HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT (HHERA) NANISIVIK MINE, BAFFIN ISLAND, NUNAVUT

RESPONSE TO SECOND ROUND REVIEW COMMENTS

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1.0 INTRODUCTION

Nunavut Water Board has provided CanZinco Limited with a number of follow-up comments, dated June 10, 2003, on our report, Nanisivik Mine Human Health and Ecological Risk Assessment (the HHERA report). These comments follow our inital response to peer review comments that was provided on May 19, 2003. The follow-up comments include:

- Indian and Northern Affairs Canada, letter from Michelle McChristie to Rita Becker, Nunavut Water Board, dated June 10, 2003;
- Nunavut Department of Justice, letter from Susan Hardy to Philippe di Pizzo, dated June 11, 2003; and
- Acres/Dillon, review comments commissioned by Dionne Filiatrault, Nunavut Water Board, dated June 5, 2003.

We were pleased to see that this "second round" of review comments is generally of a smaller scope and more specific than the first round. We see this as an indication that our response to the first round of comments was perceived as being constructive, and resolved many of the questions and requests for clarification.

In addition, we were gratified by the fact that the overall consensus of the peer review process was that the report was prepared in accordance with accepted standards. Notwithstanding further discussion and clarification of a number of technical issues, the peer reviewers generally agreed that the conclusions of the report were robust, and not likely to change substantially as a result of the review process.

The present document provides a response to the "second round" of comments transmitted by the Nunavut Water Board on June 11, 2003. Reviewer comments are fully reproduced, in italics. JWEL responses are provided in normal text.

INDIVIDUAL REVIEW COMMENTS

Reactions to the Canzinco Limited Response to Peer Review Comments, dated May 19, 2003, are provided here and are organized by reviewer.

2.0 COMMENTS FROM INDIAN AND NORTHERN AFFAIRS CANADA (INAC)

The following comments have been extracted from the letter to Rita Becker (Nunavut Water Board) from Michelle McChristie (INAC, Water Resources) dated June 10, 2003.

On behalf of Indian and Northern Affairs Canada (INAC), I have reviewed Canzinco Limited's Response to Peer Review Comments dated May 19, 2003 (hereafter referred to as the "Response"). Generally, INAC is pleased with the response as the company has incorporated our primary concerns with the Human Health and Ecological Risk Assessment (HHERA) into the reassessment. Example calculations have been provided, including an improved explanation of variable (terminology) applied. In addition, background data for the townsite has been re-valued and this is a significant factor in reducing the Soil Quality Remediation Objectives (SQROs) for the townsite. Explanations of other concerns previously identified provide a clearer understanding of the actions and decisions taken in the Risk Assessment Process followed by Jacques Whitford Environmental Limited (JWEL). However, there are some exceptions to this and the outstanding issues are summarized below.

2.1 Human Health Risk Assessment (HHERA) Uncertainty Analysis (Response, Comment 5, page 13)

INAC is of the opinion that the combined exposure should be considered when different elements can impact the same organ, in this case lead and cadmium and the kidney. In cases where the impact of each single element has no known effect at the exposure experienced, it is the combined exposure that affects the organ, and the additive effects should be considered. The challenge resulting from this is that the accepted contaminant concentrations become interdependent on one another. For example, in the townsite, the lead SQRO is below the EPC; however, cadmium is also present. If additive effects are considered, the accepted lead concentration (SQRO) will be influenced by the concentration of cadmium present.

JWEL Response: JWEL remains of the opinion that summation of hazard quotients (HQs) for lead and cadmium is not toxicologically warranted or correct. The tolerable daily intake (TDI) employed for lead in this risk assessment is based on no increase in baseline blood lead levels (approximately 4 µg/dL) or body burden of lead. While lead poisoning is known to be associated with renal disease, chronic nephropathy in adults and children has not been detected below blood lead levels of 40 µg/dL (Campbell

et al. 1977, Lilis *et al.* 1977). Therefore, at the exposure levels predicted for Nanisivik, lead-induced renal effects are not expected.

However, it is worth noting that if the hazard quotients for lead and cadmium in either the town site or general mine area were summed, the total hazard index (HI) would remain less than the target HI of 1. This indicates that no adverse effects would be expected even if the individual risks from lead and cadmium were assumed to be additive.

On a minor point of clarification, INAC state that in the townsite the lead SQRO is below the EPC. In fact, the lead SQROs are greater than the EPCs in both the townsite and the general mine area.

2.2 HHERA Comment - House Dust (Response, page 38)

Under separate cover, BC Research provided comments regarding the significance of lead in house dust. The response to the Government of Nunavut states that lead in the houses is most likely a result of "tracking-in of dust from residents/ employees during the time of mine operation when ores, concentrates and tailings were being handled". This has not been verified, and an equally probable source is townsite contamination being tracked-in by not only the miner, but also other family members including children. Further consideration of this second source is required. If lead contamination in the townsite is a factor, remediation of the townsite should be sufficiently thorough to ensure that further contamination of the homes does not occur.

JWEL Response: The Human Health Risk Assessment (HHRA) already accounts for the possibility that soil may be tracked into the homes and that exposure may then occur via household dust. The HHRA assumes that all dust in the home is derived from outside soil and has the same lead concentration as the soil outside the home. This is reasonable since in the future (and after cleaning of the homes) there will be no other potential source of metals. The soil ingestion rate is a total (soil + re-suspended dust) ingestion rate and is not apportioned between indoors or outdoors in this risk assessment.

This approach is more conservative than is typically adopted in human health risk assessment where concentrations of chemicals of potential concern (COPC) in indoor dust are generally assumed to be only a fraction of the COPC concentration in the outside soil, as not all household dust is derived from soil. However, as noted by Dillon Consulting, use of this assumption then requires that a receptor's time is apportioned between time spent indoors and time spent outdoors to calculate an overall daily intake of the COPC from soil + dust ingestion. Exposure to soil is effectively reduced as more time is spent indoors.

In the Nanisivik HHRA, JWEL have removed the requirement to apportion time spent indoors versus time spent outdoors by conservatively assuming that indoor dust and outdoor soil have the same COPC concentrations.

2.3 Environmental Risk Assessment (ERA) for Lemming, ERA Comment 2 (Response, page 14)

The further explanation is adequate, including the information from the Cantox (Polaris) study which demonstrated that the inhalation pathway contributed less than 1% of the lemming exposure. It should be noted that Cantox did consider inhalation as a reasonable pathway for their evaluation.

JWEL Response: The comment indicates that no further response is required..

2.4 ERA Comment 5 (Response, page 15)

An adequate evaluation of exposure to birds based on reference criteria (HERD note 4, December 2000) regarding adult/juvenile exposures would reflect that differing health outcomes between adult and juvenile birds can be expected. Ecological risk factors were also used to set SQRO values for all contaminants (cadmium, copper, lead, and zinc) at the dock and for copper at the mine site. However, since these values are significantly above the EPC values, INAC agrees with Canzinco that further refinement of the ERA on this basis in not required.

JWEL Response: Based upon the concluding sentence, it appears that no further action or explanation is required.

2.5 ERA Comment 12 (Response, page 17)

Please refer to comments under HHERA, Comment 5. INAC believes it would be prudent to recognize that metal exposures may have additive effects on organs (like humans, animals must process contaminant metals through the liver and kidney and these organs become vulnerable to combined effects of exposure). As a minimum, Canzinco should recognize this in the ERA, and provide clear justification as to why the SQRO values are significantly above the EPC and the further step is unnecessary.

JWEL Response: There is a fundamental difference between human health risk assessments, and ecological risk assessments, that is relevant to this question. In human health risk assessment, the focus is on protection of the health of a maximally exposed individual. As such, it may be reasonable to give consideration to effects on organs or tissues. (See also JWEL response to INAC question 1, above.) In contrast, ecological risk assessment typically focuses on populations, and there is usually a focus on

toxicity reference values that consider mortality or reproductive endpoints. Effects on organs that would lead to mortality or population level responses would be captured at this level. At the level of ERA that has been completed for the Nanisivik site, a focus on organs (i.e., a more detailed risk assessment at a sublethal level of detail) would not be expected unless there was evidence of significant risk to some of the biota at the current level of risk assessment.

