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Risk Assessment of Metals in Dust from Red Dog

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Introduction and background

Teck Cominco uses the DeLong Mountain Regional Transportation System (DMTS) road and port for transport of zinc and lead ore concentrate from Red Dog Mine to ships on the Chukchi Sea. The National Park Service (NPS) published a study in 2001, which found that concentrations of metals in tundra near the DMTS road were higher than these observed in outlying areas. Following the NPS discovery, Teck Cominco began studying the distribution of metals in the tundra environment surrounding the DMTS and mine (Figure 1), and also began preparation of a risk assessment.

This fact sheet defines risk assessment, describes the risk assessment process, and presents the results of the DMTS Fugitive Dust Risk Assessment. The risk assessment is a study to determine whether metals in dust found in the tundra within and around the DMTS port, the DMTS road, and outside the Red Dog Mine boundary are likely to have any effects on human health or the environment. The study includes both a human health risk assessment and an ecological risk assessment. The results of the risk assessment help managers decide what additional actions are needed to minimize risk to human health and the environment.

What is fugitive dust?

"Fugitive dust" is defined in the risk assessment as any dust or particulate matter that enters the environment from activities at the mine and port, and from transportation of ore concentrate along the road. Along the DMTS, fugitive dust may be ore concentrate, road dust, or a combination of both. Near the mine, fugitive dust may originate from various sources within the mine, including blasting in the pit, ore stockpiles, waste rock dumps, tailings pond sediments (historically), and road dust from truck traffic, which may also include some ore concentrate dust.

DMTS Fugitive Dust Risk Assessment

The DMTS fugitive dust risk assessment is available on the DEC website (http://www.dec.state.ak.us/spar/csp/sites/reddog.htm)

