MEMO

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SUBJECT: Peer Review Human Health and Ecological Risk Assessment for the Nanisivik Mine

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As per your request we have reviewed the human health and ecological risk assessments for the Nanisivik Mine, prepared by Jacques Whitford Environmental Ltd (JWEL). The review comments are presented in 3 sections. The first presents issues related to the ecological risk assessment. The second presents issues related to the human health risk assessments. The final section addresses the additional questions raised by Acres.

1. Ecological Risk Assessment Review

In general, the ecological component of the risk assessment for the Nanisivik Mine was conducted properly and in accordance with standard and accepted risk assessment practices. Within the scope of the assessment, as indicated in Section 7.0, the conclusions appear to be acceptable. There were a number of points, however, that require further clarification or correction, but it is felt that none of these issues will significantly impact the conclusions of the risk assessment. Of particular concern were the number of potentially significant data gaps with regards to the characterization of background soil, surface water, and sediment quality. This deficiency impacted every level of the assessment from the screening of COCs to the estimation of exposure, the assessment of risks, and the subsequent derivation of SSTLs intended to be protective of indigenous wildlife. This and other issues requiring further clarification and/or correction are listed in the following sections.

.1 The scope of the risk assessment considers all potential contaminants within the mine site as identified in the GLL and EBA documents. A review of the GLL (Gartner Lee, 2003) document indicates a number of contaminants of concern in addition to those screened in the risk assessment. A summary of the table from this document is provided below.

Contaminants of Environmental Concern

Volatile Petroleum Hydrocarbons: Constituents of gasoline (<C10), benzene, ethylbenzene, toluene and xylene ("BETX") compounds;

Extractable Petroleum Hydrocarbons: Constituents of diesel, oils and greases (>C10);

Naphthalene: Constituent of diesel;

Chlorinated Ethenes – Volatile Organic Compounds: Constituents of Xanthate; and

Cadmium, Copper, Lead, Zinc: Constituents of ore, concentrate and tailings.

These contaminants should be included in the screening process used to identify Chemicals of Concern, or a rationale needs to be provided for excluding them from the risk assessment.

.2 The selection of Valued Ecosystem Components also seems to ignore the information provided in the Phase II Environmental Assessment provided by Gartner Lee. It is advisable to consider a broader range of wildlife and not restrict the assessment to animals that have been noted in the area. It is recommended that caribou, snow geese or eider duck, a polar bear, and the aquatic ecosystem (freshwater and marine) be included as VECs. It is understood that the local freshwater streams and lakes do not support fish populations but there are other elements of an aquatic ecosystem (invertebrates and plants) that are important. Impacts to marine sediments have been documented in the Phase II report and are the result of contaminants migrating from the mine site via the freshwater streams. Some discussion regarding this is warranted. Either the assessment of potential risks to marine wildlife is included in the report, or a rationale needs to be provided for excluding this area from the risk assessment.

.3 Data characterizing the unimpacted or background areas are crucial for both screening the chemicals of concern and for quantifying exposure to VECs. It appears that background data was available for only three metals (copper, lead, and zinc). Background information for cadmium, and any of the other contaminants of potential concern, should have been collected as part of the risk assessment process. If surrogates, such as the Ontario Typical Range, are to be used, some discussion is necessary to support the validity of these values for application to soils in Baffin Island. It is unlikely that metal concentrations in soils typical of Ontario are representative of what is present in the vicinity of a mine in Northern

Canada. It is strongly recommended that a more appropriate source of background information be identified and used.

.4 Section 3.2 Selection of Data: Please provide a reference for the designation of the upper 10 to 15 cm of soil as "surface soil" while that below would be subsurface soil. In most jurisdictions the cut-off depth is 1.5 m. For burrowing animals, plants and humans, the top 15 cm does not necessarily represent the only soil that is "relevant to potential exposures". If permafrost is felt to provide a barrier to soil exposure, then this needs to be documented and explained.

.5 Section 3.5.2 Water: As with the background soil data, the contaminants studied in the local streams and lakes were limited to cadmium, lead and zinc. This time copper was omitted. A complete data set is required both for COC screening and the assessment of wildlife exposures. Where significant data gaps are identified, some discussion is required regarding the use of available data from similar sites or areas, or the use of generic values.

.6 Section 3.6 Statistical Analysis of Data: For the derivation of EPCs, why was the geometric mean used? For this type of data, the arithmetic mean would be more appropriate and more conservative. If the geometric mean is appropriate, please provide a reference.