The existing risks to the ecological receptors (based upon the conservatively estimated EPC values) are very small (see Tables 7.8 to 7.11 in the HHERA report). Even if the hazard quotients for cadmium, copper, lead and zinc were added, the sum (the total hazard index or HI) would remain less than 1. Therefore, further investigation of this issue is not deemed necessary.

2.6 Sample Calculation (Response, page 37)

The sample calculation in the appendix of the Response does not provide the final step in calculating the SSTL and SQRO (the same applies to the equation in the original HHERA). This is required as it will clarify whether background soil concentrations are being used in determining acceptable future soil concentrations of contaminants.

JWEL Response: Several reviewers have raised the issue of the importance of the background soil concentration and its role in the SQRO calculation. On further review of the original HHERA report, we acknowledge that the form of the equation presented in the text of the report may have led to some confusion. This was originally intended as a generic presentation of the general form of risk calculation but does not accurately represent the final method adopted for the Nanisivik risk assessment. Rather than solve the equation directly for the SQRO, the final equation employed was designed to start with the soil concentration (C_{soil}) and solve for the hazard quotient that is associated with that C_{soil}. The calculation is then conducted iteratively as a "goal seeking" exercise by increasing the starting soil concentration until the target HQ is reached. As the starting soil concentration increases, all of the receptor's COPC intakes also increase via all routes of exposure (soil ingestion, dermal contact, inhalation, and wild game ingestion).

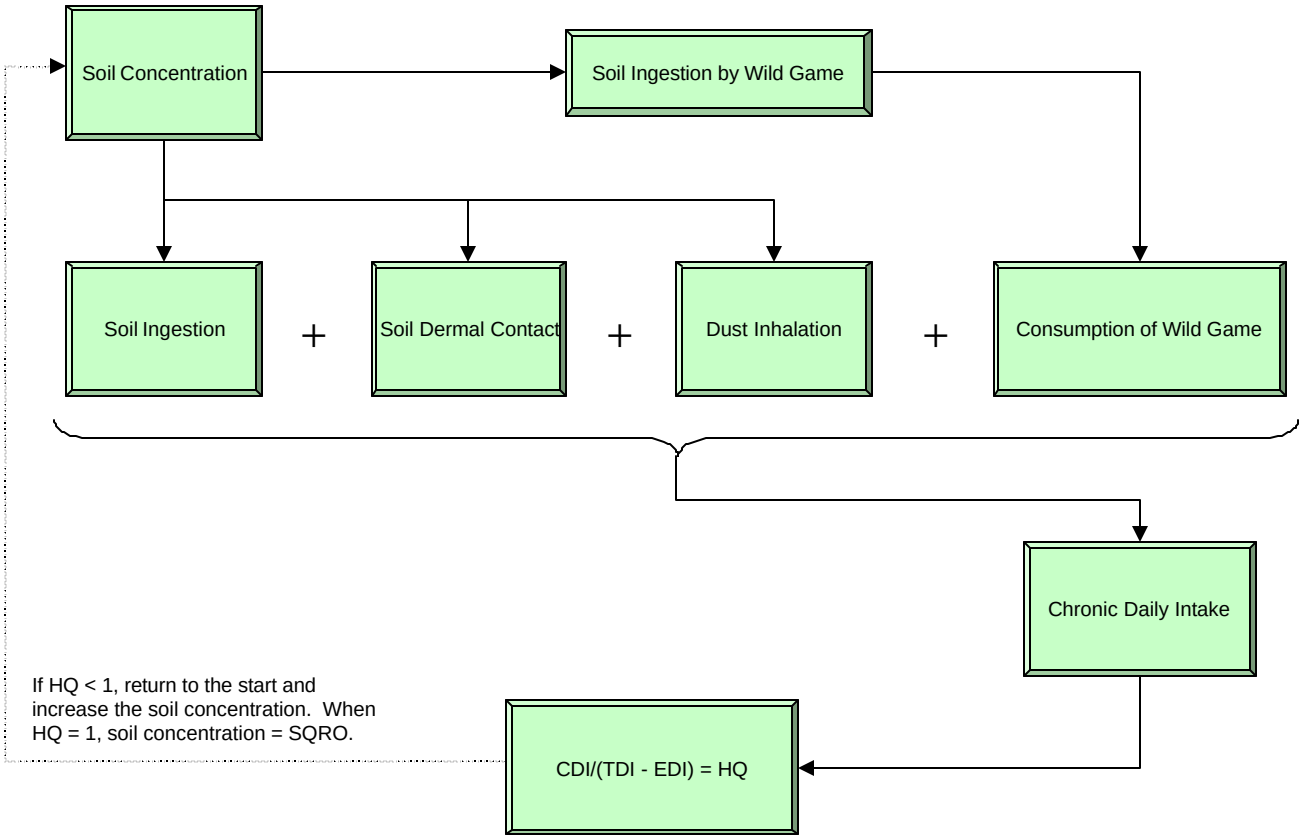
This approach was adopted primarily to ensure that the consumption of wild game pathway was properly incorporated. As the soil concentration increases, it is not only the human receptor that ingests this more contaminated soil but also the wild game that is caught and eaten.

The soil concentration that produces the target HQ of 1 then becomes the SQRO. To solve for the HQ, the predicted chronic daily intake (CDI) by all routes of exposure is divided by the tolerable daily intake (TDI) minus the estimated daily intake (EDI). The background soil concentration is one component of the EDI but has no other role in the risk calculation. Within the calculation of a receptor's chronic daily intake, the portion of the soil concentration that is "background" and the portion that is anthropogenic is not important. It is the total exposure to soil that is being assessed. In fact, by continuing to include a

background soil component in the EDI there is some double conservatism due to counting of soil exposure in the townsite where the risk calculation is already based on year-round exposure.

JWEL also wishes to emphasize that the background concentration provides the basis for a part of the EDI, as illustrated in Section 6.4.1.5 of the HHERA report. The EDI is subtracted from the TDI to estimate how much "additional" metal intake can be tolerated (the RTDI) in order to calculate the SQRO. It follows that if the background metal concentration is overestimated, then the SQRO that results will be lower. Hence our opinion that the 1985 background data are suitable for the purposes of this HHERA. If the 1985 background data were compromised (i.e., elevated) by mine operations prior to that time, the net effect would be to reduce the SQRO value that can be used as a remedial target.

The drawing below will help illustrate the form of the HHRA calculation:



We trust that the above response will clarify the nature of the HHRA calculation and the role of the background soil concentration. JWEL will ensure that the final report accurately portrays this calculation.

2.7 Lead as a Carcinogen comment 2 (Response, page 4)

It appears that Canzinco is not accepting the suggestion that lead is a carcinogen or could be a concern in the future, and there is significant reference to the absence of appropriate reference values needed to conduct calculations. In addition, the rating of lead as a Group 2B carcinogen by the IARC (possible human carcinogen) and a B2 carcinogen by the EPA (probable human carcinogen) has been ignored. The presence of lead in homes, lead in the townsite, and the cancer concern suggests that this should be considered. If, as has been suggested, no data is available, this uncertainty should be incorporated into these considerations.

JWEL Response: In determining the correct approach to assessing the potential toxicity of COPCs, JWEL relies upon current guidance and standard practice from major regulatory agencies. Neither Health Canada nor the United States Environmental Protection Agency (US EPA) treat lead as a carcinogen for the development of soil quality guidelines. The US EPA specifically advises against doing so. Both agencies develop soil quality guidelines on the basis of limiting increases in blood lead levels, the US EPA via their IEUBK model and Health Canada via the adoption of a TDI that is associated with no increase in baseline blood lead levels. It is generally accepted that by limiting increases in body burdens of lead, a more than adequate level of protection is provided against other potential health effects (e.g., renal and developmental effects). We note that the senior toxicologist from Dillon Consulting supports this view in his Memo to Ramli Halim of Acres International Limited, dated June 3, 2003 (p.9, response 3.4).

It is also important to note that the forms of lead that have been associated with tumour development in laboratory animal experiments were lead salts of lead acetate and lead phosphate (administered at very high doses orders of magnitude higher than the CDIs at Nanisivik). Neither of these forms of lead are likely to be found at Nanisivik where the majority of the lead from the mine operation will be lead sulphides.

As suggested by the reviewer, JWEL will include a qualitative discussion of this issue in the uncertainty section of the final report.