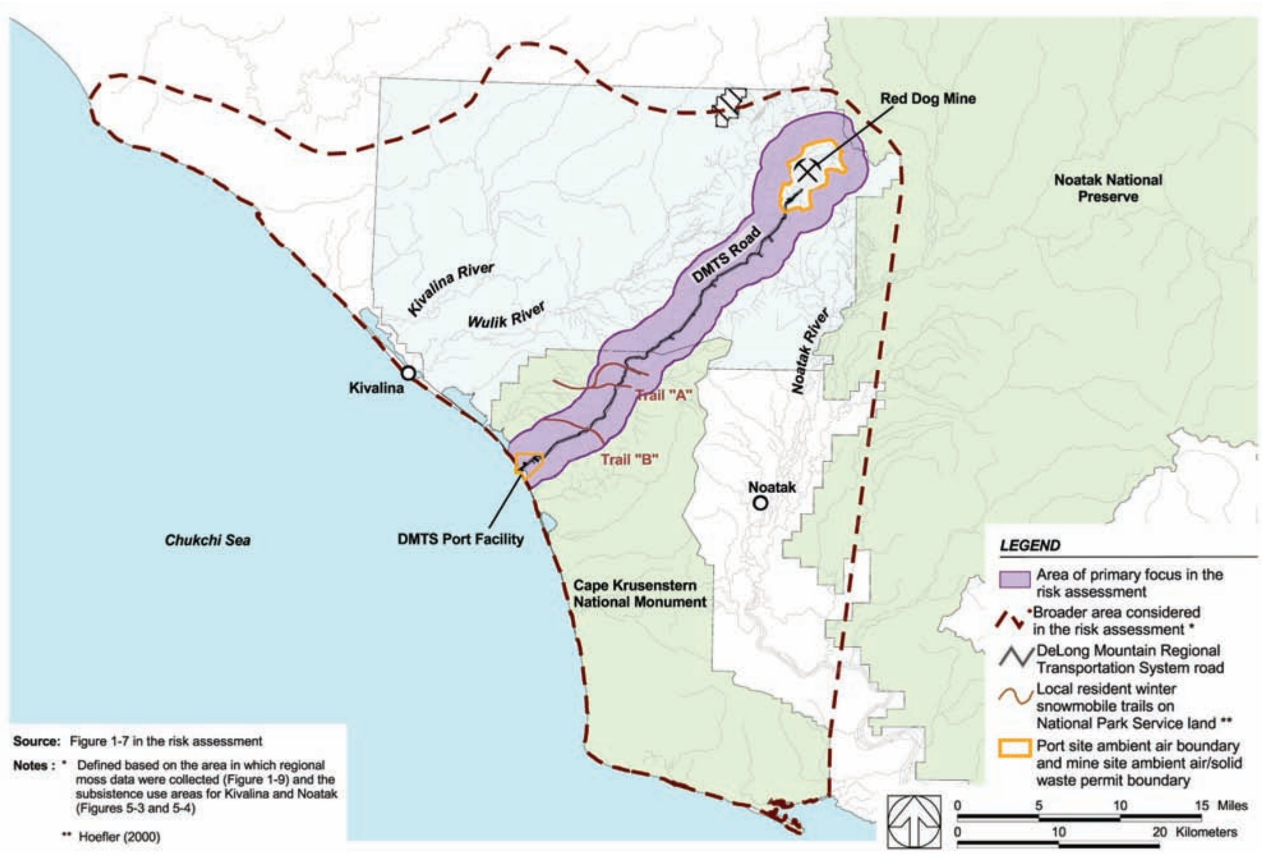

Figure 1. Risk assessment study areas and subsistence use areas

What is the DMTS?

The DeLong Mountain Regional Transportation System (DMTS) refers to the entire transportation corridor from the Red Dog Mine to the deepwater ships offshore. Thus, the DMTS includes the road, the port facilities, and the barges that transfer ore concentrates from the port to the ships offshore.

What is risk assessment?

Risk assessment evaluates the likelihood that adverse health effects may occur or are occurring as a result of exposure to one or more things that cause stress (stressors). Risk assessments use information on what we know about levels of toxic substances that have caused harm in other settings (toxicity assessment) and compare those levels to estimates of potential exposure in a setting of interest (exposure assessment) to estimate potential risks to health (risk characterization). Where there is uncertainty, the risk assessment process makes conservative (health protective) assumptions to help ensure the safety of those being evaluated. "Estimated risk" is a mathematical calculation of the possibility that harm could occur.

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For any risk to exist, exposure to stressors (such as chemicals) must be occurring. Risk assessment looks at what chemicals are present, where they are, who or what might be exposed (receptors), and how they might be exposed. This is done systematically by developing what is referred to as a conceptual site model, which uses a diagram or illustration to show chemical sources, exposure pathways, and receptors (people, plants, and animals).

How does risk assessment work?

In order to evaluate risk to receptors (such as people, plants, and animals) at Red Dog, the following questions needed to be studied:

- How much metal (for example, lead) is in the environment surrounding the DMTS and mine?
- How much metal is taken up/taken in by the receptors in the area? (exposure assessment)
- How much metal does it take to cause harm? (toxicity assessment)
- What is the potential for harm to receptors? (risk characterization)

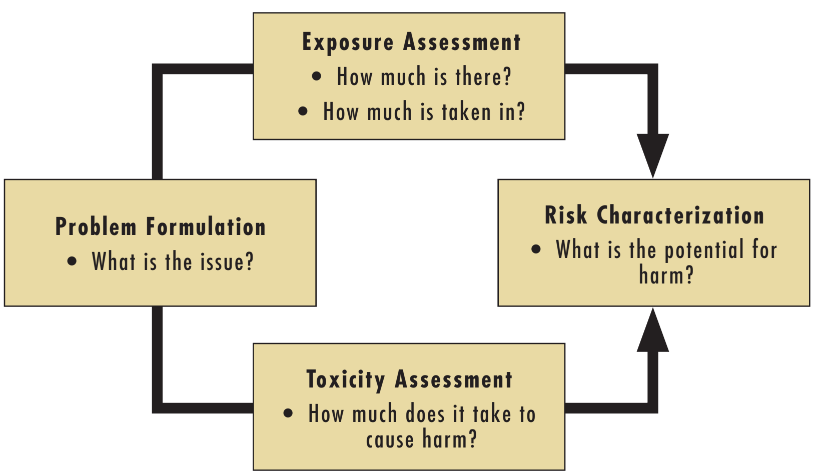

Figure 2. How does risk assessment work?

