Response to Alaska Community Action on Toxics (ACAT) Comments (dated 11 July 2005) on the April 2005 Draft DMTS Fugitive Dust Risk Assessment

No.	Comment	Priority	Recommendation	Response	DEC Remarks
ACAT -1	• **Important contaminants are not addressed** None of the elements tested as CoPCs were speciated (e.g. chromium or mercury). Elemental forms and speciations should be examined as separate analytes (for example in Table 3-3). It is especially important to assess the most toxic forms of compounds for presence and effects. For example, this risk assessment does not speciate mercury, nor does it present testing methods and results for inorganic and methyl mercury. As discussed in Peplow (2005), mercury is extremely toxic and is ubiquitous in the environment. It is imperative that this risk assessment examine the environmental and human health effects of mercury in all of its forms.	Medium	Please respond to the issue of the metal speciation. Please ensure that the revised ERA clearly indicates that mercury was conservatively evaluated as methylmercury and that chromium was conservatively evaluated as hexavalent chromium so that ecological risks from these metals would not be underestimated.	Total metals concentrations were measured for use in the risk assessment. The ERA used the most conservative (lowest) toxicity reference values (TRVs) of those available for different forms of the metals. In other words, the total metals concentration was treated as if it was present in the most toxic form. Also, the TRVs are generally developed from animal studies that used more bioavailable forms of metals than those actually present at the site. In addition, 100% bioavailability was assumed in the ERA. The ERA text has been revised to indicate that mercury and chromium were conservatively evaluated as their most toxic forms.	Response is acceptable.
ACAT -2	• **Metals are bioavailable in the environment, and thus their risk is underestimated** The risk assessment does not refer to or acknowledge recent scientific advancements in understanding metal bioavailability. Dr. Peplow discusses several natural biological and chemical processes that result in metals being more bioavailable in the environment than the risk assessment discloses. ACAT (May 2004) also presents a lot of information on bioavailability of lead that has not been acknowledged, discussed, nor incorporated into risk characterizations by Exponent. Standard methods to predict mineral speciation, the solubility of oxidized metals, and solubility products using Eh-pH stability diagrams were not used. Similarly, sequential extraction techniques to characterize the relative concentrations of the different forms of the metal compounds and the potential bioavailability were not used.	Medium	Please respond to the concern that there is continued research on metal bioavailability. Please acknowledge that the risk assessment used both a site-specific bioavailability and the EPA default bioavailability.	Bioavailability was assumed to be 100% for all metals in the ERA (Section 6.6.3.1.6.) and HHRA, with the exception of lead in the HHRA, for which site-specific bioavailability data are used for comparison with EPA default values. Please see Sections 5.2.2.1, 5.4.1.1, and 5.4.2.1 for discussion of bioavailability in the HHRA.	Response is acceptable.
ACAT -3	• **The effects of metal mixtures on toxicity and bioavailability were not considered** All sampling sites (terrestrial and aquatic) showed the presence of several heavy metals in combination. Scientific literature has documented that the toxicity of heavy metals interact in a number of ways. Metal mixtures can affect bioavailability and bioaccumulation. Youn-Joo et al. (2004) found that "Binary metal combinations of copper and cadmium, copper and lead, and cadmium and lead produced three types of interactions: concentration additive, synergistic, and antagonistic. …bioaccumulation of one metal was	Medium	Please address the issue in the uncertainty section that there is not quantitative data to evaluate the additive, synergistic, and antagonistic effects of multiple chemicals and that exposure to multiple chemicals was assumed to be additive, consistent with DEC and EPA guidance.	Although it is possible that interactions between combinations of metals could result in differences in bioavailability and/or toxicity relative to individual metal exposures, these potential interactions are poorly characterized, at best. Furthermore, the effect of the interaction could be positive or negative. For example, zinc can reverse cadmium-induced toxicity (Peraza et al. 1998). According to EPA guidance, cumulative risk assessment should consider the combined health effects of a group of chemicals with a common mechanism of action, defined as two or more chemicals "that produce an adverse effect(s) to human health by the same, or essentially the same, sequence of major biochemical events. The underlying basis of the toxicity is the same, or essentially the same, for each chemical" (US EPA 1998). Thus, risks from multiple chemicals should only be summed if those chemicals operate through the same mechanism. DEC (2002) guidance provides the same direction, indicating that cumulative risk should be addressed by calculating a hazard index (HI), where "HI is the summation of all of the [Hazard Quotients] for all	Response is acceptable.