3.0 COMMENTS FROM NUNAVUT DEPARTMENT OF JUSTICE

Letter to Philippe Di Pizzo from Susan Hardy (Nunavut Department of Justice) dated June 11, 2003.

This is the third letter in which the Government of Nunavut responds to the HHERA and Phase 2 ESA, submitted by Canzinco/ Breakwater Resources Ltd. pursuant to License NWB1NAN0208, and updated with additional comments on May 19th, 2003.

The various GN regulators have reviewed CanZinco's comments of May 19th, 2003; however, the GN as a whole cannot venture any cohesive statement in response, without input from the Public Health experts. For example, GN Regulators are not able to reassess or revoke previous recommendations to the Board with regard to the need for wider soil sampling to establish reliable background data, or to make final comments about the other concerns raised by ourselves or EBA Engineering, until expert public health advice is also available to be weighed together with the other perspectives before the Board.

As proposed in the Board's Timeline on June 2nd 2003, Drs. Rogers and Zelt, retained to provide review from a human health perspective, will be endeavoring to submit their comments prior to the June 20th teleconference of regulators.

JWEL Response: Comments indicate that no response is needed until further information has been received from the Public Health Experts retained by the Nunavut Department of Justice.

4.0 COMMENTS FROM ACRES INTERNATIONAL LIMITED

Letter to Dionne Filiatrault from R. Halim (Acres International Limited) dated June 5, 2003.

On May 19, 2003 Canzinco submitted documents which contain replies to the queries and questions raised during the technical meeting held in Iqaluit on March 28, 2003, and submitted by various respondents for the following three documents:

- *Phase II Environmental Site Assessment (ESA) for the Nanisivik Mine, as prepared by Gartner Lee Limited for Canzinco Ltd. and issued on January 30, 2003. The Phase II ESA report was submitted as per Section G, Item 13 of the Water License NWB1NAN0208.*

- *Emergency Response Plan (ERP) prepared by Nanisivik Mine/Canzinco Ltd. and issued on February 28, 2003. The ERP report was submitted as per Section E, Item 1 of the Water License NWB1NAN0208.*

- *Human Health and Ecological Risk Assessment (HHERA), as prepared by Jacques Whitford Environment Limited For Canzinco Ltd., and issued on January 30, 2003. The HHERA report was submitted as per Section G, Item 14 of the Water License NWB1NAN0208.*

The following recommendations summarize our reviews of Canzinco's May 19, 2003 reply to Acres/Dillon queries and questions submitted to the Nunavut Water Board (NWB) on March 21, 2003, as well as reviews by other respondents, including EBA Engineering Consultants (EBA)/BC Research Inc. on behalf of DIAND, Government of Nunavut (GN), Amec Earth and Environmental Limited (Amec) on behalf of Nunavut Tunngavik Incorporated (NTI), Environmental Canada (EC) and Canada – Fisheries and Oceans (Department of Fisheries and Oceans).

[Note – Section 1 of the letter has been omitted here, as it deals with the Phase II ESA Report, for which responses have been provided under separate cover by Gartner Lee Ltd.]

4.1 HHERA Report

This section has been prepared by Dillon, who has been working together with Acres in reviewing the HHERA document submitted by Canzinco. The comments with respect to the HHERA issues at Nanisivik are finalized as follows.

Based on the comments prepared by Dillon, we recommend that NWB requests Canzinco to redo the analysis, incorporating the various inputs and comments made by other parties. This final round of analyses and revisions should include new input or justifications for the use of the 1985 background

data. In summary, the HHERA report requires additional analysis before their recommended SQRO values be approved and adopted for Nanisivik.

We also recommend that the revision should not include or wait for any additional test results from any new proposed field program to be carried out this summer. Such additional data should only be incorporated in the remediation program at Nanisivik, unless there is new data which may critically change the SQRO values.

To bring the SQRO values and HHERA report to a final conclusion, it may be necessary (and more practical) to have a conference call among the parties who are involved in the preparation of the documents and comments on the report. This may be the only solution to finalize the issues and concerns among the parties in a timely manner.

Details information from Dillon is attached to this letter.

JWEL Response: We are unclear on the direction the reviewer's comments are intended to provide. The comments from the reviewer are based upon the June 3, 2003, memorandum from Dillon to Acres. In Paragraph 2, it is "*requested*" that the HHERA analysis should be redone, incorporating various inputs and comments made by other parties, and that the revision should include new input (data?) or justifications for the use of the 1985 background data. In Paragraph 3, however, it is recommended that the revision should not include any new site-specific data. Further, it is not clear to us by what mechanism new data would be incorporated in the remediation program at Nanisivik, unless it is through the HHERA document which establishes SQRO values.

Perhaps this would be the most appropriate juncture at which to reiterate our position with respect to the 1985 background data set. Based upon our review and understanding of the factors associated with this issue, it is our opinion that the 1985 data set is credible and therefore appropriate for inclusion in the HHERA. The relationship of background data to the SQRO has been outlined earlier in this response to comments. If the 1985 background data are significantly elevated with respect to the historical background at Nanisivik, the net effect of this bias would be to lower the SQRO (inherently a conservative and safe error), rather than raising the SQRO. Introducing different (lower) background data values into the HHERA would permit higher SQRO values. JWEL remains of the opinion that the 1985 background data set represents the best available source of background data, and that in spite of any deficiencies in the data set, its use is both conservative and appropriate in the HHERA.

With this in mind, our response to this round of review comments will focus on the comments provided by Dillon in their original format.

[Note – section 3 of the letter has been omitted here, as it deals with the ERP Report, for which responses have been provided under separate cover by CanZinco Ltd.]

5.0 COMMENTS FROM DILLON CONSULTING LIMITED

These comments are extracted from the Memorandum to Mr. Ramli Halim (Acres International Limited) from Mr. Bryan Leece and Mr. Ulysses Klee (Dillon Consulting), dated June 3, 2003

As per your request we have received the response to our peer review comments on the human health and ecological risk assessments for the Nanisivik Mine, prepared by Jacques Whitford Environmental Limited (JWEL). Our review of the JWEL responses are provided in three sections. The first addresses the JWEL responses to the ecological risk assessment (ERA). The second addresses the JWEL responses to the human health risk assessment (HHRA). And the third address the additional questions you raised in your email of May 29, 2003.

5.1 Review of Responses to ERA Comments

ERA Comment 1.1: Chemical Screening

The response provided was acceptable. It is suggested however that this information be included in the report as it represents an important element of the site remediation process and thus impacts on the scope of the risk assessment.

JWEL Response: The comment from Dillon indicates that the response already provided by JWEL was acceptable. This information will be included in the final report, either as an amendment to the text, or an attachment to the document.

ERA Comment 1.2: Selection of Valued Ecosystem Components

Disagree. The "careful consideration" of biota that are likely to be found on the site was based on the information provided in the report by Gartner Lee and this information was not reflected accurately in the risk assessment. The objective of the risk assessment is to assess the impacts of the contaminants on the ecosystem. This is not based solely on exposure. The toxicity of the metal to the animal must also be considered. It is agreed that animals with a large home range will be expected to receive a lower exposure but this needs to be quantified and compared to their respective exposure limit in order to conclude that they are not of concern. Likewise, migratory species that use the area extensively will potentially receive unacceptable levels of exposure while on site. This too needs to be quantified in order to address the issue in a transparent and complete manner. It is not acceptable or necessary to rely on the authors "experience or judgement" with these matters.

The question regarding the exclusion of marine wildlife was not addressed.

JWEL Response: The statements made by Dillon in this question are incorrect, and contradictory. In the earlier round of comments, Dillon stated *"the selection of valued Ecosystem Components also seems to ignore the information provided in the Phase II Environmental Site Assessment provided by Gartner Lee"*. In the present round of comments, they state that *"the 'careful consideration' of biota that are likely to be found on the site was based on the information provided in the report by Gartner Lee and this information was not reflected accurately in the risk assessment"*. Neither of these statements is fully correct.