These questions follow from one to another, and together they help us understand the potential for harm to humans or the environment. The information about metal concentrations in the environment is put together with information about the amount of metal taken in by these human, plant, and animal receptors. To assess risks, estimates of potential exposure at the site are compared with concentrations at which harmful effects are expected to occur based on scientific studies (Figure 2).

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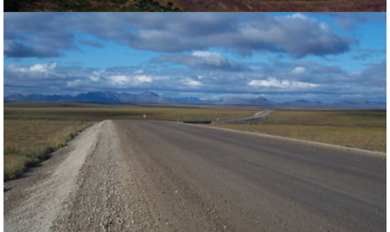
What can risk assessment do and what can't it do?

Risk assessment attempts to predict risks for groups (populations) of human or environmental receptors (such as plants and animals) based on their exposure to chemicals of concern.

Risk assessment cannot predict risk to individuals, because each person has their own behavior patterns relative to the factors being evaluated and also have other individual factors affecting their health. There are many issues that affect the health of individuals, which are not addressed by risk assessment, for example: genetics, smoking, diet and nutrition, exercise, exposures other than those specifically being evaluated (for example, in the case of lead, making lead bullets, and the presence of lead paint in the home), and the particular risks and hazards related to life in the Arctic.



Why do a risk assessment?

Ore concentrates (ground-up ore/rock) that are trucked from Red Dog Mine along the DMTS road have escaped into the environment over time, and there were concerns that metals within the ore concentrates may have affected subsistence foods and the environment. A risk assessment is a way to evaluate whether harm could occur as a result of these metals being present. The Alaska Department of Environmental Conservation (DEC) and the U.S. Environmental Protection Agency (EPA) use risk estimates to evaluate what needs to be done to protect public health and the environment.

How was this study conducted?

The study was conducted using standard, widely-used risk assessment methods. The risk assessment follows State of Alaska guidance, which is based on EPA guidance for risk assessment. The guidance defines a process in which documents are prepared for agency review and public comment (including a draft risk assessment work plan and draft risk assessment). DEC was the lead agency that oversaw the work.

The general steps of the risk assessment process are described below, including preparation of a conceptual site model, identification of the list of metals to be studied, the list of types of people, plants, and animals (receptors) to be studied, collection of data for the risk assessment, and then the steps of the evaluation shown in Figure 2.

What is a conceptual site model?

In planning the risk assessment, a conceptual site model was prepared to look at sources of metals and to show the ways in which plants, animals, and people (receptors) might be exposed to these metals (Figure 3). In the conceptual site model, the primary sources of metals were identified as the port, road, and mine. Metals dust from these sources are transported into the environment primarily by wind carrying the dust particles onto tundra, streams, ponds, lagoons, and the Chukchi Sea. In these environments, metals from dust may be taken up into plants such as moss, lichen, willow, or berries, and into animals such as caribou, ptarmigan, and fish, some of which may be eaten by people as subsistence foods, or which may be eaten by other animals.