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	influenced by the presence of other metals in metal mixtures." These complex interactions increase the risk of toxicity to receptor species and organs. Although these interactions have not been quantified and captured in water and sediment quality criteria, their contribution to the overall environmental and human health toxicity must be acknowledged in the risk evaluation.			pathways and exposure routes that affect the same target organ or system endpoint." Nevertheless, as a conservative measure the HHRA presented cumulative HIs combining HQs from all chemicals and all pathways, regardless of the lack of shared toxicological endpoints. Bioavailability was conservatively assumed to be 100 % for all metals in both the HHRA and the ERA, with the exception of lead in the HHRA. For human exposure to lead, risks were evaluated assuming both the conservative default value recommended by EPA where site-specific information is not available, and the site-specific value determined for Red Dog concentrate. The modeling technique used in the ERA evaluates each chemical individually, because the TRVs used for evaluating the ecological significance of exposure are also chemical-specific. Chemical-specific HQs calculated by this method permit identification of specific chemicals that may cause adverse effects in ecological receptors. Simultaneous exposure to multiple chemicals could produce cumulative effects greater than the effects predicted for individual chemicals. However, to determine this requires a detailed understanding of mode of action and target organ for each chemical in each receptor. Simple approaches such as summation of individual HQs to calculate an HI are sometimes used to estimate cumulative effects; however, this assumes effects are additive, which may not be true based on the chemical-specific modes of action, and may be an overly conservative approach if some metals act antagonistically. Please refer to Sections 6.6.3.2 and 6.6.4.3. *Peraza et al. 1998. Effects of micronutrients on metal toxicity. Environ Health Perspect. 106 Suppl 1:203-16.*	
ACAT -4	• **Reference areas are not appropriately chosen** Sites should be located farther away from the DMTS, in a geographically separate area. There is discussion of the separation provided by a mountain range south of the haul road in the 2004 NPS survey. Further, the location of reference sites should not be based on their situation on the "prevailing upwind" side of the road. Winds don't always blow from the south, especially in the summer (TCAK 2005, figures 8 and 9) when fugitive dust is not captured within the snowpack, and so is at its most mobile. Also, trends in wind direction vary greatly from year to year (personal communication Colleen Swann to Amy Crook, June 14, 2005). Thus these "upwind" sites aren't references, but could and should be subjects of another study, a comparison between north and south transects along the haul road.	High	Please respond to the adequacy of their proposed reference sites.	Particulates are likely to be most mobile during winter, when wind speeds are greatest, and particulate generation may be greatest during the winter as well, when the air has the lowest moisture content, and watering cannot be used on roads. Wind speeds are much lower during the summer, and the uneven surfaces of tundra vegetation are more apt to capture particulates, further limiting particle travel distance during the summer. Additional figures and discussion of the NPS/Hasselbach data have been added in Section 1 describing nature and extent of fugitive dust deposition. The composite map of moss data referenced therein best illustrates the temporally averaged depositional patterns around the mine, road, and port. The uncertainty assessment in Section 6.6.1 has been updated with additional discussion regarding selection of reference areas, uncertainties associated with the reference area data, and their use in the assessment (including implications for CoPC selection). The revised Section 6.6.1 (Uncertainties Related to Reference Area Selection) is included below: *This section describes the selection and use of the reference areas in the risk assessment, reviews uncertainties about the reference area data, and discusses implications of these uncertainties for the use of the reference area data and the findings of the risk assessment.*	Response is acceptable.