The risk assessment report (Section 7.3) outlines the criteria and process that was followed to identify potential receptors for use in this ERA. Nowhere in Section 7.3 does JWEL indicate that the selection of receptors for the ERA was based on information in the Gartner Lee report. As indicated in Section 7.3, the selection process gave consideration to the following criteria:

- keystone species known to be central to ecosystem function;
- exposed to surface soils at the site;
- representative of lower and higher trophic feeding levels (i.e., herbivorous and carnivorous animals);
- present on or near the Mine site for some or most of the year;
- of significant cultural and/or economic significance; and
- endangered or sensitive species (no such species were determined to be indigenous to the study areas).

Receptor selection was based in part on fundamental ecological considerations, but was also guided by information solicited from members of the local community for this specific purpose. In addition, a number of other documentary sources were considered, including but not limited to the 1975 terrestrial baseline study carried out by BC Research, and information present in the Gartner Lee report. The professional judgement of JWEL biologists and risk assessors was also involved. The approach that was taken was thorough, reasonable, and consistent with the ecological risk assessment general guidance provided by the Canadian Council of Ministers of the Environment (CCME 1996, Section 2.5) for the identification of receptors (Valued Environmental Components).

The Dillon reviewers assert that *"it is not acceptable or necessary to rely on the authors 'experience or judgement'"* in matters related to the selection of Valued Ecosystem Components. This not the case, and is inconsistent with CCME (1996) guidance on Ecological Risk Assessment. CCME (1996, Section 2.1) states, with respect to the role of professional judgements in ERA:

"ERAs are based on scientific data that may be complex, conflicting, and incomplete (U.S. EPA 1992). The whole ERA process relies on professional judgement based on experience and specialized knowledge in the various aspects required (CCME 1996).

And further (CCME 1996),

"Professional judgement on the part of ERA practitioners is necessary to

- *plan the risk assessment*
- *evaluate and select the tools for each ERA component*
- *ensure the data are optimal for the objective(s)*
- *track the uncertainty introduced by each component*
- *interpret the ecological significance of the data, and relate them to the site".*

With regards to the marine environment, we have previously provided clarification that explained that marine wildlife were not the focus of this report because the objective of the report was to establish Soil Quality Remediation Objectives (SQROs). These relate solely to on-site soils and do not require consideration of the marine environment or marine environmental receptors.

In conclusion, JWEL remains of the opinion that our selection of VECs is appropriate to the objectives of the risk assessment, and consistent with CCME guidance.

ERA Comment 1.3: Applicability of the OTR data to Nanisivik Mine Site

If the authors of the risk assessment were aware that background data for the mine site area was not available then why was this data not collected as part of the assessment work? The importance of data characterizing the background soil conditions, particularly when assessing contaminants that are naturally occurring and naturally elevated, is very important. This oversight represents a significant data gap and undermines the development of SQROs. Background concentrations of metals in the soil are used in the calculation of SQROs and these soil clean-up levels should not be lower than the natural background. It is unfortunate that the OTR values are the only ones available but this does not make them valid for application at a mine site in Nunavut. The authors comment does not satisfy the concern raised by the question.

JWEL Response: JWEL remains of the opinion that the 1985 Nanisivik background data represent the best available data set that can be used to estimate background metals (copper, lead, and zinc) concentrations at Nanisivik. This is the case for the following reasons.

- The Nanisivik mine exists because of the presence of a natural mineralized zone, which outcrops to the surface. Owing to the presence of this natural mineralization, the background metals concentrations at Nanisivik are naturally elevated. It would not be reasonable or practical to require the mine operators to reduce metals concentrations in soils to levels below those that naturally occur at the site.
- The 1985 data covered a wide area, including areas outside the mineralized zones, and shows a wide range in metals concentrations present in surface soils.

- Although the mine had been operational for a number of years in 1985, all mine tailings up to that time had been disposed of in a subaqueous setting. Therefore potential bias from wind dispersion of tailings in a non-issue..
- Background metals data from other individual sites would reduce the site specific considerations resulting from the naturally mineralized aspects of the site.
- Collection of current data from Nanisivik would increase the likelihood of including impacts from mining which has continued for 17 years following the collection of the 1985 data.

In our opinion, this leaves two options open:

- Acceptance of the 1985 data for copper, lead, and zinc. JWEL has explained elsewhere in this document that the use of the 1985 background data is not invalidated if there was some minor metals contamination prior to that time.
- Use of the Ontario Typical Range (OTR) data, for metals other than copper, lead, and zinc. The OTR data represents Canadian metals data collected over a very large area, that have been statistically evaluated to identify the upper range of conditions that can be considered normal.

The OTR data were used in metals screening in the HHERA, for those elements where background data were not otherwise available. The 1985 Nanisivik background data were used in the estimation of SQROs for the human health risk assessment for lead, copper and zinc. We have discussed the use of these data for that purpose elsewhere in this response.

ERA Comment 1.4: Surface versus subsurface soil

The response does not address the question. Why was 10 to 15 cm used as a designation for surface soil? Surface soil, in terms of the ecological risk assessment should be considered as that depth of soil that will provide a reasonable potential for exposure to terrestrial biota. Consideration should be given to the depth of plant roots, and the presence of burrowing mammals and soil invertebrates. It is agreed that using the top 10 to 15 cm will provide a conservative estimate of exposure but the statement "only soil samples that accurately reflect concentrations in the upper 10 to 15 cm from ground surface are relevant to potential exposures" is false. The use of "surface" and "subsurface" to describe the soil above and below 30 cm is inappropriate unless the nature of the soil supports this. No information or discussion regarding this is provided in Section 3.2.1.

In addition, the actual value of the EPCs is irrelevant for the development of SQROs. More important is the relationship between the contaminated areas and the naturally occurring background, and the relationship between the concentration of contaminants in the soil and the concentration of contaminants in biota.

JWEL Response: The selection of a 10 to 15 cm surface layer to be designated "surface" soil was arbitrary. As was explained in the HHERA report, contamination resulting from mine activities was deposited onto the soil surface, resulting in an enriched surface layer. Data generated during the ESA process (either by Gartner Lee on behalf of the mine, or by EBA on behalf of the Government of Nunavut) was collected at a number of depth intervals in the soil profile. Examination of these data showed that using all of the soils data (disregarding depth) resulted in significantly lower EPC concentrations than using only the "surface" soils. In JWEL's opinion, in order to be conservative, the appropriate approach was and remains to segregate the soils data, and to use only the "surface" soils to estimate EPC values. To do otherwise would underestimate the present risk levels at the site.

JWEL agrees that if there was significant subsurface contamination caused by mining activities, then the Dillon comments about burrowing animals and rooting depth would be relevant. However, this is not the case, and the approach taken by JWEL remains the most appropriate, in our opinion.

The final statement by Dillon, *"in addition, the actual value of the EPCs is irrelevant for the development of SQROs"*, is correct, but misleading. It is important to know whether present metal levels on the site are likely to cause adverse effects. The EPCs provide this information, through the risk estimates presented in Tables 7.8 – 7.11 of the HHERA Report.

ERA Comment 1.5: Copper in surface water

Copper was designated as a chemical of concern and thus the data gap is a significant deficiency. The water was screened for the other contaminants where data was available. The approach should be consistent. The surface water could represent an important contaminant source depending on the concentrations of copper present and thus should be quantified. If the authors were aware of the data gaps, then the appropriate sampling should have been initiated at the beginning of the project in order to address this. Surface water sampling is a relatively simple and inexpensive process but represents an important element of the site characterization with regards to ecological risk assessment.

JWEL Response: JWEL agrees that the absence of data for copper is a deficiency, but in our opinion it is not significant deficiency to the risk assessment. As was noted in our earlier response to the similar previous comment, copper was a minor risk factor in the site soils, and the water ingestion pathway is a minor pathway for ecological receptors, when compared to the soil and food ingestion pathways. Finally, copper was a COPC for wildlife receptors only at the dock area. Intuitively, it is highly likely that copper will be remediated in this area when CanZinco removes areas of high lead and zinc contamination resulting from spillage of metal concentrates. Metals concentrations in creek water (including copper), and their potential effects on aquatic biota, will be measured as part of the aquatic Environmental Effects Monitoring program to be undertaken by the mine under the new Metal Mines Effluent Regulations (MMER).

ERA Comment 1.6: Arithmetic versus geometric means

It is agreed that the geometric mean is an alternate measure of the central tendency when data is not normally distributed. It offers the advantage of being relatively immune to outliers associated with highly skewed data sets. But, it is not appropriate to take the geometric mean of log-normally distributed data after it has been log-transformed (as is stated in Section 3.6). By performing the transform, the distribution will be normal and the arithmetic mean is the more appropriate measure of the central tendency. Section 3.6 should be corrected.

