) * I_{soil} (mg dw/kg ww/d)

= 8.757 * 0.0174

= 0.152

DW_{ref} (mg/kg ww/d) = Pb_{water} (mg/L) * I_{water} (L/kg ww/d)

= 0.00 * 0.205

= 0.00

DF_{ref} (mg/kg ww/d) = Pb_{sedge} (mg/kg ww)*25% + Pb_{lichen} (mg/kg ww)*0% + $Pb_{berries}$ (mg/kg ww)*5% + $Pb_{insects}$ (mg/kg ww)*70% * I_{food} (kg ww/kg ww/d)

= 1.01*25% + 2.85*0% + 0.02*5% + 0.31*70% * 0.656

= 0.309

EDI_{Pb} (mg/kg ww/d) = 33%(0.195 + 0.00 + 0.228) + 67%(0.152 + 0.00 + 0.309)

= 0.45

Risk Characterization

HQ = EDI (mg/kg ww/d) / LOAEL-based TRV (mg/kg ww/d)**

= 0.45 / 11.30

= 0.04

**see values in Appendix B

Appendix B

Toxicity Reference Values

Parameter				Antimony[2,3,4]	Arsenic[1]	Barium[1]	Beryllium[1,2]	Cadmium[1]	Chromium[1,5]	Cobalt[7]	Copper[1]
TRVs for Test Species											
Mammals	**NOAEL-based TRV:**	Test Species		Mouse	Mouse	Rat	Rat	Rat	Rat	Rat	Mink
		BW_{NOAEL}(kg wet)		0.03	0.03	0.435	0.35	0.303	0.35	0.15	1
		NOAEL (mg/kg wet/day)		98.0	0.126	5.1	0.66	1	3.28	0.2	11.7
	LOAEL-based TRV:	Test Species		Rat	Mouse	Rat	na	Rat	Rat	Rabbit	Mink
		BW_{LOAEL}(kg wet)		0.27	0.03	0.35	na	0.303	0.35	3	1
		LOAEL (mg/kg wet/day)		112.9	1.26	19.8	na	10	13.14	2	15.14
Birds	**NOAEL-based TRV:**	Test Species		Rat (see above)	Brown-headed cowbird	Chicken	Rat (see above)	Mallard	Black duck	Pek. Duckling	Chicken
		NOAEL (mg/kg wet/day)		9.8	2.5	21	0.066	1.5	1	2.37	47
	LOAEL-based TRV:	Test Species		Rat (see above)	Brown-headed cowbird	Chicken	na	Mallard	Black duck	Pek. Duckling	Chicken
		LOAEL (mg/kg wet/day)		11.29	7.4	42	na	20	5	4.74	62
TRVs for Wildlife Species		**Body Weight (kg wet)**	**TRV (mg/kg wet/day)**								
Mammals	Northern Red-backed Vole	0.02	NOAEL-based TRV:	108.5	0.1	11.0	1.3	2.0	6.7	0.3	31.1
	Northern Red-backed Vole	0.02	LOAEL-based TRV:	216.4	1.4	40.5	na	19.7	26.9	7.0	40.3
	Caribou	75	NOAEL-based TRV:	13.9	0.0	1.4	0.2	0.3	0.9	0.0	4.0
	Caribou	75	LOAEL-based TRV:	27.7	0.2	5.2	na	2.5	3.4	0.9	5.1
Birds	Lapland Longspur	0.023	NOAEL-based TRV:	9.8	2.5	21.0	0.1	1.5	1.0	2.4	47.0
	Lapland Longspur	0.023	LOAEL-based TRV:	11.3	7.4	42.0	na	20.0	5.0	4.7	61.7
	Canada Goose	2	NOAEL-based TRV:	9.8	2.5	21.0	0.1	1.5	1.0	2.4	47.0
	Canada Goose	2	LOAEL-based TRV:	11.3	7.4	42.0	na	20.0	5.0	4.7	61.7
	Semi-palmated Sandpiper	0.03	NOAEL-based TRV:	9.8	2.5	21.0	0.1	1.5	1.0	2.4	47.0
	Semi-palmated Sandpiper	0.03	LOAEL-based TRV:	11.3	7.4	42.0	na	20.0	5.0	4.7	61.7