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				Terrestrial Reference Area *Terrestrial reference areas were selected after review of existing studies and data, with a focus on factors such as prevailing wind directions, bedrock geology, topography and physiography (including slope, aspect, and water features such as streams and tundra ponds), and plant and animal communities. Possible reference areas were considered to the east, north, west, and south of the mine and DMTS. The prevailing wind originates from the east, between the northeast and southeast quadrants; thus, the most significant dust deposition has occurred to the north and west of the DMTS road and mine. As a result, areas to the north and west were not preferred areas for establishing the terrestrial reference area. Areas to the east were eliminated because the topography is more mountainous than most of the DMTS area. Thus, the focus was on selecting an area to the south of the mine and DMTS road. However, selecting an area too far south would have put the reference area into the Noatak valley, where the plant community includes trees and would not be as good for comparison with plant communities at the site. Therefore, the terrestrial reference area was targeted for placement somewhere within several miles south of the DMTS. Within that band south of the DMTS, the selected area was to be in a geologic area known to be relatively free of lead/zinc base metal mineralization. The selected area also needed to contain a variety of topographic conditions (elevations, slopes, and aspects), streams and ponds, and plant communities, providing the opportunity to sample environments similar to those along the length of the DMTS road. Based on these criteria, the Evaingiknuk Creek drainage was selected as the best choice. This basin met the most criteria, and had low base metal mineralization compared with other possible reference locations that were considered to the south of the DMTS.* *Subsequent to the selection of the Evaingiknuk Creek drainage as the terrestrial reference area, sampling was conducted in two phases. The first phase included sampling of moss, which, when included with the overall moss database (including the NPS data, Ford and Hasselbach 2001, Hasselbach 2003b, pers. com., Hasselbach et al. 2005) and plotted together, provided a clearer perspective on overall patterns of deposition in the areas surrounding the DMTS and mine (Figure 1-9). Prior to the first phase of sampling, no moss data were available in that area.* *The mean lead concentration for the three moss samples in the reference area is 8.0 mg/kg. Tundra soil was also sampled in the reference area, and the lead concentration ranged from 2.9 to 23.3 mg/kg, with a mean of 8.9 mg/kg, very similar to the mean moss lead concentration. In the area beyond approximately 16 miles north of the DMTS, where there is no apparent trend in the NPS moss concentration data, the mean lead concentration in moss is 8.5 mg/kg, or 6.4 if one outlier duplicate sample is excluded (Dixon's outlier test was used to confirm that the 38.6 ppm lead result is a statistical outlier at the 0.05 level [0.02 < P < 0.05]). The concentrations in the reference area and the area beyond 16 miles north of the DMTS appear to be similar. In the southern extent of Cape Krusenstern National Monument (CAKR), beyond 12 to 13 miles south of the DMTS, the NPS moss lead concentrations average 2.0 mg/kg. It should also be noted that the area surrounding the Red Dog*	

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				district is more mineralized than the southern part of CAKR. If there were dust depositional influence in the reference area, or the northern extent of the data collection area, it would appear to be very limited. *The communities in the reference area appear to be healthy, unimpaired communities suitable for use in reference/site comparisons. Even if there were some evidence suggesting low-level deposition in the reference area, the potential for this dust deposition to cause adverse effects to receptors is minimal. The metals concentrations in moss and lichens were very low; copper and zinc concentrations were far below effects levels reported in the literature (e.g., see Tables CK1 and CK2 for moss and lichen comparisons with threshold values). Furthermore, in almost every case, metals concentrations in terrestrial sedge and shrub samples were below phytotoxicity thresholds, even though samples consisted of unwashed tissues (Tables 6-17 and 6-18). Lead and zinc exposures for all wildlife receptors were uniformly low and never exceeded toxicity reference values (TRVs) in the terrestrial reference area. Hazard quotients did exceed 1.0 for some receptors in the reference area, particularly for aluminum and barium, although as discussed in the risk assessment, this appears to be a function of the conservative nature of the TRVs for these metals rather than their concentrations in reference area media. For example, aluminum concentrations in reference area moss were similar to or less than concentrations in the southern extent of the CAKR, many miles further away in a prevailing upwind direction from the DMTS. This would suggest a similar level of risk would be predicted from aluminum in south CAKR. However, because south CAKR is well beyond the potential influence of the DMTS, it just illustrates the overly conservative nature of the aluminum TRV.* ***Coastal Plain Reference Area*** *In the second phase of sampling, a plant community assessment was conducted, and in order to better match the coastal plain plant community at the port, an additional reference area was selected south of the port in the CAKR (sample station TS-REF-12). Although moss was not collected at this location, tundra soil had a lead concentration of 5.8 mg/kg, slightly lower than the 8.9 mg/kg concentration in the terrestrial reference area.* ***Reference Lagoons*** *The reference lagoons included the Control Lagoon, approximately 2 miles south of the port, and an unnamed lagoon approximately 5 miles south of the port. The Control Lagoon was established as a reference in early port site studies (ENSR 1990), and the unnamed "Reference" lagoon was added during the first phase of the risk assessment sampling efforts (Exponent 2003e). At these distances, any depositional influence would be small, given prevailing wind directions. Mean sediment concentrations (from the 2003 and 2004 sampling events) in the two lagoons at different distances from the site are almost identical, with lead 9.6 and 9.5 mg/kg, zinc 86.6 and 86.9 mg/kg, and cadmium 0.2 and 0.3 mg/kg in the Control and Reference lagoons, respectively.*	