JWEL Response: We wish to confirm that in our calculations, the arithmetic mean of the log-transformed data was used, as this provides the geometric mean value. The relevant sentence in Section 3.6 contains a typographical error, and should read "hence, the EPC and BSC were calculated as the 95% UCL on the arithmetic mean of the log-transformed data". The typographical error will be corrected in Section 3.6. No correction is required to the data.

ERA Comment 1.7: Omitted metals from the screening process

The author did not sufficiently answer the question and conveniently omitted the relevant section. Metals such as mercury, barium, beryllium, chromium, selenium, tin and vanadium, that were omitted from the screening process, are of great interest from an ecotoxicological perspective. Why were they omitted from the screening process?

JWEL Response: The elements antimony, barium, beryllium, chromium, mercury, molybdenum, selenium, tin and vanadium were screened out of the HHERA at a very early stage. This was justified as not a single analytical result obtained for any of these elements through the GLL or EBA Environmental Site Assessment studies exceeded applicable generic guidelines for the protection of human health or ecological receptors. The text of the report will be amended to make this clear. Other elements, where one or more observed analytical result exceeded a relevant guideline, were carried forward into the screening process and appear in the relevant tables. Many of these were subsequently screened out, as indicated in the tables.

ERA Comment 1.8: Position of Conceptual Model in the text

Response accepted.

JWEL Response: No response required.

ERA Comment 1.9: Stream sediment characterization

Do the soil SQROs take into consideration the potential for run-off into the stream and subsequent downstream contamination of the marine environment? This is a valid concern for the development of the SQROs and needs to be considered. Additional text in the report is required.

JWEL Response: The objective of the HHERA is to develop SQROs for the terrestrial environment based upon risk to human receptors and terrestrial biota. The natural mineralization at Nanisivik has over the ages led to the formation of a metal-enriched deposit of sediments at the mouth of Twin Lakes Creek, which is documented in the 1975 report by BC Research, and elsewhere. Discharges to Twin Lakes Creek from the mine site and tailings area are subject to monitoring, and will continue to be monitored under the Metal Mining Effluent Regulation (MMER). As a result of the mine closure and decommissioning process, it is expected that metal loadings to Twin Lakes Creek will decline significantly in comparison with loadings that have occurred while the mine was operating. With reduced metals loadings from Twin Lakes Creek due to completion of the waste rock recovery plan and a cessation of operations, as well as the intended clean-up at the Dock, metals loadings to the marine environment will naturally decline over time.

Therefore it is JWEL's opinion that this pathway, while technically interesting, does not need to be incorporated into the HHERA.

ERA Comment 1.10: Site characterization focusing on ecology

The response was completely inadequate. Section 2.1 provides several sentences with reference to the physical environment and Section 4.0 discussed the Community Consultation. Please provide the requested information in the text of the report.

With regards to the selection of VECs, please refer to Comment 1.2, provided above.

JWEL Response: There are existing reports that are already in the record that describe local ecosystems. These include the 1975 reports on baseline Marine and Terrestrial environments (BC Research 1975a, b), as well as portions of the Phase II Environmental Site Assessment prepared by Gartner Lee Limited (GLL 2002). These reports will be referenced in the revised HHERA, and Section 2.1 will be expanded as requested by the reviewers.

ERA Comment 1.11: Unique characteristics of Arctic ecosystems

It is agreed that knowledge gaps can be compensated for by making conservative assumptions, but knowledge of these gaps must be understood and conveyed in the report in order to ensure that the steps taken in risk assessment are truly conservative. No information was provided regarding the unique

nature of Arctic ecosystems and the wildlife that inhabit them. No adjustments were made to the exposure limits to account for hibernation strategies or feast/famine strategies. As stated earlier, migratory species are of concern and it has to be demonstrated that the site does not contribute an unacceptable level of contaminant loading to these animals while they are on-site.

Again, the response by the author to this issue was inadequate.

JWEL Response: The review comments are interesting from a technical perspective, but do not require modifications to the Ecological Risk Assessment. The approach that was taken was to select appropriate VEC organisms that are known to be present on the site, and have life history characteristics that make them suitable and representative for the risk assessment. None of the organisms that were assessed are "hibernating" animals. Lemmings, Ptarmigan, Arctic fox and Gyrfalcon remain active throughout the year, and the life history characteristics that were used to describe these animals in the risk assessment were selected to be suitable and conservative descriptors of their behaviour.

While we agree that unique life history strategies might alter (increase) exposure to contaminants, the hibernation strategy is not one of these. Feast and famine strategies are common to many wildlife species, and these variations in feeding rate are accommodated by the life history traits that have been included in the risk assessment. Migratory behaviour will result in much lower estimates of risk than those that have been evaluated for resident biota. JWEL is not aware of any significant biota or life history strategies, that should be assessed, that will result in a substantive change in the conclusions of the risk assessment.

The guidance of the Canadian Council of Ministers of the Environment on Ecological Risk Assessment (CCME 1996) states that a three-tiered framework composed of sequentially more sophisticated and complex evaluations is recommended. If the ERA process was triggered due to significant ecological concerns and the results indicates that they are not at risk, the process ends (CCME 1996). It remains our opinion that the risk assessment that has been carried out to date is reasonable and conservative and that the results do not indicate a need for more detailed analysis.

ERA Comment 1.12: Terrestrial invertebrates

Disagree, the statement that soil invertebrates will be rare is unfounded.

"About 2,000 species of resident arthropods (insects, spiders, mites, and related forms) have been reported from the North American arctic, and probably about the same number of additional species are yet to be recognized or discovered. Over 550 species have been found in the high arctic Queen Elizabeth Islands."

From "The Biological Survey of Canada"

Terrestrial invertebrates represent an important element of all biologically active soils, and the Arctic is certainly no exception. Although a primary role will be as decomposers, they will likely represent a food source as well. Birds (particularly the ptarmigan) and small mammals, including the fox, will utilize this food source. The potential for these invertebrates to be significant vectors for metal bioaccumulation needs to be included as a pathway.

Direct impacts of the contaminants on soil microbes and microbial processes in the soil are also important and should be included as a VEC within the risk assessment. This is supported by the following excerpt.

From the Nordic Arctic Research Program

"The vast majority of studies of physiological adaptations in invertebrates have concerned themselves with single stress types. The Arctic environment is a sink for a large number of environmental contaminants and there is a growing body of evidence suggesting that tolerance to climatic stress may be decreased by pollution. The ecological implications of this synergism is that pollution in arctic regions may play a much more dramatic role for local extinction and the geographical distributions of species than in more benign climates. Investigation of this type of synergism will be a central element in Arctic risk assessment.

JWEL Response: The Dillon response to our earlier statement has keyed on a single aspect of the response: the statement that "soil invertebrates are expected to be rare". We acknowledge responsibility for unclear wording in our earlier response. JWEL did not mean to suggest that few species of soil invertebrates are known from the Arctic. Our intent was to convey the idea that one of the characteristics of the Nanisivik site is its barren nature. Over most of the site there is little or no vegetation, no soil development, and there will be a low abundance of soil invertebrates.

In those intermittent areas where vegetation is present, it is expected that wildlife will find most of their food resources. The conceptual model for the ERA was constructed with these areas in mind. There are no shrews known from Baffin Island, and it is these small mammals, which are insectivorous or eat earthworms, which the soil to soil invertebrate to mammal pathway would normally be built around.

There is no reason to suggest that soil microbes or soil invertebrates are inherently more sensitive to metals than are mammals and birds inhabiting these environments. Finally, even if small pockets of soil were subject to impacts arising from high metals concentrations (either naturally occurring at Nanisivik or anthropogenic), the mammals and birds living on the site have home ranges that would allow them to exploit other resources. Therefore, impacts are unlikely at the population level for the wildlife VECs that were assessed. JWEL remains of the opinion that the VECs that have been assessed are appropriate

and adequate for this risk assessment. The Hazard Quotient values that have been estimated are low for all VECs, and even if they are summed, are still less than 1. The results of the ERA do not indicate any need for further or more detailed assessment.