Notes:

Based on Sample et al. (1996), the following allometric equation was used for interspecies extrapolations among mammals: $NOAEL_w = NOAEL_{ts} * (BW_{ts}/BW_w)^{0.25}$; the equation also applies to the LOAEL

Based on Sample et al. (1996), an allometric scaling factor of 1 was considered appropriate for interspecies extrapolations among birds

underline corresponds to an unbounded LOAEL (10X safety factor used to derive the NOAEL) (see text for details)

na indicates that there was no TRV (NOAEL or LOAEL) available

[1] Sample et al. (1996)

[2] Bird TRVs calculated by multiplying the mammal TRVs with a safety factor of 0.1 (see text for discussion)

[3] NOAEL from Dieter et al. (1991) as quoted in Lynch et al. (1999)

[4] LOAEL from Rossi et al. (1987)

[5] Mammals TRV based on chromium VI; bird TRV based on chromium III

[6] Ueberschar et al. (1986)

[7] Chetty et al. (1979) for mammal NOAEL TRV, Szakmary et al. (2001) for mammal LOAEL TRV, Van Vleet (1982) for bird TRVs.

[8] Ma and Pritsos (1997); uncertainty factor of 10 was applied to account for chronic exposure (Golder, 2004)

Parameter				Lead[1]	Manganese[1]	Total Hg	Inorg-Hg[1]	MeHg[1]	Molybdenum[1]	Nickel[1]	Selenium[1]	Strontium[1,2]
TRVs for Test Species												
Mammals	**NOAEL-based TRV:**	Test Species		Rat	Rat	na	Mink	Mink	Mouse	Rat	Rat	Rat
		BW_{NOAEL}(kg wet)		0.35	0.35	na	1	1	0.03	0.35	0.35	0.35
		NOAEL (mg/kg wet/day)		8	88	na	1	0.015	0.26	40	0.2	263
	LOAEL-based TRV:	Test Species		Rat	Rat	na	Mink	Mink	Mouse	Rat	Rat	na
		BW_{LOAEL}(kg wet)		0.35	0.35	na	1	1	0.03	0.35	0.35	na
		LOAEL (mg/kg wet/day)		80	284	na	na	0.025	2.6	80	0.33	na
Birds	**NOAEL-based TRV:**	Test Species		Japanese quail	Japanese quail	na	Japanese quail	Mallard	Chicken	Mallard	Mallard	Rat (see above)
		NOAEL (mg/kg wet/day)		1.13	977	na	0.45	0.0064	3.53	77.4	0.4	26.3
	LOAEL-based TRV:	Test Species		Japanese quail	na	na	Japanese quail	Mallard	Chicken	Mallard	Mallard	na
		LOAEL (mg/kg wet/day)		11.3	na	na	0.9	0.064	35.3	107	0.8	na
TRVs for Wildlife Species		**Body Weight (kg wet)**	**TRV (mg/kg wet/day)**									
Mammals	Northern Red-backed Vole	0.02	NOAEL-based TRV:	16.4	180.0	na	2.7	0.0	0.3	81.8	0.4	537.9
	Northern Red-backed Vole	0.02	LOAEL-based TRV:	163.6	580.9	na	na	0.1	2.9	163.6	0.7	na
	Caribou	75	NOAEL-based TRV:	2.1	23.0	na	0.3	0.0	0.0	10.5	0.1	68.7
	Caribou	75	LOAEL-based TRV:	20.9	74.2	na	na	0.0	0.4	20.9	0.1	na
Birds	Lapland Longspur	0.023	NOAEL-based TRV:	1.1	977.0	na	0.5	0.0	3.5	77.4	0.4	26.3
	Lapland Longspur	0.023	LOAEL-based TRV:	11.3	na	na	0.9	0.1	35.3	107.0	0.8	na
	Canada Goose	2	NOAEL-based TRV:	1.1	977.0	na	0.5	0.0	3.5	77.4	0.4	26.3
	Canada Goose	2	LOAEL-based TRV:	11.3	na	na	0.9	0.1	35.3	107.0	0.8	na
	Semi-palmated Sandpiper	0.03	NOAEL-based TRV:	1.1	977.0	na	0.5	0.0	3.5	77.4	0.4	26.3
	Semi-palmated Sandpiper	0.03	LOAEL-based TRV:	11.3	na	na	0.9	0.1	35.3	107.0	0.8	na