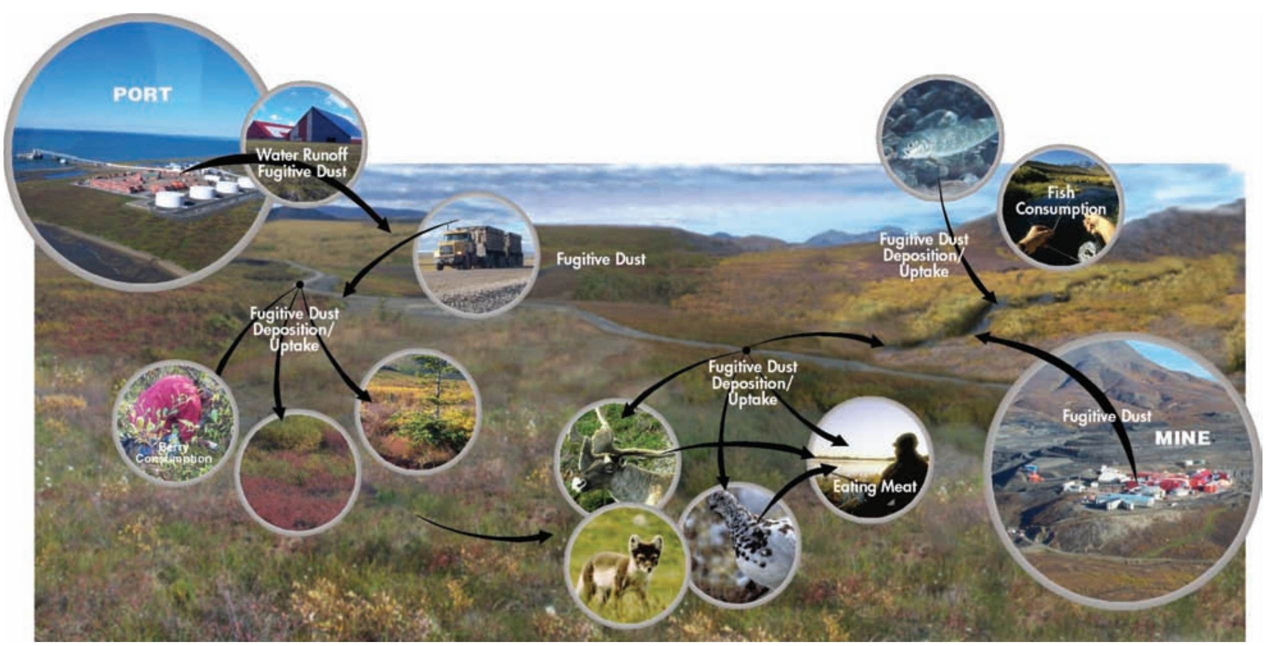


Figure 3. Conceptual site model

Which metals were evaluated?

The metals found in lead and zinc ore concentrates provided a starting point for the assessment. This list of metals was then shortened by comparing metal concentrations in site samples against protective state and federal standards or values, and against background concentrations to identify those metals that are higher in concentration. The list of metals that was studied for the human health risk assessment included antimony, barium, cadmium, lead, thallium, and zinc. The list of metals that was studied for the ecological risk assessment included aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, lead, mercury, molybdenum, selenium, thallium, vanadium, and zinc.

What groups of people were studied?

Several groups of people (human receptors) were identified that might be exposed to metals at the site based on their lifestyle and activities. These included children, adults, and adults who also work at Red Dog. The types of activities evaluated included eating subsistence foods, drinking water from streams, and being in contact with dust and soil. Combining lifestyle and activities resulted in three types of human receptors that were studied:

- Children who live in Kivalina or Noatak and eat subsistence foods from the area (child subsistence user)
- Adults who live in Kivalina or Noatak and eat subsistence foods from the area (adult subsistence user)
- Workers along the DMTS road who also live in a local village and eat subsistence foods from the area (worker subsistence user)

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What types of plants and animals were studied?

Because there are so many types of plant and animals (ecological receptors) that could be studied, receptors were selected to represent different categories, such as those that live in different environments, or eat different types of food. The receptors selected for the ecological risk assessment are listed below.

- Plant communities in land (terrestrial) and water (aquatic) environments
- Water insects (aquatic invertebrates)
- Fish
- Birds and mammals that live in various land (terrestrial) and water (aquatic) environments, and which eat various plants (herbivores), insects (invertivores), and animals (carnivores), were studied:
  - Caribou (herbivore)
  - Moose (terrestrial and aquatic herbivore)
  - Willow ptarmigan (herbivore)
  - Arctic fox (carnivore)
  - Snowy owl (carnivore)
  - Lapland longspur (invertivore)
  - Common snipe (aquatic invertivore)
  - Green-winged teal (aquatic herbivore)
  - Muskrat (aquatic herbivore)
  - Black-bellied plover (lagoon aquatic invertivore)
  - Tundra vole (herbivore)
  - Tundra shrew (invertivore)

What types of data were collected?

The conceptual site model helped identify which plants, animals, and people (receptors) are potentially exposed to metals. In order to evaluate the exposure of these various receptors, sampling programs were designed to collect data needed to answer the question:

- How much metal (for example, lead) is in the environment within and around the DMTS, and outside the mine?