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				Marine Reference Area *The marine reference area is located approximately 3 miles to the south of the port. Sediment samples were collected there during several marine sampling events. Even if there were any depositional influence this far south, the influence would be very slight, and would likely be largely dissipated by dynamic ocean action, including wind, waves, and prevailing northward currents. Regardless of whether there is any detectable influence at the marine reference area, site sediment data from recent sampling events have been below all available screening thresholds, as described in Section 4.3.* ***Effect of Uncertainties*** *There are clearly uncertainties with regard to the potential influence from dust deposition on reference areas. However, the possible effect of these uncertainties on the analyses, such as comparison of site and reference area conditions, appears to be limited. Based on the discussion in Section 6.6.1.1, there is very little if any measurable depositional influence from the mine within the terrestrial reference area. Thus, the possible influence of mine dust deposition in the reference area is so small as to be highly unlikely to result in any incremental effects to receptors in that area. Therefore, comparisons of communities (e.g., benthic and plant communities) at the site with those in the reference area are acceptable for the analyses. Further discussion of uncertainty related to the use of reference area comparisons in CoPC selection is included below in Section 6.6.3.* ***Summary*** *While all of the reference areas are suitable for the risk assessment, there are clearly some uncertainties with regard to the potential influence from dust deposition. The possible need for additional study to further address these uncertainties will be considered during development of a risk management plan.*	

Notes: Please note that RA text quoted herein may differ from that in other comment response documents, and in comparison with the final RA document, as a result of successive revisions made during the comment resolution process.

Comments submitted by Pamela Miller, Executive Director, ACAT, 505 West Northern Lights, Suite 205 Anchorage, Alaska 99503. ACAT comments were prepared by Erin Steinkruger.

See the original ACAT comment letter for complete citations of cited literature.

ACAT - Alaska Community Action on Toxics
DEC - Department of Environmental Conservation (Alaska)
DMTS - DeLong Mountain regional Transportation System
NA - not applicable
RA - risk assessment
TC - Teck Cominco

Noatak National Preserve

Cape Krusenstern National Monument

Port detail view

Mine detail view

LEGEND

Sample data set
- Exponent 2003
- Exponent 2002
- Exponent 2001
- National Park Service 2001
- National Park Service 2000

Lead (mg/kg)
- < 10
- 10–49
- 50–99
- 100–249
- 250–499
- 500–999
- ≥1,000

Port site ambient air boundary and mine site ambient air/solid waste permit boundary

Source: All samples were unwashed hylocomium splendens.

0 10 20 Miles
0 10 20 30 Kilometers

0 1 Miles
0 1 Kilometers

0 2 Miles
0 2 Kilometers

Exponent®

Figure 1-9. Lead concentrations in moss samples

Table CK1. Comparison of tissue threshold concentrations in moss samples (*Hylocomium splendens*)