Notes:

Based on Sample et al. (1996), the following allometric equation was used for interspecies extrapolations among mammals: $NOAEL_w = NOAEL_{ts} * (BW_{ts}/BW_w)^{0.25}$; the equation also applies to the LOAEL
Based on Sample et al. (1996), an allometric scaling factor of 1 was considered appropriate for interspecies extrapolations among birds
underline corresponds to an unbounded LOAEL (10X safety factor used to derive the NOAEL) (see text for details)
na indicates that there was no TRV (NOAEL or LOAEL) available

[1] Sample et al. (1996)
[2] Bird TRVs calculated by multiplying the mammal TRVs with a safety factor of 0.1 (see text for discussion)
[3] NOAEL from Dieter et al. (1991) as quoted in Lynch et al. (1999)
[4] LOAEL from Rossi et al. (1987)
[5] Mammals TRV based on chromium VI; bird TRV based on chromium III
[6] Ueberschar et al. (1986)
[7] Chetty et al. (1979) for mammal NOAEL TRV, Szakmary et al. (2001) for mammal LOAEL TRV, Van Vleet (1982) for bird TRVs.
[8] Ma and Pritsos (1997); uncertainty factor of 10 was applied to account for chronic exposure (Golder, 2004)

Parameter			Thallium[1,6]	Tin[1]	Uranium[1]	Vanadium[1]	Zinc[1]	Cyanide[8]
TRVs for Test Species								
Mammals	**NOAEL-based TRV:**	Test Species	Rat	Mouse	Mouse	Rat	Rat	na
		BW_{NOAEL}(kg wet)	0.365	0.03	0.028	0.26	0.35	na
		NOAEL (mg/kg wet/day)	<u>0.0074</u>	23.4	3.07	<u>0.21</u>	160	na
	LOAEL-based TRV:	Test Species	Rat	Mouse	Mouse	Rat	Rat	na
		BW_{LOAEL}(kg wet)	0.365	0.03	0.028	0.26	0.35	na
		LOAEL (mg/kg wet/day)	0.074	35	6.13	2.1	320	na
Birds	**NOAEL-based TRV:**	Test Species	Chicken	Japanese quail	Black duck	Mallard	White leghorn hen	Mallard
		NOAEL (mg/kg wet/day)	0.202	6.8	16	11.4	14.5	na
	LOAEL-based TRV:	Test Species	Chicken	Japanese quail	Black duck	Mallard	White leghorn hen	Mallard
		LOAEL (mg/kg wet/day)	0.757	16.9	na	na	131	0.025
TRVs for Wildlife Species								
	Body Weight (kg wet)	**TRV (mg/kg wet/day)**						
Mammals Northern Red-backed Vole	0.02	NOAEL-based TRV:	0.0	25.9	3.3	0.4	327.2	na
Northern Red-backed Vole	0.02	LOAEL-based TRV:	0.2	38.7	6.7	4.0	654.5	na
Caribou	75	NOAEL-based TRV:	0.0	3.3	0.4	0.1	41.8	na
Caribou	75	LOAEL-based TRV:	0.0	4.9	0.9	0.5	83.6	na
Birds Lapland Longspur	0.023	NOAEL-based TRV:	0.2	6.8	16.0	11.4	14.5	na
Lapland Longspur	0.023	LOAEL-based TRV:	0.8	16.9	na	na	130.9	na
Canada Goose	2	NOAEL-based TRV:	0.2	6.8	16.0	11.4	14.5	na
Canada Goose	2	LOAEL-based TRV:	0.8	16.9	na	na	130.9	na
Semi-palmated Sandpiper	0.03	NOAEL-based TRV:	0.2	6.8	16.0	11.4	14.5	na
Semi-palmated Sandpiper	0.03	LOAEL-based TRV:	0.8	16.9	na	na	130.9	0.025

Notes:

Based on Sample et al. (1996), the following allometric equation was used for interspecies extrapolations among mammals: $NOAEL_w = NOAEL_{ts} * (BW_{ts}/BW_w)^{0.25}$; the equation also applies to the LOAEL