.7 Table 7.1: The screening procedure considers only 10 metals while section 3.5.1 indicates that as many as 19 were analyzed in the soil samples. Why were metals such as mercury, barium, beryllium, chromium, molybdenum, selenium, strontium, tin and vanadium omitted from the screening procedure?

.8 Section 7.2 Conceptual Model: The conceptual model would be more appropriately placed after the discussion regarding Valued Ecosystem Components (VECs).

.9 Figure 8 Conceptual Site Model for Ecological Receptors: Sediment from the local streams should also be considered as a source media along with terrestrial invertebrates. For the marine ecosystem, both the surface water and the sediment should be considered. If these are to be exluded, some discussion is required.

.10 Section 7.3 Receptor Identification: In order to demonstrate an understanding and appreciation of the local ecosystem, some details regarding the local environment, food webs, migratory species, typical Arctic flora and fauna would be useful. Once this is developed, the selection of surrogate species and VECs becomes much clearer. As mentioned earlier, waterfowl, large herbivores, large carnivores, terrestrial plants, soil invertebrates, microbial processes, and aquatic species (both freshwater, and marine) should also have been considered. Further explanation is required since the statement, "Receptors were selected to be representative of all potential wildlife receptors at the site" is clearly false.

.11 Section 7.3.1 Receptor Characterization: One of the challenges associated with the assessment of Arctic ecosystems is the application of receptor characteristics, exposure factors, and toxicity data developed with animals typical of more temperate climates, to animals that endure the cold, harsh and long winters typical of Canada's northern areas. It is often unrealistic to address this in a quantitative manner but some discussion is required that includes the following:

- i migratory versus non-migratory species and exposure on-site versus exposure from the more southerly part of the animals range;
- ii feast-or-famine feeding habits associated with mammals that remain in the area all year round particularly with respect to contaminants that have the potential to bioaccumulate or are stored in fatty tissue; and
- iii hibernation and other winter survival strategies.

.12 Section 7.4 Exposure Assessment: Additional sources of exposure should include terrestrial invertebrates (thus a soil-to-invertebrate uptake factor should be considered), and the ingestion of sediment from the local streams.

.13 Table 7.5 Uptake Factors: The paper by Efroymson et al. (2001) provides several equations relating the concentration of the contaminant in the soil to that in the plant. Please explain what rationale was used to make the selection. There seems to be a discrepancy for zinc. By including the soil pH, the correlation appears to improve but this was not incorporated into the risk assessment.

.14 Section 7.5 Exposure Estimates: This section seems to be named improperly. Exposure estimates are not provided and only a brief description of the approach is included. In addition, it appears that the approach used for the exposure assessment included only the potential for metal intake from the site. For animals with a small home range (i.e., smaller than the site area), this is appropriate. For animals whose home range extends beyond the area of the site, exposure associated with the background must also be included. Exposure limits consider the total daily exposure and all relevant contributions to this exposure should be quantified. If elements are missing then only a fraction of the exposure limit (often 20%) can be applied. This needs to be corrected and will impact both the value of the hazard quotients, (Tables 7.8 to 7.11) and the SSTLs (Table 7.12).

.15 Section 7.7 Site-Specific Threshold Limits (last paragraph): The statements “These results indicate that there may be some benefit to ecological receptors if remedial activities are undertaken at areas where the soil metals concentrations (lead and zinc) exceed the $SSTL_{ECO}$.” and “However, the overall ERA results indicate that the existing conditions at Nanisivik are not likely to result in adverse effects to exposed biota at the population level” are contradictory and are not adequate in terms of discussing the results of the ecological risk assessment. The assessment endpoints were defined and were aimed at protecting indigenous wildlife at a population /community level. Interpretation of the SSTLs needs to be framed within this context both in terms of defining the potential risks and the application of the SSTLs with regards to site remediation. Further discussion and analysis of the results is required.

.16 Section 7.9 Chemical Interactions: The issues associated with chemical mixtures and chemical interactions, both within the environment and within an animal or plant, should be discussed as part of the “Model Assumptions and Uncertainties”. In the last paragraph, a number of good points are raised regarding the potential similarity of toxicity characteristics, modes of toxic action, sites of toxic action, structural similarity and the potential for chemical interactions. However, the instance of chemical interactions in the environment are not rare and there is a growing body of literature that looks at these interactions and how they impact on toxicity to wildlife. The Efroymson et al. paper (2001), sited in the risk assessment, is a good example of how the soil pH is incorporated into the exposure assessment of metals. It is agreed that the uncertainty introduced by chemical interactions is potentially significant but making the statement that “ risk may be greatly overestimated or underestimated” with the additive approach, is misleading, and undermines the conclusions of the assessment. Further clarification is required with specific reference to the site, the COCs and the VECs. If addition of the HQ values greatly underestimates the risk, the SSTLs are inappropriate and would require reassessment.