Station	Zone	Sample ID	Event	Copper	Tissue Threshold Concentrations[a]	Zinc	Tissue Threshold Concentrations[a]
				mg/kg	A = 25 - 60	µg/g	A = 150 - 290
				dry	B = 35 - 90	dry	B = 190 - 350
					C = 70 - 110		C = 300 - 400
Site							
001P-M01	ECO-R	001P-M-01	2001			1530	C
002P-M01	ECO-R	002P-M-01	2001			1970	C
003P-M01	ECO-R	003P-M-01	2001			2060	C
004P-M01	ECO-R	004P-M-01	2001			1420	C
005P-M01	ECO-R	005P-M-01	2001			2090	C
006P-M01	ECO-R	006P-M-01	2001			1970	C
007P-M01	ECO-R	007P-M-01	2001			1280	C
008P-M01	ECO-R	008P-M-01	2001			1330	C
009D-M01	ECO-R	009D-M-01	2001			3440	C
009P-M01	ECO-R	009P-M-01	2001			3210	C
010P-M01	ECO-R	010P-M-01	2001			2490	C
011P-M01	ECO-R	011P-M-01	2001			1110	C
013P-M01	ECO-R	013P-M-01	2001			1450	C
015P-M01	ECO-R	015P-M-01	2001			424	C
016P-M01	ECO-R	016P-M-01	2001			1160	C
017P-M01	ECO-R	017P-M-01	2001			191	B
018D-M01	ECO-R	018D-M-01	2001			261	B
018P-M01	ECO-R	018P-M-01	2001			264	B
019P-M01	ECO-R	019P-M-01	2001			518	C
020P-M01	ECO-R	020P-M-01	2001			901	C
021P-M01	ECO-R	021P-M-01	2001			1250	C
022P-M01	ECO-R	022P-M-01	2001			602	C
023P-M01	ECO-R	023P-M-01	2001			981	C
024P-M01	ECO-R	024P-M-01	2001			1140	C
025P-M01	ECO-R	025P-M-01	2001			862	C
026D-M01	ECO-R	026D-M-01	2001			420	C
026P-M01	ECO-R	026P-M-01	2001			290	B
028P-M01	ECO-R	028P-M-01	2001			922	C
029P-M01	ECO-R	029P-M-01	2001			119	
030P-M01	ECO-R	030P-M-01	2001			209	B
030R-M01	ECO-R	030R-M-01	2001			124	
031P-M01	ECO-R	031P-M-01	2001			301	C
031R-M01	ECO-R	031R-M-01	2001			348	C
032P-M01	ECO-R	032P-M-01	2001			207	B
032R-M01	ECO-R	032R-M-01	2001			169	A
033P-M01	ECO-R	033P-M-01	2001			117	
034D-M01	ECO-R	034D-M-01	2001			93.6	
034P-M01	ECO-R	034P-M-01	2001			109	
034R-M01	ECO-R	034R-M-01	2001			97.3	
035P-M01	ECO-R	035P-M-01	2001			92.5	
036P-M01	ECO-R	036P-M-01	2001			559	C
036R-M01	ECO-R	036R-M-01	2001			436	C
037P-M01	ECO-R	037P-M-01	2001			179	A
038P-M01	ECO-R	038P-M-01	2001			116	
038R-M01	ECO-R	038R-M-01	2001			153	A
039P-M01	ECO-R	039P-M-01	2001			187	A
040P-M01	ECO-R	040P-M-01	2001			72.3	
040R-M01	ECO-R	040R-M-01	2001			71.9	

Table CK1. (cont.)