ERA Comment 1.13: Soil to plant bioaccumulation models

Soil pH is an important modifier of both the fate/behaviour and toxicity of metals in soil. if the authors were aware of this data gap, why was it not addressed.

The paper by Efroymson et al. (2001), provides 4 equations (two that consider pH and two that do not). For zinc, the consideration of pH significantly improves the correlation (r^2 of 0.85 versus 0.32). Without pH, an r^2 of 0.32 to 0.40 hardly provides strong predictive power. The author should refer to the graphs on page 2564 of the journal paper to get a better understanding of the "predictive powers" associated with these models.

The author should also review a paper presented by Fordham et al. (1999) that provides an evaluation of the bioaccumulation models. Their conclusion was that in order to estimate the contribution of dietary pathways in risk assessment, at least limited tissue data from the site should be collected. Was this considered during the conception of the risk assessment and identified as a data gap?

JWEL Response: The soil to plant bioaccumulation models that were selected were, in the opinion of JWEL, the best available and most appropriate for the site. Given the range of soils concentrations measured, the wide variety of plant types included in the database, and the fact that the data came from an analysis of many different studies, the relationships are in fact quite remarkable. In addition, the levels of statistical significance obtained (p=0.0001) are also remarkable.

The reviewers suggest that JWEL should revisit the Efroymson et al. (2001) paper. We have done this and found that the paper shows that although the addition of pH to the plant uptake model for zinc resulted in an r^2 value of 0.85 for the "original" dataset, it achieved only an r^2 value of 0.41 when the original and validation datasets were combined. This was effectively unchanged from the original result, and did not build confidence in the pH-adjusted model.

Finally, the alternative to using a regression model, which has a demonstrated high level of statistical significance and power, is to use the mean value of a large number of independent studies. The mean value as a "model" has an r^2 value of zero, and fails to take advantage of variations in soil metals concentrations, which are demonstrably an important factor in predicting soil to plant uptake factors.

We remain of the opinion that we have used an appropriate relationship to describe soil to plant uptake factors. We agree that collection of tissue data from the site would be helpful, although not essential.

ERA Comment 1.14: Exposure estimates

Although a relatively minor point, the first issue regarding the title of the section was not addressed. The title should be modified accordingly.

The deficiency may be considered insignificant to the outcome but the predicted values in Tables 7.8 to 7.11 need to be corrected to reflect contributions from background exposure. The values for the Gyrfalcon are incorrect. Again, the short sitedness jof the authors in not ensuring that adequate background data was available, is not a valid excuse.

JWEL Response: JWEL remains comfortable with the title of this section, and does not propose to modify it.

Correction is not required for Tables 7.8 to 7.10, since for these VECs, home ranges were sufficiently small that risk in the townsite and dock areas did not need to be corrected (lemming and ptarmigan), or was compensated for by assuming alternate residency in the general mine area (fox).

Regarding background exposures to Gyrfalcon (Table 7.11), possibly the reviewer is suggesting that JWEL should obtain a statistically valid and representative estimate of the background metals concentrations over an area of 100,00 ha or more of northern Baffin Island. In the absence of such an effort, which JWEL does not believe is justified by the facts, background data that will be satisfactory to these reviewers do not appear to be available.

The HHERA report makes it clear that for Gyrfalcon, the exposure estimates reflect only the exposures at the mine site, and do not include background metals that it might encounter elsewhere in its range. However, the Total Ecological Hazard Quotients for the Gyrfalcon are so low (0.0022 or lower) and the mine area is sufficiently large (about 0.05 of the home range of the Gyrfalcon) that the background concentrations of cadmium, copper, lead and zinc would have to be at least an order of magnitude higher than those at the mine site in order to result in hazard quotients approaching unity.

JWEL respectfully suggests that this situation is not likely to exist, and that the risk to Gyrfalcon, with or without consideration of background metals concentrations, can be dismissed.

ERA Comment 1.15: Site remediation recommendations

The reviewer does not require information to be stated "simply". It would be appreciated, however, that information, both in the RA report and the comments, be stated, accurately, clearly, concisely, and properly supported with data and/or references.

The "hotspots" either represent a risk to ecological receptors at the population/community level or they do not. Using a phrase such as "there may be some benefit" is vague and meaningless within the context of the risk assessment and the application of the SQROs. If the issues are associated with aesthetics and public perception then this needs to be made clear in the report text.

JWEL Response: JWEL holds the opinion, based upon the analysis presented in the HHERA report, that the hotspots do not represent a significant risk to ecological receptors at the population or community level. However, as participants in the review process, including consultations in Arctic Bay with community members and with various government agents at the technical meeting in Iqaluit, we appreciate that any reduction in metal levels achieved by cleanup in limited areas will provide comfort to members of the public, and to the regulatory community. As responsible stewards of the environment, CanZinco has indicated its willingness to undertake this cleanup wherever practical, even though it is not indicated as being required on the basis of the risk assessment.

ERA Comment 1.16: Chemical interactions

The comment provided is inadequate, irrelevant and significantly different from the position provided in Section 7.9 of the risk assessment document. The interaction of metals with regards to wildlife toxicology is not simply a function of similarities in the mode of toxic action. It is unclear what is meant by the physiological behaviour of a metal. And the fact that cadmium and lead have no known biological function is irrelevant in terms of the potential for interactions.

JWEL's statement regarding chemical mixtures included that "there is considerable uncertainty associated with the additive approach in that risk may be greatly overestimated or underestimated." This latter element is of considerable importance and requires further discussion with respect to the potential risks to wildlife and the impact on the SQROs. Is information available to support this statement (provide reference) and how does it apply to the current group of COCs under the conditions present at the mine site?

JWEL Response: JWEL intended the additional information that was provided to be constructive, and to add to the information provided in Section 7.9 of the HHERA document. To clarify, the essential metals are subject to physiological regulation, and are readily managed (excreted or detoxified) by most animals when exposures are high. Thus, for copper and zinc there is usually a broad range of dose that can be tolerated. In contrast, metals like lead and cadmium are less readily managed, physiologically, and may tend to accumulate in certain tissues (such as kidney or bone). Thus, the term "physiological behaviour" refers to the internal partitioning, fate, and physiological mechanisms for handling metals at the subcellular, cellular, tissue and organ levels of organization.

As an indication of the complexity of modelling interactions, we refer Dillon to the ATSDR (2002) report on chemical interactions among arsenic, cadmium, chromium, and lead. While the above

referenced report is specific to human toxicology, many of the supporting studies and data are based on other mammalian models. Therefore, many of the conclusions may be expected to apply to wildlife, as well as to humans. The report notes that:

"The binary mixtures with the most extensive interaction databases are the lead-arsenic mixture and the lead-cadmium mixture. The predicted direction of interaction for these mixtures is not consistent across endpoints. This observation is most striking for the effects of cadmium on the toxicity of lead. The predicted direction is greater than additive for the neurological effects (the critical effect) and testicular effects (a less sensitive effect), less than additive for renal and hematological effects, and additive for cardiovascular effects" (ATSDR 2002).

JWEL is not aware of documentation at the level of ATSDR (2002) that addresses the toxicity of other metals that were included in the ERA, such as silver, copper and zinc. At the present time, it remains our professional opinion that insufficient data exists to properly estimate the combined effects of metal mixtures on wildlife receptors, and that the best approach is to evaluate the potential effects individually in a conservative manner.

However, we reiterate that even if an additive approach is taken, the ERA has shown that no substantive risks to wildlife receptors are present at the Nanisivik mine site.

5.2 Review of Responses to HHRA Comments

HHRA Comment 2.1: Identification of COCs

The original comment indicated that not all potential COCs had been considered in the HHRA. The JWEL response indicates that the HHRA focused on metals because CanZinco has indicated that soil contamination with other COCs will be remediated. Therefore, JWEL indicates that it is not necessary to include these compounds in the HHRA. The only way that this can be considered valid is if remediation is intended to mean that all other COCs will be completely removed from the site. The current responses from JWEL indicate that the intent is to bury these contaminated soil in the permafrost where they will become encapsulated, thereby eliminating exposures. While this would appear to be an adequate means of limiting or eliminating exposures, there will likely be some requirement for monitoring to ensure that the assumptions made regarding disposal are indeed correct. Provided that measures are put in place to ensure that the intended remediation option is effective, the elimination of these COCs from the human health risk assessment is adequate. However, the explanations provided in the Response Comments should be included in the final report.

