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RESPONSE TO PANEL QUESTIONS

WHITES POINT QUARRY AND MARINE TERMINAL

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ACRONYMS

BAF	Bioaccumulation Factor
CCC	Criterion Continuous Concentration
CMC	Criterion Maximum Concentration
EIS	Environmental Impact Statement
EQL	Estimated Quantitation Limit
GMAV	Genus Mean Acute Value
ISQG	Interim Sediment Quality Guidelines
LC50	Lethal Concentration 50%
PEL	Probable Effects Level
TSS	Total Suspended Solids
UFU	Upper Flow Unit
VEC	Valued Environmental Components

1.0 INTRODUCTION

AMEC Earth and Environmental, Inc. (AMEC) was asked to review the current Environmental Impact Statement (EIS) for the Whites Point Quarry and Marine Terminal proposed for a location in Digby Neck, Nova Scotia, Canada. Based on this review, AMEC was tasked to provide responses to each of the questions and comments originated by the EIS Joint Review Panel as well as other authorities in Canada (e.g., Environment Canada, Health Canada, etc.). These were excerpted from the original comment and question document for the EIS review by the client and proponent, Bilcon of Nova Scotia Corporation. The excerpted questions and comments, coverage in the EIS and responses for each are listed in order below.

2.0 GEOLOGY (9.1.2)

2.1 Panel

The chemistry of the basalts is currently characterized by only three analyses from different levels of a single borehole. Copper values, which are of special concern to the assessment, range from 27 to 170 ppm from those three samples. (Considerably higher values have been determined by others in tests of the North Mountain Basalts.) Provide statistically meaningful averages, especially for copper, from the basalts that are to be quarried, along with the range of values encountered. Document the sampling protocol used for the analysis. (For this purpose, "statistically meaningful" may be defined as +/- 10% at 95% confidence level of the measured statistics.)

2.2 EIS Coverage:

EIS Volume VI, Chapters 9.1 - Physical Environmental and Impact Analysis, Section 9.1.2.

Field surveys and borings found the Upper Flow Unit (UFU) to be a uniform, hard, massive, vesicle free, medium dark gray to black basalt. The thickness of the upper flow unit reportedly varies from 0 to 154 m deep. Basalt bedrock samples from core #1 were laboratory analyzed by PSC Analytical Services for baseline metals. Three rock samples from depths of 5 m, 33 m, and 61 m were analyzed – see Appendix 4 for analytical test results for metals in the bedrock.

The results of copper analysis of the basalt from core #1 are 27, 48, and 170 mg/kg for depths 5, 33, and 61 meters respectively.

2.3 Response to the Panel:

In order to characterize basalt and determine a "statistically meaningful" average for any constituent there would be a requirement for extensive boring and sampling. It was stated that "considerably higher values have been determined by others in tests of the North Mountain Basalts". Available data on North Mountain Basalt could be used to estimate a range of values that would be expected to occur, as well as estimate the sampling size. An estimate of the sampling effort that would be required to meet the suggested +/- 10% at 95% probability, statistically meaningful average, was completed using North Mountain Basalt glacial till data from NSDME (1982) and with data available from the Ocean Drilling Program for basalt off the coast of Greenland (Hooper et al. 1999). Based on these data roughly 60 to 66 samples would be necessary to allow for the derivation of a "statistically meaningful" average. As this is an extreme amount of effort, it is suggested that the available data are evaluated. In addition, Bilcon of Nova Scotia Corporation has undertaken a reduced sampling program with 3 additional samples, one from each of 3 boreholes in the basalt of the UFU (since this is the unit to be mined). Bilcon had these basalt samples from other cores in storage and has initiated the proposed analysis. Preliminary results indicate copper levels of 39, 230, and 91 mg/kg for depths of approximately 36, 34, and 16 meters respectively. The sampling protocol used for the sampling and analysis will be described or included with any report of the results.

3.0 SURFICIAL GEOLOGY AND SOILS (9.1.4)

3.1 Panel

Soil Analyses

In view of the ISQG guidelines for copper in marine (18.7 ppm) and freshwater sediments (35.7ppm), provide statistically meaningful averages for concentration levels of inorganic parameters, particularly for copper, from the soils on the property. Describe the range of values encountered. Document the sampling protocol and spatial distribution used for the analysis. (For this purpose, “statistically meaningful” may be defined as +/- 10% at 95% probability of the measured statistic).

On Pg 36, the Proponent should note that the sample taken from the existing sediment pond is not typical of material that is expected to be in the sediment ponds during the operation of the Project. (It is the product of surface runoff from grubbing the site, not the result of a basalt-crushing process.)