Based on Sample et al. (1996), an allometric scaling factor of 1 was considered appropriate for interspecies extrapolations among birds

<u>underline</u> corresponds to an unbounded LOAEL (10X safety factor used to derive the NOAEL) (see text for details)

na indicates that there was no TRV (NOAEL or LOAEL) available

[1] Sample et al. (1996)

[2] Bird TRVs calculated by multiplying the mammal TRVs with a safety factor of 0.1 (see text for discussion)

[3] NOAEL from Dieter et al. (1991) as quoted in Lynch et al. (1999)

[4] LOAEL from Rossi et al. (1987)

[5] Mammals TRV based on chromium VI; bird TRV based on chromium III

[6] Ueberschar et al. (1986)

[7] Chetty et al. (1979) for mammal NOAEL TRV, Szakmary et al. (2001) for mammal LOAEL TRV, Van Vleet (1982) for bird TRVs.

[8] Ma and Pritsos (1997); uncertainty factor of 10 was applied to account for chronic exposure (Golder, 2004)

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Appendix C

Standard Operation Procedure for Soil and Vegetation Sampling Based on Azimuth (2006)

Meadowbank Project - Standard Operating Procedure

Collection of soil and vegetation samples for the Screening Level Risk Assessment program (from Azimuth, 2006)

March, 2016

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1. Sample Locations

Three external reference (control) areas and eleven treatment areas are to be sampled. Control areas were selected northwest and west of the project area, upwind from mine related activities (C-1 to C-3). Treatment areas (main minesite, near-field, AWAR, Whale Tail Pit, Whale Tail Haul Road) were selected to represent wind distribution of contaminants from mining related activities (T-1 to T-11). Within each control and treatment area, five sample sites (S1 to S5) were selected within a 200 to 300 m radius, at least 150 m apart from one another. Within each sample site, composite tissue and soil samples are collected within a 10 to 30 m radius, depending on tissue (particularly berry) availability. UTM coordinates for each sample site are presented in Table 1.

Table 1. UTM coordinates for soil and vegetation sampling locations (NAD 83).

Sampling Area	Site #1	Site #2	Site #3	Site #4	Site #5
T1 – Main minesite	14W 0639238 7215692	14W 0639137 7215734	14W 0639061 7215668	14W 0639109 7215569	14W 0639010 7215459
T2 – Near-site	15W 0359410 7214020	15W 0359403 7214128	15W 0359507 7214072	15W 0359459 7213912	15W 0359391 7213816
T3 – Main minesite	14W 0640069 7212342	14W 0640146 7212421	14W 0639967 7212281	14W 0639976 7212409	14W 0639991 7212541
T4 – Near-site	14W 0640916 7210294	14W 0640994 7210201	14W 0641112 7210194	14W 0640890 7210137	14W 0640802 7210271
T5 – Near-site	14W 0637020 7211270	14W 0636978 7211160	14W 0637013 7211394	14W 0637162 7211419	14W 0637057 7211513
T6 – Main minesite	14W 0638559 7213995	14W 0638651 7213953	14W 0638780 7214028	14W 0638515 7214226	14W 0638400 7214038
T7 – Near-site	14W 0640847 7218280	14W 0640872 7218395	14W 0640755 7218444	14W 0640719 7218338	14W 0640788 7218177
T8 - AWAR	14W 0626884 7200614	14W 0626837 7200520	14W 0626806 7200427	14W 0626746 7200306	14W 0626675 7200224
T9 – Whale Tail Pit	TBD	TBD	TBD	TBD	TBD
T10 – Whale Tail Pit	TBD	TBD	TBD	TBD	TBD
T11 – Whale Tail Haul Road	TBD	TBD	TBD	TBD	TBD
T12 – TSF (sediment and water)	TBD	TBD	TBD	TBD	TBD
C1 – External Reference	14W 0623453 7211586	14W 0623450 7211467	14W 0623416 7211345	14W 0623339 7211252	14W 0623217 7211558
C2 – External Reference	14W 06255518 7221488	14W 0625569 7221607	14W 0625743 7221542	14W 0625790 7221388	14W 0625825 7221244
C3 – External Reference	14W 0624717 7222685	14W 0624818 7222623	14W 0624850 7222504	14W 0624861 7222349	14W 0624636 7222313