2 Human Health Risk Assessment Review

In general, the human health risk assessment for the Nanisivik Mine was conducted in accordance with standard risk assessment practices. Within the scope of the assessment, the conclusions generally appear to be correct. There are some issues that require clarification and/or correction. Addressing these issues may alter the SSTLs from the values that are currently presented in the report. However, these changes are not expected to have a significant effect on the conclusions of the report. Of particular concern are, the identification of chemicals of concern in the screening process, the use improper use of bioavilability factors to adjust exposure estimates and the soil ingestion rate factors used for toddlers. The issues that require clarification/correction are discussed in the following sections.

.1 Identification of Contaminants of Concern

The current assessment focuses on metals. However, as noted in the review of the ecological risk assessment, other contaminants of potential concern were identified during the Phase II ESA. These chemicals should have been considered in the HHRA.

.2 Use of Bioavailability Factors

Section 6.3.2 of the report correctly defines bioavailability as the amount of material that is absorbed into the blood at the point of exposure. However, the report also indicates that bioavailability factors are used in the risk assessment *to more realistically represent the portion of contaminants held in the soil that are available.* Based on this, it is unclear if the authors are intending to use bioavailability factors to describe the amount of metal released from the soil into the gut that is available for uptake, or if bioavailability is intended to define the amount of a metal that is absorbed from the gut into the blood.

The amount of metal released from the soil into the gut that is available for uptake is described by a bioaccessibility factor and not a bioavailability factor. These two factors address very separate and distinct processes. The use of a bioavialability factor to describe bioaccessibility is inappropriate. Because bioaccessibility is soil-specific, it is not possible to determine if the use of a bioavailability factor to estimate bioaccessibility will over or under estimate potential exposures.

If the bioavailability factor is being used to adjust the estimated exposure by the amount that is absorbed into the blood, then its use is only appropriate if the toxicity values are also adjusted by the same factor. Toxicity values are based on administered dose and not on absorbed dose. Therefore, adjusting the exposure to reflect the absorbed dose, without also adjusting the toxicity value to reflect an absorbed dose under estimates the potential hazard or risk associated with exposure.

A review of the calculations presented in Section 6.4 and in Appendix C suggest that the bioavailability factor is being used to adjust the absorbed dose and not to describe the bioaccessibility. This however, should be clarified. The review also indicates that the toxicity values have not be adjusted to reflect absorbed doses. Therefore, the hazards/risks will be under estimated by a factor that is equivalent to the bioavailability factor used. The bioavailability factors used in this report range between 0.5 to 0.1 for oral exposures. This represents a potential 2-fold to 10-fold under estimation of exposure and hazard/risk.

.3 Soil Ingestion Factors for Toddlers

Table 6.4 lists 2 soil ingestion factors for toddlers, 41 mg/day and 80 mg/day. The 80 mg/day is a standard value used by many regulatory agencies in Canada. However, there is no precedent for the 41 mg/day value cites as the incidental soil ingestion rate for residential assessment. The table refers the a justification presented in Section 6.5.1.1. However the justification for this value is not presented as indicated. This value is well below the 80 mg/day used for incidental soil ingestion for the hunting scenario. It is also below the 100 mg/day which has also been used by regulatory agencies in Canada and the United States.

The use of the 41 mg/day will under estimate potential exposures and the attendant hazards or risks. Although it is not clear in the report, it is possible that the 41 mg/day is intended to represent and averaged daily intake value. Typical practice for the application of averaging factors is to use a standard intake rate and adjust the frequency of contact. If the 41 mg/day is intended to represent an averaged value, its use in this assessment is non-standard. Further, the assumptions that the averaging is based on must be provided for review and/or the report must provide the justification for the 41 mg/day before it can be evaluated properly.

.4 Apportionment of Soil Ingestion

The report apportions soil/dust ingestion between indoor and outdoor events. Indoor soil/dust ingestion is treated as a background exposure that is separate from soil/dust ingestion that occurs outdoors. Apportionment between indoor and outdoor soil/dust ingestion can be considered when there is sufficient information to show that the levels of a given contaminants in indoor dust is independent of the levels in soil, or when the levels in indoor dust are expressed as a function of the levels of the contaminant soil.