JWEL Response: It is our understanding that post-remediation monitoring will be an integral part of the remedial solution and that the effectiveness of the cover will be established by this monitoring. It is unlikely that other COCs will be removed "completely" as this is rarely a practical option, nor do we believe that "complete" removal is necessary. It is the intent to adopt generic guidelines (e.g., CCME) to govern the remediation of other COCs.

HHRA Comment 2.2: Use of Bioavailability Factors

The original comment related to the inappropriate use of bioavailablility factors to adjust exposure estimates without the corresponding adjustment of the toxicity reference values (TRVs). The response provided by JWEL indicates that bioavailablility factors (AF) for soil has been set to be the same value that was used for game. This seems to indicate that the revised report has applied a bioavailablility factor of 100% to all components. If this is indeed what was done, then the issue has been appropriately addressed. However, the current response provided by JWEL is confused and difficult to follow. If a factor of 100% has been used, this should be clearly stated.

JWEL Response: JWEL did adopt the reviewer's recommendations and this issue has been appropriately addressed. To clarify, the oral bioavailability factors now incorporated into the risk calculations are as follows:

- Cadmium - 100% for both dietary intake and soil ingestion;
- Lead - 100% for dietary intake; 60% relative bioavailability for soil ingestion; and
- Zinc - 100% for both dietary intake and soil ingestion.

Adoption of the above bioavailability factors will overestimate the intake of cadmium and zinc by soil ingestion as contaminants are generally less bioavailable from soil than from the dosing media used in laboratory toxicity studies. The relative bioavailability for lead in soil is adopted from the default value employed by the US EPA in their IEUBK model for childhood lead exposure. This value is supported by many studies in the scientific literature. An overview of this issue can be found in ATSDR (1993) . It is likely that the relative soil bioavailability of lead is still overestimated for Nanisivik where much of the lead from the ore concentrate would be in sulphide form which has a low bioavailability.

HHRA Comment 2.3: Soil Ingestion Factors for Toddlers

The JWEL response to this comment appears to have addressed the original concern. However, the data have not been reviewed in detail to determine if appropriate exposure averaging factors have been applied in the adjusted calculations.

JWEL Response: JWEL adopted the reviewer's original recommendations on this point and the issue has been addressed. Exposure averaging factors were based on 30 year climate normals published by Environment Canada for Pond Inlet and Arctic Bay.

HHRA Comment 2.4: Apportionment of Soil Ingestion Rates

The initial comment was directed at the fact that exposures to metals in indoor dust were being treated as background exposures. By definition, background exposures are not related to site sources. This clearly is not the case for metals in Nanisivik, where the levels of metals in indoor dust will be driven by the levels of metals in outdoor soil and dust. Thus, both indoor and outdoor dust exposures must be considered in the development of the SSTLs for metals in soil.

The JWEL authors are correct in indicating that apportionment of intake between outdoor and indoor soil/dust in a common practice in risk assessment. However, inclusion of these types of considerations in a risk assessment requires substantial scientific justification to support the apportionment selections. None of this justification was provided in the original report and has not been provided in the current response document. In the absence of this justification, it is possible to say that the approach used in the report is valid, but it is not possible to state that the assumptions used as values in the approach are sound. Until such justification is provided, it is not possible to fully evaluate the SQROs developed in the HHERA.

JWEL Response: This issue is addressed above in the response to the same concern raised by INAC.

HHRA Comment 2.5: Receptor Parameters

Drinking Water Consumption Rates

The drinking water consumption rates used by JWEL are inadequate. JWEL indicates that a drinking water ingestion rate of 0.2L/day was used as indicated by Health Canada. The rationale for using this low value rather than the standard 0.8L/day is based on the fact that the upper limit includes the consumption of drinking water as part of food and reconstituted drinks. This suggests that the use of the upper limit would result in some level of double counting of exposure. However, the are a couple of problems with this.

Firstly; for the toddler, the Health Canada estimates of the intake of foods/drinks that may contain tap water account for approximately 173 grams/day (0.173 L/day) which is short of the 0.8 L/day cited by Health Canada as recommended daily intake. Therefore, using 0.2 L/day and assuming that the remainder is accounted for by the use of tap water in food preparation results in an daily intake of approximately 0.4 L/day which is only 50% of the recommended value.

Secondly; The current report classifies food intakes as a non-site or background source. Using this approach effectively limits the estimated intakes to a total tap water exposure of 0.2 L/day. It is reasonable to assume that local drinking water will be used for cooking and preparing other drinks in the homes in this community. Therefore, excluding these intakes from tap water under estimates the exposure to metals in drinking water. If as the authors suggest, that drinking water accounts for less than 5% in the current assessment (based on an estimated daily intake of 0.2 L/day) this would rise to somewhat less than 20% if proper drinking water ingestion rates had been used.

JWEL Response: JWEL adopted the approach and default values for calculation of the drinking water portion of the EDI directly from the Health Canada technical supporting document to the CCME generic soil quality guideline for lead and believe that the approach contained therein is appropriate. It is important to note that modifications to the drinking water portion of the EDI will have only a minor effect on the outcome of the risk assessment calculation. Drinking water ingestion accounts for only 7.5% of the EDI (not 7.5% of the risk assessment) and if modified as suggested by the reviewer would result in a 15% increase in the EDI. In turn, this would result in a change in the calculated HQ of only 0.03. JWEL will provide a qualitative discussion of this variable in the final report to address any potential uncertainty but will continue to follow the Health Canada guidance for the risk calculations.

Inclusion of drinking water ingestion as a separate exposure pathway outside of the dietary intake built into the EDI would result in double counting this intake and would not be appropriate. According to CanZinco, the Nanisivik town water supply is tested and no problems have been reported.

Receptor Body Weights

The response provided by JWEL is adequate. However, the fact that the values selected for use in the assessment are less conservative than those typically used in a standard risk assessment should be acknowledged and the effect that this lack of conservatism will have on the overall conclusions should be properly addressed.

JWEL Response: The values chosen by JWEL were adopted from the most up to date source for this material and are the values most commonly chosen in current human health risk assessments. The values used in the Nanisivik risk assessment are the values typically used in risk assessments in Canada and we do not believe that there is any lack of conservatism in these values.

Receptor Inhalation Rates

The response provided by JWEL is adequate. However, if these values are to be used, it will be necessary to adjust the inhalation toxicity values to account for the differences in inhalation rates between the assumptions used in the development of the values and the inhalation rates used in the report.

JWEL Response: Adjustment of the inhalation TRV only applies to cadmium as the TRVs used for lead and zinc were adopted from the oral route of exposure. This adjustment has already been incorporated into the risk assessment. The cadmium inhalation TRV used by JWEL was the Tumorogenic Concentration (TC_{05}) published by Health Canada. The TC_{05} was converted to a cancer slope factor using the inhalation rate and body weight used in the HHRA.

HHRA Comment 2.6: Review of Calculations

Bioavailability Factor for Lead in Drinking Water

If, as the authors suggest, a bioavailability factor is not used, then reference to its use should be removed from the text of the report.

JWEL Response: JWEL confirms that no bioavailability was applied to lead intakes from drinking water and will ensure that no such reference exists in the final report.

Background Soil/Dust Apportionment

The original comments were intended to indicate that justification is required to support the values used. Although JWEL indicates that this issue has been addressed in previous comments, as noted above, the scientific justification necessary to support the assumption made in this report have not been adequately provided.

JWEL Response: This issue has already been addressed in our response to INAC above.

Calculation of SSTLs for Lead and Zinc
The JWEL response is adequate

JWEL Response: The reviewer indicates that JWEL's response to his original comment is adequate.

5.3 Responses to Additional Questions

At the end of the Dillon document, several questions were included which were relayed from their client (Acres) via email on May 29, 2003. Dillon has provided and included answers to these questions. JWEL assumes that by inclusion of this information our comments are also requested. The questions from Acres are presented below in underlined format. Responses from Dillon appear in italics.

3.1 *Did Canzinco properly and satisfactorily address your questions and comments?*

The responses provided by CanZinco/JWEL adequately address some of the issues raised in the original review. However, as noted above, a number of outstanding issues remain to be resolved. Some of these will have an effect of the SQROs calculated for the community.

