# Executive Summary

## Purpose of the Risk Assessment

Elevated metals concentrations have been identified in tundra in areas surrounding the DeLong Mountain Regional Transportation System (DMTS), primarily as a result of deposition of fugitive dust originating from the DMTS corridor that is used to transport zinc and lead ore concentrates from the Red Dog Mine, which is operated by Teck Cominco Alaska Incorporated. The purpose of the DMTS fugitive dust risk assessment is to estimate possible risks to human and ecological receptors posed by exposure to metals in soil, water, sediments, and biota in areas surrounding the DMTS, and in areas surrounding the Red Dog Mine ambient air/solid waste permit boundary. The risk assessment is part of the overall process in which areas of fugitive dust deposition surrounding the DMTS are being evaluated (see the main text Section 1, *Introduction*, for a review of regulatory context). The results of the risk assessment provide a snapshot of risk under current conditions that will help risk managers to determine what additional actions may be necessary to reduce those risks now and in the future.

## What This Document Includes

This document presents a revised risk assessment for the DMTS and the area outside of the Red Dog Mine ambient air boundary. The major parts of the risk assessment document include the preliminary human health and ecological conceptual site models, which are presented and then refined based on the results of screening and selection of chemicals of potential concern (CoPCs). Human health and ecological risk calculations are then presented, the risk assessment results are summarized, and a brief discussion of risk management follows. Appendices to the document describe the Phase I and Phase II field programs conducted to provide data for the risk assessment, present data used in the assessment, as well as food-web model and results tables, and also include a chronology of dust control improvements to the DMTS and port operations.

## Document History and Public Involvement

This section provides an overview of the history of the risk assessment document, from the development of the conceptual site model, to the draft and final work plan, to the draft and final risk assessment documents.

**Conceptual Site Model—**A preliminary conceptual site model was included in the Fugitive Dust Background Document (DEC et al. 2002). DEC et al. (2002) also incorporated an appendix documenting specific comments and concerns voiced by village residents in the area of Red Dog Mine. An overview of the conceptual site model was presented to Kivalina and Noatak residents in June 2002. A revised conceptual site model was submitted to DEC in January 2003.

**Draft and Final Risk Assessment Work Plan—**A draft work plan was submitted to DEC in January 2003 (Exponent 2003b). Following submittal of the draft work plan, a public comment period was held in February 2003, and presentations were made to Kivalina and Noatak residents about the work plan. The revised work plan submitted in February 2004 incorporated revisions based on written and verbal comments and feedback (DEC 2003b) obtained during the public comment period from individuals (e.g., village residents), non-governmental organizations (e.g., Trustees for Alaska, NANA Regional Corporation [NANA]), and government agencies (e.g., DEC, Alaska Industrial Development and Export Authority, National Park Service [NPS]) on the January 2003 work plan. DEC provided comments on the February 2004 work plan in April 2004 (DEC 2004a), and the work plan was approved with response to comments in October 2004 (Exponent 2004b; DEC 2004b).

**Draft and Final Risk Assessment—**The draft DMTS risk assessment was issued to the DEC in April 2005 (Exponent 2005a). The draft document expanded upon the work presented in the risk assessment work plan (Exponent 2004b), using the framework established in that document, and incorporating revisions agreed to in the response to comments on the work plan (Exponent 2004b; DEC 2004b). After the draft risk assessment was issued to DEC in April 2005 (Exponent 2005a), a public comment period of 45 days followed. Upon closure of the public comment period for the draft DMTS risk assessment, comments had been received from DEC, U.S. Environmental Protection Agency (EPA), NPS, U.S. Geological Survey, NANA, Center for Science in Public Participation, and Alaska Community Action on Toxics. Comment response documents accompany this final risk assessment, and this document incorporates revisions based on the comment responses and comment resolution process conducted by DEC, as lead agency on the risk assessment.

## Human Health Risk Assessment Results

A site-specific human health risk assessment (Section 5) was conducted to evaluate exposure to DMTS-related metals through incidental soil ingestion, water ingestion, and subsistence food consumption under three scenarios: 1) child subsistence use, 2) adult subsistence use, and 3) combined worker/subsistence use. The estimated risks from each of the scenarios were within acceptable limits and are summarized below. Risks are necessarily expressed separately for lead and for the other (non-lead) metals because a different methodology is used to estimate lead exposure and risks, as described in Section 5.2.2.1.

### Child Subsistence Use

- Using EPA's integrated exposure uptake/biokinetic child lead model (U.S. EPA 1999b), with the model default soil lead bioavailability of 30 percent, the model predicted a geometric mean blood lead level of 1.2 $\mu$g/dL, with a less than 0.0005 percent chance of exceeding the target blood lead level of 10 $\mu$g/dL.