For the Nanisivik Mine, the levels of metals in indoor dust will be related to, and driven by, the levels of metals present in the soil. Therefore, to treat exposure to indoor dust as a background exposure that is independent of the levels in the soil, is inaccurate. Further, treating exposure to metals in indoor dust as background exposure will result in SSTLs for soil that are too high. As an example; Section 6.4.1.5 of the report provides a breakdown of the contributions made by several pathways, to the total daily exposure to lead. This figure indicates that incidental soil ingestion accounts for approximately 11.5 % of the total daily intake of lead. Air, supermarket food, drinking water and indoor dust account for 88.5% of the total daily exposure. The calculation of the SSTL presented in Section 6.5.1.1 shows that the larger the background concentration is, the larger the calculated SSTL will be. Because the levels of metals in indoor dust will be dependent on the levels of metals in the soil, incidental ingestion of soil and indoor dust should be treated as a combined exposure. This will lower the SSTLs for metals and will be more reflective of actual exposures.

.5 Receptor Parameters

There are several points that need to be made with reference to the receptor parameters that have been selected for use in this assessment.

i drinking water consumption rates are not provided. Based on a review of the calculations, a value of 2 L/day appears to have been used for the toddler. This is a significant over estimate. Typical drinking water consumption rates for toddlers in Canada are approximately 0.8 L/day. Intakes for adults in Canada are generally considered to be 1.5 L/day.

ii the body weight value used for toddlers in this report (16.5 kg) is greater than what is generally accepted by Canadian regulators. Typically a body weight of 13 kg is used. The larger body weight will under estimate both exposure and the attendant hazards/risks. The reference for this value should be corrected to Richardson, 1997, a source which has not received any significant peer review. The Canada Wide Standard CCME, 2001 reference provided in the report correctly reflects the fact that the Richardson 1997 values were used in the CWS, however, given the Richardson was the primary author of the CWS for PHC, it is hardly surprising that these values were selected.

iii inhalation rates also have been taken from Richardson, 1997. These values will over estimate inhalation exposures for toddlers (9.3 m^3/day compared to a standard 5 m^3/day) however, the Richardson values will under estimate inhalation exposures for teens and adults 1(15.8 m^3/day against standard values of 21 and 23 m^3/day for teens and adults respectively). The overall effect will under estimate inhalation exposures for the life-time receptor which would be a particular concern when assessing inhalation exposures to cadmium.

.6 Review of Calculations

A review of the calculations presented in Section 6.4, 6.5 and Appendix C has identified a number of areas where clarification and/or correction are required. These are listed below;

i Calculation of Drinking Water intake for lead. A review of the calculations indicates that a bioavailability factor of 0.1 has been included in the calculation to arrive at the EDI of 0.058 :g/kg-day. Table 6.7 indicates that the bioavailability factor of 0.5 should have been used.

ii Section 6.4.1.4: Background Soil/Household Dust. A review of the calculations shows that a soil ingestion factor of 80 mg/day has been used for the town area and that these values have not been adjusted for bioavailability when calculating the EDIs. Further, the background soil intake appears to have been adjusted by a factor of 4/24 to account for 4 hours spent outside. Adjustments of this nature are seldom used because soil ingestion, unlike inhalation, is an event driven exposure and does not depend on time spent in a given location. If the authors feel that they can scientifically justify the apportion soil ingestion between indoor dust and outdoor soil, they must use a more reasonable apportionment factor. Soil ingestion will not occur while a child is sleeping. Therefore, 12 to 16 hours should be used as an adjustment factor and not 24 hours (12 hours would be the more conservative assumption).

iii The calculation of the SSTLS for lead and zinc in the town area (Appendix C) do not adjust the toxicity values to correct for bioavailability. Further, the calculation of the SSTL seems to use a soil ingestion rate of 41 mg/day while the estimation of intake from background used a value of 80 mg/day. The combination of these two factors will result in an over estimation of the SSTLs for lead and zinc in the town area.

3 Additional Questions

.1 *Does HHERA report typically concern only with metals concentrations? Why the report does not contain any assessment (for both human and ecological) for the presence of petroleum hydrocarbon contamination ? The Phase II ESA indicates that there are some concerns of hydro carbon contaminations.*

Human health and ecological risk assessments generally consider all chemicals that have been identified by the Phase II ESA in the initial screening fro contaminants of concern. Only substances that are present at concentrations that exceed their respective guidelines are carried through to the detailed quantitative risk assessment. This report does not provide a rationale for why only metals were addressed. Petroleum hydrocarbons should have been addressed in the screening section of the human health and ecological risk assessments.