Station	Zone	Sample ID	Event	Copper	Tissue Threshold Concentrations[a]	Zinc	Tissue Threshold Concentrations[a]
				mg/kg	A = 25 - 60	µg/g	A = 150 - 290
				dry	B = 35 - 90	dry	B = 190 - 350
					C = 70 - 110		C = 300 - 400
041P-M01	ECO-R	041P-M-01	2001			309	C
042D-M01	ECO-R	042D-M-01	2001			84.2	
042P-M01	ECO-R	042P-M-01	2001			83	
042R-M01	ECO-R	042R-M-01	2001			82.9	
044P-M01	ECO-R	044P-M-01	2001			230	B
044R-M01	ECO-R	044R-M-01	2001			184	A
045P-M01	ECO-R	045P-M-01	2001			74.4	
046P-M01	ECO-R	046P-M-01	2001			223	B
048P-M01	ECO-R	048P-M-01	2001			129	
048R-M01	ECO-R	048R-M-01	2001			148	
050P-M01	ECO-P	050P-M-01	2001			377	C
051A-M01	ECO-P	051A-M-01	2001			358	C
052P-M01	ECO-P	052P-M-01	2001			637	C
053D-M01	ECO-P	053D-M-01	2001			197	B
053P-M01	ECO-P	053P-M-01	2001			193	B
059D-M01	ECO-P	059D-M-01	2001			300	B
059P-M01	ECO-P	059P-M-01	2001			384	C
060P-M01	ECO-P	060P-M-01	2001			340	C
102P-M01	ECO-R	102P-M-01	2001			141	
103P-M01	ECO-R	103P-M-01	2001			85.6	
116P-M01	ECO-R	116P-M-01	2001			87.8	
117P-M01	ECO-R	117P-M-01	2001			101	
117R-M01	ECO-R	117R-M-01	2001			119	
161P-M01	ECO-P	161P-M-01	2001			128	
161R-M01	ECO-P	161R-M-01	2001			156	A
201P-M01	ECO-R	201P-M-01	2001			132	
HR01-01A	ECO-P	HR-01-01-M	2001			4180	C
HR01-02M	ECO-P	HR-01-02-M	2001			2040	C
HR01-03M	ECO-P	HR-01-03-M	2001			273	B
HR02-01M	ECO-P	HR-02-01-M	2001			3140	C
HR02-02M	ECO-P	HR-02-02-M	2001			949	C
HR02-03M	ECO-P	HR-02-03-M	2001			59.2	
HR03-01M	ECO-R	HR-03-01-M	2001			1160	C
HR03-02M	ECO-R	HR-03-02-M	2001			435	C
HR03-03M	ECO-R	HR-03-03-M	2001			164	A
HR04-01B	ECO-R	HR-04-01-M	2001			1240	C
HR04-02M	ECO-R	HR-04-02-M	2001			889	C
HR04-03M	ECO-R	HR-04-03-M	2001			167	A
HR05-01M	ECO-R	HR-05-01-M	2001			1360	C
HR05-02M	ECO-R	HR-05-02-M	2001			460	C
HR05-03M	ECO-R	HR-05-03-M	2001			118	
HR06-01M	ECO-M	HR-06-01-M	2001			1440	C
HR06-02M	ECO-M	HR-06-02-M	2001			1200	C
HR06-03M	ECO-M	HR-06-03-M	2001			1450	C
HR06-04M	ECO-M	HR-06-04-M	2001			433	C
HS1N0003	ECO-R	HS-1N-0003-M	2000			1570	C
HS1N0050	ECO-R	HS-1N-0050-M	2000			1020	C
HS1N0100	ECO-R	HS-1N-0100-M	2000			554	C
HS1N0250	ECO-R	HS-1N-0250-M	2000			281	B

Table CK1. (cont.)