Data were collected in the marine, lagoon, stream, pond, and tundra environments surrounding the port, road, and mine. Some data were collected for use in the human health risk assessment, some were collected for use in the ecological risk assessment, and some were collected for use in both. Samples of soil, water, sediment, and plant and animal tissues were collected from these environments and analyzed to determine metals concentrations. The foods eaten by the representative receptors were identified so that samples of those foods could also be collected to determine metals concentrations. Thus, the sampling included moss, lichen, willow, birch, sedge grasses, insects in land and water environments, and shrews and voles.

Subsistence foods that were evaluated in the human health risk assessment included caribou, ptarmigan, fish, salmonberry, and sourdock. These foods were chosen to represent different types of subsistence foods, and also because they were foods that could be collected close to the port, road, and mine areas being studied. Caribou were studied early in the assessment and found not to have elevated metals.

What types of subsistence foods were studied?

- Caribou
- Ptarmigan
- Fish
- Salmonberry
- Sourdock

Data were also collected to evaluate the health of plant and insect communities. Plant communities were evaluated in land (terrestrial) and water (aquatic) environments, including coastal plain and tundra, hillslope, stream and pond, and coastal lagoon communities. These plant communities were studied to determine whether there were any effects on community structure (for example, species diversity and abundance) and health of species within the communities, at different distances from the port, road, and mine. Insect communities were evaluated in streams and lagoons. Samples of the aquatic insect community were collected from streams to determine their diversity and abundance in comparison to similar streams offsite. Sediment (bottom mud) samples from the lagoons were collected for laboratory testing with insects to determine if the sediment could affect the health of lagoon insects.

Where are the higher concentrations of metals found in the environment?

Although metals are found everywhere in the earth's crust and metals are generally higher in the mining region surrounding the DMTS, this evaluation included extensive sampling of soil, water, plants, and animals to determine where concentrations are higher than the levels typically found in areas without a known source (background or reference locations).

Metals concentrations were highest in soils within the mine and port sites, and less so along the road. In the tundra, samples of moss also showed that concentrations are highest near the mine and port, and along the road. Concentrations decrease with distance away from these dust sources, with the highest concentrations to the north and west of the port, road, and mine, which is the downwind direction (Figure 4).

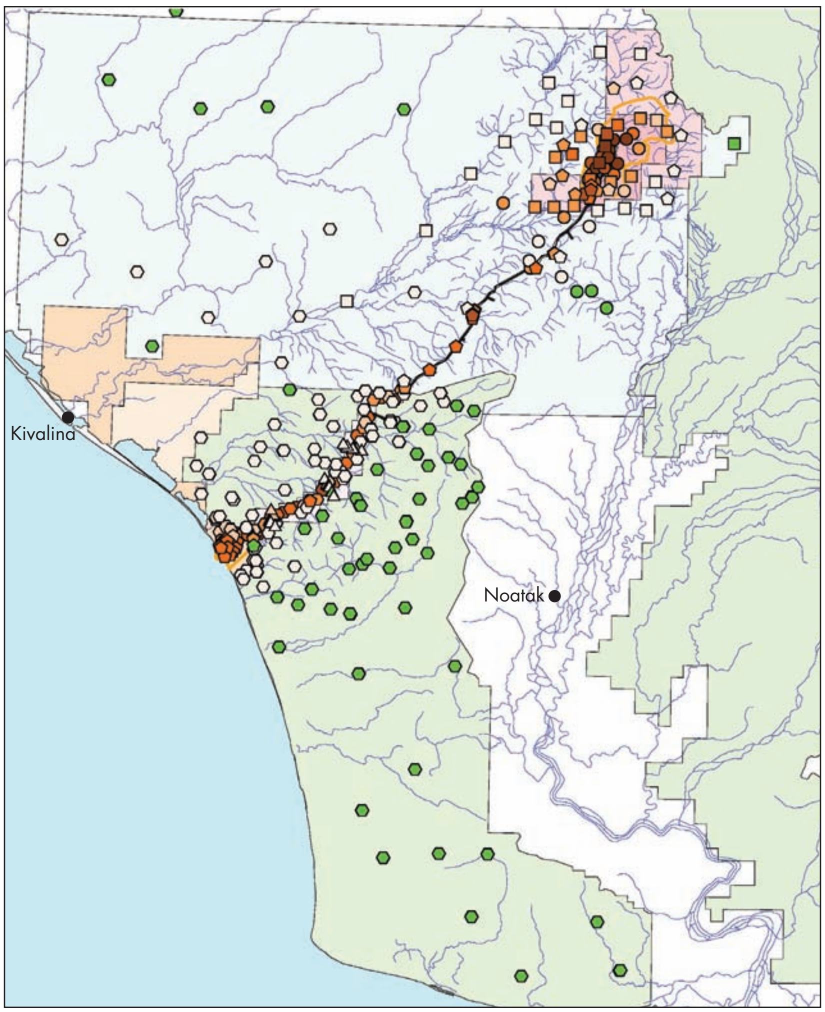
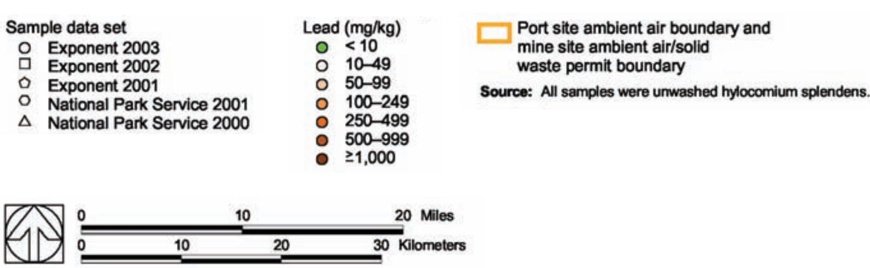