.2 *This report does not discuss about ecological risk and concern in the marine environment (fish, seal and other organism at Strathcona Sound). Is it because the collected data (water sample, marine sediment, etc) is found to be lower than guidelines ?, or because there is not enough data to justify a risk assessment for the marine life ?*

This comment has been addressed in the ecological risk assessment review.

.3 *Table 7.2 on page 52 :The discussion for General mine indicates that Copper (Cu) is eliminated for consideration, but Silver (Ag) is not. However, the table shows otherwise.*

This comment should be included in the comments that go to JWEL.

.4 *Ecological Risk - Surface water assessment*

a *Table 7.14 : Assumption is based on 95% UCL data for the Exposure Point Concentrations (EPC). Table 7.3 indicates that surface water EPC is based on mean concentration using 2001 data for metals. This is a contradictory statement. It should be noted that monthly data for the metal concentrations usually have spikes (depending on the time when ice melts, and when disturbance of nearby waste rock dumps during mining activities). Therefore, average or mean readings and 95% UCL will be different.*

This comment should be included in the comments that go to JWEL.

b. *Nanisivik Mine collected data for metals at the Twin Lakes Creeks between 1996 to 2001. The average metal concentrations appear to be increasing with time. However, as the mine stops operation, the concentrations may level off or decreasing over time. What concentrations should be used for the analysis? Average over the years, or the latest data (2001).*

This comment should be included in the comments that go to JWEL.

.5 *Hazard screening using guidelines for Human Health Assessment - Table 6.1*

a. *What are usually the justifications to use various guidelines (CCME, MOEE, USEPA,etc). CCME - CEQD has a complete list of guidelines for almost all metals for agricultural, residential, commercial and industrial. Why don't the assesssor stick with one guideline ?*

Screening guidelines for all chemicals of potential concern may not be available from all agencies. In general, the screening process starts by identifying the primary source of screening guidelines. When a guideline if not available for a specific contaminants from the primary source, guidelines from secondary sources are used. For this risk assessment, the primary source of guidelines should be the CCME. Secondary sources such as the Ontario Ministry of the Environment and the US EPA can be used to identify screening guidelines that CCME does not list.

While the CCME does list screening guidelines for many compounds, many of these are 1991 values for which the rational and basis for development are not available. The use of guidelines from other, more recent sources actually provides a better assessment of potential risks.

b. *When mixing with other guidelines, in most cases the values are relaxed (ie. higher allowable). This means that one can manipulate the guidelines to suit the metal concentrations tested for a specific site. Comment ?Example : CCME for Zn - residential is 200 mg/kg. For MOEE for Zn - residential is shown 16000 - huge difference !*

When choosing screening guidelines for a particular assessment it is important to remember what receptors are being considered. In developing guidelines, most agencies consider both human and ecological receptors. Guideline values are developed for human and ecological receptors based on appropriate toxicology. The lower of the two guideline values is selected as the final guideline. By protecting the receptor that is affected at the lower exposure level, protection is also provided for other receptors. This can present problem when conducting risk assessments for receptors that are not a sensitive as the receptor that the guideline is based on. Using the Zn example noted above. The CCME Zn guideline in soil is based on the protection of ecological receptors. However, Zn does not really represent a potential human health risk. When conducting a human health risk assessment, it is appropriate to use screening guidelines that are based on the protection of human health. For Zn, which is an essential nutrient and required in the daily diet for humans, Zn does not pose a significant health risk. This is reflected in the human health value for Zn of 16,000. The CCME has not developed a human health guideline for Zn because Zn is not really considered a potential human health risk.

The selection of appropriate guideline values should not be viewed as *manipulating the guidelines*. This is a standard and correct practice provided that the hierarchy of selection is maintained throughout the process.

.6 *Ecological Risk Assessment : Exposure Point Concentration for metals in surface water (Table 7.3)*

a. *For the town area, data from SNP 159-9 was used in the analysis. Would other data, such as 200-10 and/or NML 28 be more appropriate ?*
This comment should be included in the comments that go to JWEL.

b. *For the general mining site, should data from SNP 200-1 (located near the mill) be included in the evaluation ? This station collect all of the metal loading from the main mining operation site (and including water from WTL and ETL)*
This comment should be included in the comments that go to JWEL.

This completes our review of the human health and ecological risk assessments for the Nansivik Should you have any additional questions, please contact Bryan Leece or Ulysses Klee at (519) 650-9833.

Sincerely

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