Station	Zone	Sample ID	Event	Copper	Tissue Threshold Concentrations[a]	Zinc		Tissue Threshold Concentrations[a]
				mg/kg	A = 25 - 60	µg/g		A = 150 - 290
				dry	B = 35 - 90	dry		B = 190 - 350
					C = 70 - 110			C = 300 - 400
HS1N1000	ECO-R	HS-1N-1000-M	2000			153		
HS1S0003	ECO-R	HS-1S-0003-M	2000			1500		C
HS1S0050	ECO-R	HS-1S-0050-M	2000			352		C
HS1S0100	ECO-R	HS-1S-0100-M	2000			207		B
HS1S0250	ECO-R	HS-1S-0250-M	2000			148		
HS1S1000	ECO-R	HS-1S-1000-M	2000			111		
HS1S1600	ECO-R	HS-1S-1600-M	2000			96.1		
HS2N0003	ECO-R	HS-2N-0003-M	2000			2750		C
HS2N0050	ECO-R	HS-2N-0050-M	2000			1880		C
HS2N0100	ECO-R	HS-2N-0100-M	2000			1040		C
HS2N0250	ECO-R	HS-2N-0250-M	2000			516		C
HS2N1000	ECO-R	HS-2N-1000-M	2000			237		B
HS2S0003	ECO-R	HS-2S-0003-M	2000			1200		C
HS2S0050	ECO-R	HS-2S-0050-M	2000			321		C
HS2S0100	ECO-R	HS-2S-0100-M	2000			255		B
HS2S0250	ECO-R	HS-2S-0250-M	2000			138		
HS2S1000	ECO-R	HS-2S-1000-M	2000			118		
HS3N0003	ECO-R	HS-3N-0003-M	2000			1180		C
HS3N0050	ECO-R	HS-3N-0050-M	2000			856		C
HS3N0100	ECO-R	HS-3N-0100-M	2000			695		C
HS3N0250	ECO-R	HS-3N-0250-M	2000			259		B
HS3N1000	ECO-R	HS-3N-1000-M	2000			158		A
HS3N1600	ECO-R	HS-3N-1600-M	2000			169		A
HS3S0003	ECO-R	HS-3S-0003-M	2000			2860		C
HS3S0050	ECO-R	HS-3S-0050-M	2000			751		C
HS3S0100	ECO-R	HS-3S-0100-M	2000			453		C
HS3S0250	ECO-R	HS-3S-0250-M	2000			222		B
HS3S1000	ECO-R	HS-3S-1000-M	2000			112		
MI-02M	ECO-M	MI-02-M	2001			589		C
MI-104	ECO-R	MS0024	2003			74.5		
MI-107	ECO-R	MS0020	2003			137		
MI-108	ECO-R	MS0023	2003			386		C
MI-25-M	ECO-R	MI-25-M	2002			440		C
MI-26-M	ECO-R	MI-26-M	2002			166		A
MI-42-M	ECO-M	MI-42-M	2002			611		C
MI-45-M	ECO-M	MI-45-M	2002			748		C
PO-01M	ECO-P	PO-01-M	2001			1370	*J*	C
PO-02M	ECO-P	PO-02-M	2001			2540	*J*	C
PO-04M	ECO-P	PO-04-M	2001			2090	*J*	C
PO-05M	ECO-P	PO-05-M	2001			6480	*J*	C
PO-06M	ECO-P	PO-06-M	2001			3950	*J*	C
PO-07M	ECO-P	PO-07-M	2001			1580	*J*	C
PO-09M	ECO-P	PO-09-M	2001			1560	*J*	C
PO-10M	ECO-P	PO-10-M	2001			1930	*J*	C
PO-11M	ECO-P	PO-11-M	2001			1260	*J*	C
PO-13M	ECO-P	PO-13-M	2001			1580	*J*	C
PO-15M	ECO-P	PO-15-M	2001			1500	*J*	C
PO-16M	ECO-P	PO-16-M	2001			1520	*J*	C
PO-17M	ECO-P	PO-17-M	2001			1550	*J*	C

Table CK1. (cont.)

Station	Zone	Sample ID	Event	Copper	Tissue Threshold Concentrations[a]	Zinc		Tissue Threshold Concentrations[a]
				mg/kg	A = 25 - 60	µg/g		A = 150 - 290
				dry	B = 35 - 90	dry		B = 190 - 350
					C = 70 - 110			C = 300 - 400
PO-18M	ECO-P	PO-18-M	2001			1480	*J*	C
TT1-0100	ECO-P	MS0005	2003	24.2		8120		C
TT1-1000	ECO-P	MS0008	2003	4.56		869		C
TT2-0010	ECO-P	MS0004	2003	21.6		2910		C
TT2-0100	ECO-P	MS0003	2003	13.1		1340		C
TT2-1000	ECO-P	MS0006	2003	3.85		251		B
TT3-0010	ECO-R	MS0002	2003	16.8		1110		C
TT3-0100	ECO-R	MS0001	2003	9.73		595		C
TT3-1000	ECO-R	MS0015	2003	3.49		135		
Reference								
TS-REF-7	ECOREF	MS0011	2003	3.73		47.9		
TS-REF-8	ECOREF	MS0010	2003	4.35		64		
TS-REF10	ECOREF	MS0009	2003	3.29		55		

Note: [a] Tissue threshold concentration ranges defined as follows based on effects thresholds reported for multiple species in Folkeson and Andersson-Bringmark (1988).