Figure 4. Lead concentrations in moss samples

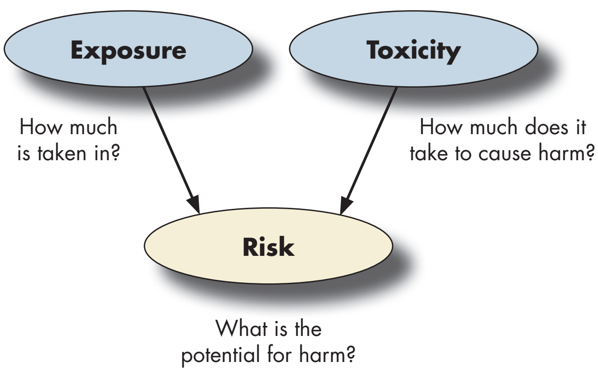


How much metal is taken in by the receptors?

The human health portion of the risk assessment studied the potential for metals to be taken in by children, adults, and adult workers (the receptors). People were assumed to come into contact with the metals through eating subsistence foods, drinking water from streams, or coming into contact with dust and soil. How much metal ends up in a person is calculated based on their exposure to the metals through their activities and how much subsistence food they eat from the area. For example, the amount of lead that a child takes in from eating ptarmigan will differ from an adult because children typically eat smaller portions.

For animals, the amount of metal taken in depends on the amount of soil and types of food they eat within the study area.

Risk Characterization



How much metal does it take to cause harm?

It is the amount of a chemical that a person gets into the body (the dose) that determines whether something is harmful, and how harmful. Metals are present naturally in the environment. Humans, animals, and plants have evolved with metals present, and have ways to cope with them at concentrations that typically occur in the environment. Some metals are required for good health (for example, zinc and iron). However, metals can cause harm when receptors take in high enough doses into the body. Information about what doses can cause harm is typically based on studies of people who were exposed accidentally, or based on studies with animals. Those studies are called toxicity studies. This information is used to determine what level of exposure could cause harm.

How was risk to people and animals estimated?

For Metals Other Than Lead: Estimates of the amount of metal taken up by various receptors (exposure estimates) are compared with how much metal it takes to cause harm (toxicity values) to determine the potential for harm to occur (risk). If the exposure estimate is less than the toxicity level, the risk is considered to be low.

Exposure Estimate < Toxicity Value = Acceptable Risk

For Lead: Lead toxicity was evaluated differently for people than toxicity from other metals because we know more about how lead moves throughout the body than we know about other metals. It was evaluated by using EPA models to estimate the amount of lead in blood that could result from exposure to lead in the environment in the study area.

Are there any health concerns for people? Are the subsistence foods safe to eat?