JWEL Response: We trust that the additional responses included in the present document will have brought closure to these issues.

3.2 *Looking at the replies to queries brought forward by other peer reviewers, are there other concerns that you feel need to addressed?*

The JWEL response report provides abbreviated versions of the comments provided by reviewers. This makes it difficult to determine if all comments are adequately addressed. However, based on the present information, it would seem that the reviews have identified all of the major concerns that could have an effect on the conclusions of the report.

JWEL Response: No response required.

3.3 *Do you have confidence that the revised SQRO values can be accepted and used to implement the remediation program at Nanisivik?*

Based on the comments of the human health component of the HHERA related to issues such as drinking water intake estimates, an additional round of revision and review will likely be necessary before the report can be considered to be acceptable.

JWEL Response: We believe that we have provided the additional information needed to bring closure to these issues.

3.4 *Do you think public health concerns brought forward by Government of Nunavut may affect the remediation objectives set by the revised SQROs for the town site?*

The issues related to the selection of background concentrations may have an effect on the final SQROs developed for the community. If the background levels used in this report are high and not reflective of actual background, then the SQROs developed for the site will be higher than they would be if lower background concentrations were used.

JWEL Response: This is a misconception, as we have explained in this latest round of responses to review comments. High background metal levels will lead to reduced SQRO values.

With regard to the issues related to the carcinogenic potential of lead and the effects of metal exposures on pregnant women, the issues raised by GN should not have an effect on the SQROs developed for the community. It should be noted that the development of toxicity values by regulatory agencies incorporated considerations for sensitive members of the populations such as pregnant women. The final toxicity value is based on the biological end-point that occurs at the lowest dose and therefore provides adequate protection against biological effects that only occur at higher dose levels. Thus, the investigation of metals exposures on pregnant women is unlikely to alter the conclusion of the risk assessment.

JWEL Response: No further discussion is required.

3.5 *Do you believe that the revised SQRO values are reasonable; and given their background, available data and existing CCME and other guidelines, should these values be accepted for the site remediation?*

Before the SQROs can be considered reasonable, we need to be confident that the concentrations of metals in the soil that are being used to represent background are truly representative and appropriate for such use. In addition, the review has identified a couple of areas where additional clarification is required to ensure that exposures and risks have not been under estimated. Until these issues are resolved, it is not possible to conclude that the SQROs are reasonable.

JWEL Response: We have provided additional explanation that should resolve this issue.

3.6 *Are there any concerns about the complaints of using the 1985 baseline study? If it is not acceptable, what baseline, or older reading were available to compare?*

As noted in previous comments, there are some legitimate concerns related to the use of the 1985 baseline study as an indicator of background. The JWEL report does not provide sufficient justification to support the use of the 1985 data. Additional clarification is required.

JWEL Response: We have provided the additional clarification that was requested.

3.7 *Do you agree with the Canzinco position that the work has been conducted in a conservative manner?*

The work has been carried out using standard and customary risk assessment procedures. In general, these provide conservative estimates of risk. However, because the report is intended to be a site-specific assessment, a number of site-specific assumptions have been used. While this is appropriate and in keeping with the conservative nature of a risk assessment, a number of assumptions have been used which are not as conservative as would typically be considered in a risk assessment of this nature. For example, the drinking water ingestion rate is lower than standard and the apportionment of dust intakes between indoor and outdoor events is also less conservative than standard. While these may be satisfactory, they require more scientific justification before they can be considered to be conservative in nature.

JWEL Response: The reviewer was asked whether he agreed that the work has been conducted in a conservative manner. In reply, the reviewer acknowledges that the risk assessment has been carried out using standard and customary risk assessment procedures and that, in general, these provide conservative estimates of risk. However, he cites some examples of assumptions made that in his opinion are "not as conservative as would typically be considered in a risk assessment of this nature". Specific examples are the drinking water ingestion rate and the indoor/outdoor soil/dust apportionment. As noted above, the issue of the drinking water ingestion rate does not have a significant effect on the risk assessment outcome and should not be construed as resulting in an unconservative assessment.

We believe that the risk assessment has been conducted with several layers of conservatism and likely overstates the risks at the site. We would like to offer some examples of these factors:

- **Indoor/outdoor soil/dust apportionment –** the HHRA assumes that indoor dust is entirely derived from outdoor soil and that the COPC concentrations in the dust are exactly the same as the concentrations in the soil. In reality, a portion of indoor dust comes from other sources and dust COPC concentrations are typically lower than outdoor soil COPC concentrations. Extensive risk assessment studies conducted by the Ontario Ministry of the Environment (OMOE) in Port Colborne, Ontario, confirm that indoor dust concentrations are approximately 39% of outdoor soil concentrations in that community. The OMOE incorporate this ratio into their derivation of soil quality guidelines for various metals. The assumption that indoor dust concentrations are 100% of outdoor soil concentrations in Nanisivik is inherently conservative.
- **Uptake of metals in small mammals –** the uptake equations used to predict tissue concentrations in small mammals are based on whole body concentrations, not specifically the meat that would then be consumed by the human receptor. This assumes that all metals ingested by the animal go into the

tissue. This is a very conservative assumption that over predicts uptakes via wild game consumption. In reality, a significant portion of the metals ingested by the animal would be remain in the gut, be excreted, or accumulate in other body parts (e.g., organs or bone).

- **Bioavailability –** the risk assessment assumes 100% bioavailability of cadmium and zinc from soil which will significantly overestimate actual intakes. For lead, the bioavailability of sulphidic forms of lead likely found at Nanisivik from the mining operation will be less than the default value adopted in the risk assessment, again overestimating intakes.

- **Toxicity Reference Values –** toxicity reference values used in risk assessment incorporate uncertainty and modifying factors that inherently overestimate potential risks or, in the case of lead, are based on no observable effects levels that result in a conservative analysis.

For reference purposes, it is informative to note that the proposed lead SQRO for the Nanisivik townsite of 600 mg/kg is half of the US EPA national soil lead hazard standard of 1,200 mg/kg for bare soil in residential yards. The US EPA soil lead hazard standard is applicable to any residential property in the US where exposure to soil can be expected to occur 365 days per year. In Nanisivik, permafrost and snow cover will limit soil exposure for a portion of the year.

We believe that the proposed SQROs for Nanisivik are appropriate and conservative.

6.0 REFERENCES

ATSDR (Agency for Toxic Substances and Disease Registry). 1993. Toxicological Profile for Lead. U.S. Department of Health and Human Services, Public Health Service, ASTDR, Atlanta, GA.

ATSDR (Agency for Toxic Substances and Disease Registry). 2002. Draft Interaction Profile for: Arsenic, cadmium, chromium and lead. Division of Toxicology, ATSDR, Public Health Service, U.S. Department of Health and Human Services, Atlanta, GA.

BC Research 1975a. Baseline Survey of the Marine Environment at Strathcona Sound, N.W.T. Prepared for Strathcona Mineral Services. March 1975.

BC Research 1975b. Terrestrial Environmental Studies at Strathcona Sound, N.W.T. Project 1552. Progress Report No. 2, Prepared for Strathcona Mineral Services March 1975.

Campbell, B.C., A.D. Beattie, M.R. Moore, A. Goldberg, and A.G. Reid, 1977. Renal insufficiency associated with excessive lead exposure. Br. Med. J. i:482.

CCME (Canadian Council of Ministers of the Environment). 1996. Framework for Ecological Risk Assessment: General Guidance. CCME Subcommittee on Environmental Quality Criteria for Contaminated sites. En 108-4/ 10-1996E.

Efroymson, R.A., B.E. Sample and G.W. Suter. 2001. Uptake of inorganic chemicals from soil by plant leaves: Regressions of field data. Environ. Toxicol. Chem. 20: 2561-2571.

GLL (Gartner Lee Ltd.) 2002. 2002 Phase II Environmental Site Assessment, Nanisivik Mine, Nunavut, Site Characterization. Prepared for CanZinco Limited.

Lilis, R., A. Fischbein, S. Diamond, H.A. Anderson, I.J. Selikoff, W. Blumberg, and J. Eisinger, 1977. Lead effects among secondary lead smelter workers with blood lead below 80 ug/100 mL. Arch. Environ. Health 32:256.