A - exceeds minimum threshold for first signs of reduction in cover

B - exceeds minimum threshold for obvious reductions in cover

C - exceeds minimum apparent survival thresholds (some dead individuals observed)

Both site and literature reference samples were unwashed.

J - estimated value

Data Sources: Exponent (2002a)
Ford and Hasselbach (2001)
Exponent (2003c) and Appendix A of this document
Further detail is provided in Appendix Table C-21

Table CK2. Comparison of tissue threshold concentrations in lichen samples

	Station	Sample ID	Event	Taxon	Zinc		Tissue Threshold Concentrations[a]
					µg/g dry		A = 480 - 1,300 B = 550 - 1,800 C = 600 - 2,200
Site							
	HR01-02L	HR-01-02-L	2001	*Peltigera*	1610		C
	HR02-02L	HR-02-02-L	2001	*Peltigera*	545	*J*	A
	HR02-03L	HR-02-03-L	2001	*Peltigera*	82.2	*J*	
	HR03-03L	HR-03-03-L	2001	*Peltigera*	115	*J*	
	HR05-03L	HR-05-03-L	2001	*Peltigera*	85.2	*J*	
	HR07-01B	HR-07-01-L	2001	*Peltigera*	1720	*J*	C
	HR07-02L	HR-07-02-L	2001	*Peltigera*	1040	*J*	C
	HR07-03L	HR-07-03-L	2001	*Peltigera*	185	*J*	
	HR07-04L	HR-07-04-L	2001	*Peltigera*	121	*J*	
	PO-04L	PO-04-L	2001	*Peltigera*	1010	*J*	C
	PO-11L	PO-11-L	2001	*Peltigera*	1020	*J*	C
	PO-17L	PO-17-L	2001	*Peltigera*	1050	*J*	C
	TT2-0010	LI0018	2004	*Peltigera*	780		C
	TT2-0100	LI0008	2004	*Peltigera*	292		
	TT2-1000	LI0007	2004	*Peltigera*	137		
	TT3-0010	LI0010	2004	*Peltigera*	209		
	TT3-0100	LI0037	2004	*Peltigera*	119	*J*	
	TT3-1000	LI0016	2004	*Cladina*	81.9		
	TT3-1000	LI0017	2004	*Peltigera*	94.4		
	TT5-0010	LI0038	2004	*Peltigera*	594		B
	TT5-0100	LI0006	2004	*Peltigera*	572		B
	TT5-1000	LI0002	2004	*Peltigera*	531		A
	TT5-2000	LI0019	2004	*Cladina*	278		
	TT6-0010	LI0034-D	2004	*Peltigera*	351	*J*	
	TT6-0010	LI0036	2004	*Cladina*	317	*J*	
	TT6-0100	LI0022	2004	*Cladina*	420	*J*	
	TT6-0100	LI0023	2004	*Peltigera*	392	*J*	
	TT6-1000	LI0020	2004	*Peltigera*	335	*J*	
	TT6-1000	LI0021	2004	*Cladina*	386	*J*	
	TT6-2000	LI0026	2004	*Peltigera*	163	*J*	
	TT6-2000	LI0027	2004	*Cladina*	141	*J*	
	TT7-0010	LI0025	2004	*Cladina*	2740	*J*	C
	TT7-1000	LI0024	2004	*Cladina*	996	*J*	C
	TT7-2000	LI0039	2004	*Cladina*	1260		C
	TT8-0010	LI0015	2004	*Peltigera*	627		C
	TT8-0100	LI0014	2004	*Peltigera*	397		
	TT8-1000	LI0011	2004	*Cladina*	70		
	TT8-1000	LI0012-D	2004	*Peltigera*	149		
Reference							
	TS-REF-5	LI0028	2004	*Cladina*	45.2		
	TS-REF-5	LI0029	2004	*Peltigera*	48.5		
	TS-REF-7	LI0030	2004	*Cladina*	26.9		
	TS-REF-7	LI0031	2004	*Peltigera*	39.2		
	TS-REF11	LI0032	2004	*Cladina*	19.4	*J*	
	TS-REF11	LI0033	2004	*Peltigera*	29.7	*J*	

Notes on following page