Overall, the results of the human health risk assessment showed that:

- It is safe to continue harvesting subsistence foods in all areas without restrictions.
- Although harvesting remains off limits within the DMTS, human health risks were not elevated even when data from restricted areas was included in the risk estimates.

Are there any effects on plants or animals?

The ecological risk assessment found that:

- In most cases, the potential for harmful effects to occur in the environments surrounding the road, port, and mine was considered to be low.
- No harmful effects were observed or predicted in the marine, coastal lagoon, freshwater stream, and tundra pond environments, although the potential for effects to invertebrates and plants could not be ruled out for some small, shallow ponds found close to facilities within the port site. However, no effects were observed in these port site ponds during field sampling.
- In the tundra environment, changes in plant community composition (for example, decreased lichen cover) were observed near the road, port, and mine, although it is not clear to what extent those effects may be a result of metals from fugitive dust or other chemical and physical effects typical of dust from gravel roads in Alaska.
- The likelihood of risk to populations of animals was considered low, with the exception that risks related to lead were predicted for ptarmigan living closest to the port and mine, which may affect ptarmigan populations in those localized areas.

How was the community involved in the process?

Community input was helpful in focusing the risk assessment and incorporating local knowledge on subsistence foods and wildlife occurrence and migration patterns. Information from the communities that was used in the risk assessment was gained in several ways:

- Historical surveys of subsistence use
- Public meetings and workshops
- Review and comments on draft documents, including the draft work plan, and the draft risk assessment.

Chronology of the DMTS risk assessment and public involvement

2001	
	Initial site characterization work performed
2002	
May	Fugitive Dust Background Document completed, including preliminary CSM, and appendix of public comments and concerns
June	Discussion of CSM in Kivalina and Noatak meetings
June–August	Additional site characterization work performed
2003	
January	Revised CSM submitted and subsequently approved by DEC Draft RA work plan submitted to DEC
February	Village meetings held Public review and comment period
February/March	Preliminary comments obtained on RA work plan (from village meetings and written submittals)
Summer	Phase I of RA data collection program completed
November	Final comments on RA work plan provided by DEC
2004	
February 3	Revised RA work plan submitted to DEC Response to comments submitted to DEC
February	Comment responsiveness summary distributed by DEC
April 16	Draft Phase II sampling plan submitted to DEC Sampling plan revised and approved June 2, 2004
June–September	Phase II of RA data collection program conducted (biota sampling)
2005	
April 8	Draft RA submitted to DEC
April 12–July 11	Public comment period on draft assessment
April	Multiple meetings held to present draft results (Subsistence Committee, Kivalina, Noatak, Kotzebue, Anchorage)
Sept 9	DEC provides formal comments on RA
November 2005– October 2007	Multiple comment response submittals, follow-up responses, and comment resolution discussions with DEC
2007	
November	Final RA submitted to DEC

Notes: CSM—conceptual site model
DEC—Alaska Department of Environmental Conservation
DMTS—DeLong Mountain Regional Transportation System
RA—risk assessment

Who provided technical review of the work?

DEC was the lead agency, and provided technical review of the work, with the assistance of their contractors. DEC coordinated public review of the draft work plan and draft risk assessment, including collecting comments on the documents and making sure that technical issues were addressed in comment responses and revisions to the risk assessment and related documents. The final risk assessment incorporates revisions based on written and verbal comments and feedback received over the course of the risk assessment from individuals including village residents; non-governmental organizations including Trustees for Alaska, NANA Regional Corporation, Center for Science in Public Participation, and Alaska Community Action on Toxics; and government agencies including DEC, Alaska Industrial Development and Export Authority, National Park Service, U.S. Environmental Protection Agency, and the U.S Geological Survey.

Next step—risk management plan development

The results of the risk assessment provide an understanding of risk under current conditions and will help risk managers determine what additional actions may be necessary to reduce those risks now and in the future. A risk management plan will be developed to address the issues identified by this risk assessment. 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. The risk management plan will build upon ongoing efforts by Teck Cominco to reduce dust emissions, including the use of newer trucks, installation of truck washing facilities, and significant upgrades to unloading, storage, transfer, bargeloading, and shiploading facilities.

Prepared by Exponent® for Teck Cominco Alaska Incorporated,
November 2007