2. Soil Sample Collection

Soil samples will be collected using a composite sampling method at each sample site. Representative grab samples will be collected from five separate test pits per sample site (generally no greater than a 5.0 m^2 area) using a stainless steel ladle. First, the organic layer (which ranges from 0 to 5 cm below the surface) will be removed and discarded. Second, two small scoops of soil, approximately 5-10 cm below surface, will be placed in a pre-labeled Ziploc bag and homogenized. Decontamination (i.e., cleaning to prevent cross-contamination) of soil sampling equipment (i.e. stainless steel spoons) will be conducted at the beginning of each day, between treatment and control areas and between sample site locations. The cleaning procedures will include:

- Rinsing with site water to remove any remaining sediment or organic matter
- Scrubbing with brushes using Liquinox detergent
- A final rinse with site water

3. Tissue Sample Collection

Sedges and lichen samples will be collected in close proximity to the composite soil samples. Sedges will be collected from an approximate 5.0 m^2 area, near the center of the sample site, by randomly selecting and simply grabbing/ pulling representative sedge, periodically including the roots. Samples will be placed in a pre-labeled Ziploc bag. Similarly, lichen tissue samples will be collected by hand and placed in a pre-labeled Ziploc bag. Collection of lichen and sedge should continue until the Ziploc bag is full. Berry collection sites were selected along moderately dry, rolling hills where berries are the most abundant. Approximately 2 cups of berries should be collected per site. No species of berries, sedges and lichen should be sampled preferentially, as each treatment and control area has a different variety and abundance of vegetation.

4. Sample Handling, Documentation and Analyses

4.1 Field Book

During the field-sampling program a field book will be used to maintain a record of sample collection and observations, including:

- field staff
- descriptions of photos taken
- date and time
- weather conditions
- sample identifications
- tissue and soil sample characteristics
- # of samples taken
- sample locations, including GPS coordinates
- sample time
- notes and general observations

The field logbook is intended to provide sufficient information such that personnel may reconstruct events that occurred during the sampling period, without having to rely on field personnel or memory of the individuals.

4.2 Containers and Labeling

Samples will be collected in Ziploc bags for ease of sample collection and prevention of sample destruction and mixing during shipping:

- Soil samples – one (1) 950 mL (18cm x 20cm) Ziploc® bag per soil composite
- Tissue samples – one (1) 950 mL (18cm x 20cm) Ziploc® bag, per berries, sedge, and lichen sample
- Samples will be labeled with the following:
  - Site ID
  - Sample Date and Time
  - Sample ID
  - GPS Coordinates
  - Sample Type
  - Initials of Field Staff

Sample Identification (ID) will be coordinated to accommodate ease of organization and interpretation of analytical results. As an example, the ID for a Treatment Area 1, Site No. 2, Lichen tissue sample could be: T1 S2 Li.

4.3 Tracking, Preservation, Storage and Transportation

Tissue and soil samples will be recorded in the field book following sample collection at each sample site within each area. Chain-of-custody forms will be filled out for transport. Care will be taken to ensure that the sample identification is clearly marked on each bag. A small piece of paper with the sample ID, date and sample type may be placed in the sample bag. Samples will be placed on ice in coolers and shipped, along with the chain of custody records, to an accredited laboratory (typically ALS Laboratories in Vancouver, BC).

4.4 Laboratory Analysis

All soil and tissue analyses will be conducted by a CALA-accredited laboratory (typically ALS Environmental Laboratories in Vancouver, BC). The following laboratory analyses will be requested:

Soil – soil pH and total metals; and

Plant Tissue – Moisture content and total metals.

5. Quality Assurance/Quality Control (QA/QC)

The following recommended sample collection and handling techniques will be employed during collection of vegetation tissue and soil samples:

- Sampling by qualified personnel
- Prevention of foreign material in samples or loss of sample material
- Minimization of sample handling and use of new nitrile or latex gloves during sample collection
- Use of appropriate clean containers and proper storage of samples
- Collection of sufficient sample volumes as specified by the data quality objectives
- Adequate decontamination
- Use of appropriate packaging, ice and shipping methods to ensure that holding times and storage conditions are met.