- Using the site-specific soil lead bioavailability of 9.7 percent, the model predicted a geometric mean blood lead level of 1.0 $\mu$g/dL, with a less than 0.0005 percent chance of exceeding the target blood lead level of 10 $\mu$g/dL.
- The cumulative hazard index from non-lead CoPCs was 0.3, well below the target hazard index of 1.0.
- Assuming a fractional intake from the site as high as 0.33 (which is 3.7 times the site fractional intake of 0.09), cumulative risks from non-lead CoPCs would not exceed the target hazard index of 1.0.
- The highest hazard index was 0.1 for cadmium exposure from caribou consumption. Assuming a fractional intake from the site as high as 0.95, caribou cadmium related risks would not exceed the target hazard index of 1.0.
- Assuming 100-percent intake from the site (fractional intake=1.0), no other single CoPC would have a risk exceeding the target hazard index of 1.0.

## Adult Subsistence Use

- For subsistence use, lead risks were evaluated only for children, but this would also be protective of adult exposure (see results for lead summarized above for child subsistence use).
- The cumulative hazard index from non-lead CoPCs was 0.1, well below the target hazard index of 1.0.
- Assuming a fractional intake from the site as high as 0.93, cumulative risks from non-lead CoPCs would not exceed the target hazard index of 1.0.
- Assuming 100-percent intake from the site (fractional intake=1.0), no single CoPC would have a risk exceeding the target hazard index of 1.0.

## Worker/Subsistence Use

- Using the adult lead model default soil lead bioavailability of 12 percent, the model predicted a geometric mean blood lead level in the fetuses of pregnant women of 1.9 $\mu$g/dL, with a 1.3 percent chance of exceeding the target blood lead level of 10 $\mu$g/dL.
- Using the site-specific soil lead bioavailability of 3.9 percent, the model predicted a geometric mean blood lead level in the fetuses of pregnant women of 1.6 $\mu$g/dL, with a 0.7 percent chance of exceeding the target blood lead level of 10 $\mu$g/dL.
- The cumulative hazard index from non-lead CoPCs was 0.08, well below the target hazard index of 1.0.

- Assuming 100-percent intake from the site (fractional intake=1.0), cumulative risk from non-lead CoPCs would not exceed the target hazard index of 1.0.

Overall, risks were well within acceptable public health limits. The results of the risk assessment, along with the results from the subsistence foods evaluations (Appendix H), suggest that risks associated with continued harvesting of subsistence foods from the site, including in unrestricted areas near the DMTS, are not significantly elevated. In addition, although harvesting remains off limits within the DMTS, human health risks were not elevated even when data from restricted areas were included in the risk estimates.

## Ecological Risk Assessment Results

A site-specific ecological risk assessment (Section 6) was conducted to evaluate risk to ecological receptors inhabiting terrestrial, freshwater stream and pond, coastal lagoon, and marine environments from exposure to DMTS-related metals. The risk conclusions for each habitat are summarized in the following sections.

### Terrestrial Environments

- Changes in vegetation community structure are observable within 100 m of the DMTS road and port facilities. These community shifts appear to be, in part, a result of physical and chemical influences of the road and their effect on hydrology, soil chemistry, and plant vitality. Physical and chemical stresses are commonly found associated with gravel roads in tundra environments. The importance of CoPCs in fugitive dust relative to physical stresses caused by the DMTS road in producing these changes could not be determined based on the data available at this time. However, physical factors are likely to exert their greatest influence near the road and facility areas where dust deposition is greatest and drainage may be locally altered, whereas chemical factors (e.g., elevated metals and pH) are likely to become relatively more important at greater distances from dust sources, but may also be significant near the road and port facility areas.

- Differences between reference plant communities and plant communities beyond 100 m from the DMTS road, specifically the 2- to 4.5-fold decrease in lichen cover at 1,000 to 2,000 m from the road, appear to be a result of fugitive dust deposition. Further study would be required to define the full nature and extent of lichen effects related to fugitive dust deposition from the DMTS port, road, and Red Dog Mine, and to identify the causative agent(s) of lichen decline.

- In port facility areas, particularly in the area immediately downwind of Concentrate Storage Building 1 (CSB1), the presence of stressed and dead vegetation appears to be primarily related to fugitive concentrate dust deposition.

- Herbivorous and insectivorous small mammals (e.g., voles and shrews) inhabiting tundra within 10–100 m of the DMTS road, near the port facilities, or near the mine's ambient air/solid waste boundary showed incremental risk from exposure to aluminum and barium. However, exposures decreased to no-effects levels or were comparable to reference exposures beyond 100 m from the road and 1,000 m from the mine's ambient air/solid waste boundary. Although elevated risks were predicted for aluminum and barium near the road, port, and mine, the actual potential for adverse effects is thought to be small given the highly conservative nature of the aluminum and barium toxicity reference values (TRVs) and low bioavailability of aluminum and barium at the site (Shock et al. 2007).

- Adverse effects to herbivorous birds (e.g., ptarmigan) from lead are possible near the port and mine. These effects, if occurring, could result in population-level effects in these areas. However, along the length of the road, the likelihood of adverse effects to herbivorous birds is low.

- For caribou, no adverse effects are predicted for the vast majority (>99.98 percent) of caribou that pass through the site only during migration. Caribou over-wintering near the mine have an estimated exposure to aluminum and barium that is 1.3 to 2.5 times the lowest-observed-adverse-effect levels. However, the actual potential for adverse effects to over-wintering caribou is thought to be small, given the highly conservative nature of the aluminum and barium TRVs and low bioavailability of aluminum and barium at the site (Shock et al. 2007).

- Population-level effects are considered unlikely for other terrestrial wildlife, including large-bodied mammalian herbivores (e.g., moose), avian invertivores (e.g., Lapland longspur and common snipe), and avian and mammalian carnivores (e.g., snowy owl and arctic fox), under current conditions.

## Freshwater Stream Environments

- Benthic macroinvertebrate drift assemblages indicated that the overall characteristics of the communities found in the site streams crossing the road were similar to those in reference streams.

- Fish monitoring studies have found no evidence of a road-related effect on metals concentrations in tissue of fish upstream and downstream of the DMTS in the Omikviorok River and Aufeis Creek. However, in Anxiety Ridge Creek near the mine, cadmium and lead concentrations in tissue of juvenile Dolly Varden were significantly higher in fish downstream from the haul road compared with upstream fish, and although the most conservative screening benchmarks for fish tissue were exceeded, concentrations were also within the range of no-effects values from the literature. Thus, adverse effects to fish populations are not predicted in the Omikviorok River and Aufeis Creek, but cannot be ruled out in Anxiety Ridge Creek.

- Metals concentrations in riparian area plants were generally within the range of reference concentrations and/or literature phytotoxicity thresholds. No indications of phytotoxicity were observed in plants at site streams, and plant health appeared similar at site and reference streams.

- The likelihood of adverse population-level effects to wildlife foraging in streams, including avian and mammalian herbivores (e.g., green-winged teal, muskrat, and moose) and avian invertivores (e.g., common snipe), is considered to be very low.

## Freshwater Pond Environments

- Adverse effects are not predicted in tundra ponds along the DMTS road, or at distances greater than 100 m from facilities. For these ponds, CoPC concentrations in sediment are not expected to be toxic to benthic macrofauna based on toxicity test data for coastal lagoons. Metals concentrations in plants were generally within the range of reference concentrations and/or below phytotoxicity thresholds, and food-web models indicate a very low likelihood of adverse population-level effects to herbivorous wildlife (e.g., green-winged teal and muskrat) and avian invertivores (e.g., common snipe).

- There is a potential for adverse effects to invertebrates and plants in ephemeral ponds located within 100 m of the concentrate conveyor and other port facilities, although no effects were observed during field sampling in those ponds.

## Coastal Lagoon Environments

- Sediment toxicity tests indicated no effects to benthic invertebrates in lagoons, even when exposed to elevated CoPC concentrations in sediments from locations nearest to port facilities.

- Plant community structure was similar at site and reference lagoons. Natural variability among and within lagoon plant communities likely accounts for the few differences that were observed. However, only fringing wetland vegetation was assessed for coastal lagoons, while plant communities with abundant lichen cover were assessed in the terrestrial coastal plain transects.

- The likelihood of adverse population-level effects to wildlife foraging in coastal lagoons, including herbivorous and invertivorous birds (e.g., brant and black-bellied plover), and mammalian herbivores (e.g., muskrat and moose), is considered to be very low.

- No fish were present in port site lagoons, as the lagoons have no open water connections to the Chukchi Sea, and they also freeze solid in the winter.

### Marine Environment

- No effects were predicted for receptors in the marine environment because the metals concentrations in sediment and water were below effects levels.

## Where We Are in the Process, and What Comes Next

Upon submittal of this revised risk assessment to DEC, the agency will issue a decision regarding acceptance of the risk assessment. Following completion of the risk assessment, a risk management plan will be developed to address the issues identified by this risk assessment, which are summarized above. The plan will include evaluation of risk management options within the general categories of institutional controls, engineering controls, monitoring, and remediation/restoration. The plan will identify the most appropriate combination of actions to achieve the overall goal of minimizing risk to human health and the environment surrounding the DMTS and outside the Red Dog Mine boundary over the life of the mine.[1] Development of the plan is anticipated to be a collaborative process involving DEC and other stakeholders throughout the process of identifying, defining, and refining objectives, and evaluating options and methods to achieve those objectives.

[1] Note that the mine closure and reclamation plan will address risk management within the mine boundary.