3.2 EIS Coverage

EIS Volume VI, Chapters 9.1 - Physical Environmental and Impact Analysis, 9.1.4 Surficial Geology and Soils

Soil Analyses

The EIS states Site specific soil samples were taken from the same site location (S.W.P. 1) on May 22, 2002 and again on June 4, 2002 for analysis regarding available metals and BTEX/TPH MUST – Hydrocarbons for baseline data. The analytical data are presented in Appendices 38 and 38A. The results indicate that the concentration of copper in both samples was 39 mg/kg.

A sediment sample was taken (sediment sample site 7) on July 14, 2005 for the purpose of documenting sediment contamination levels from the land disturbance due to grubbing of a four hectare quarry site. The results for the sediment pond sample are stated in the subsequent section (9.1.4.2 Analyses) as 52 mg/kg.

3.3 Response to the Panel

The sampling effort that was utilized to characterize the soil copper levels on a site wide basis was not optimum, but not considered insufficient given a weight of evidence approach. Since the sediment that was sampled from the retention pond is a result of soil runoff from the four hectare quarry site, it is in essence an “integrated” soil sample. The sediment pond samples were analyzed by Maxxam Analytics Inc. (Analytical Report

2005/08/31). Appendix 36 of the EIS containing the laboratory analysis of these samples was not included with the EIS. Appendix 36 is included here as an attached errata sheet.

The retention pond sediment sample can be considered a conservative representation of the soil copper level considering that, in general, (1) soil copper levels diminish with depth, (2) greater concentrations of copper would be expected in the upper 5–10 centimeters of soil (Breslin 1999), (3) soil particle runoff is most likely from the upper soil layer, and (4) the two previous samples of actual soil from the site were 39 mg/kg. Average soil copper levels have been reported for the U.S. and Canada. The national average concentration for copper in U.S. soils is 30 mg/kg (Davies 1986). In Canada, average copper concentration in uncontaminated soils is 25 mg/kg and in sludge amended soils is 41 mg/kg (Webber and Singh 1995). The maximum trace element concentration limit for copper in compost is 100 mg/kg (Composting Council of Canada 2006).

With the current information, it is not possible to provide statistically meaningful averages for concentration levels of inorganic parameters, particularly for copper, from the soils on the property. Historical soil concentrations on site are relatively unknown, so derivation of the expected variability for use in sample size determinations would be guesswork. The Nova Scotia Department of Mines and Energy (NSDME 1982) performed background geochemical analysis of the Beaver River Till at sample sites at Whites Cove (341A) and Whale Cove (342A). Copper in these samples ranged from 80 mg/kg at 341A to 107 mg/kg at 342A. Site 341A is located on the quarry property and 342A approximately 3 km from the quarry property. Given the totality of what is known about copper concentrations in soil, glacial till, basalt, and in the sediment retention pond at the site, reasonably good estimates of copper concentrations in soil can be made (39 to 52 mg/kg). Additional sampling is not likely to yield additional useful information.

With regard to the sediment retention pond sample, the Panel is correct in stating the sample taken from the existing sediment pond is not typical of material that is expected to be in the sediment ponds during the operation of the Project. This was made clear in the EIS. The basalt crushing process is expected to generate a slurry with a pH approaching 10. At that pH, high copper concentrations are not expected given that, on average, only 0.078% leached out of the basalt at a pH of 4.9 (Maxxam Analytics Inc., *Atlantic CGSB Leachate + Metals (Leachate) 2006/07/20*, and *Atlantic CGSB Leachate+ Metals (Liquid),* attached). The proposed sampling of pond effluents will provide confirmation (see Response to Panel under Fisheries and Oceans Canada).

4.0 BIOACCUMULATION IN LOCALLY HARVESTED SPECIES (9.2.3.2)

4.1 Panel

Clarify who will conduct the monitoring of VECs throughout the course of the Project to ensure that the effects of Project-derived metals are not significant. Ensure that monitoring intervals reflect a precautionary approach.

4.2 EIS Coverage

Section 9.2.3.2 of the EIS is labelled Analysis and does not address the issue of bioaccumulation in locally harvested species. However, it is addressed in Section 9.3.21 Human Health - Country Foods.

4.3 Response to the Panel

A response to the human health issues pertaining to copper in locally harvested species is provided later in this document.

The monitoring of VECs during the construction and operation phases will be undertaken by a qualified consultant retained by Bilcon. Monitoring results will be made available to the public.

Since the Project area has a naturally high background copper concentration, it is not expected that metal concentrations in intertidal and offshore waters will exceed current background conditions due to the site operations. Precautionary measures will reduce the possibility of contaminants entering the marine environment and affecting marine organisms. It is proposed that all outflows from sediment retention ponds be sampled semi-annually and analyzed for copper (see section 5.0 Contaminants for additional information). Total Suspended Solids and pH sampling and analysis are already planned (weekly) and that will indicate any change in that aspect of water quality. Bioaccumulation of several metals is already occurring due to the background levels. Background levels of copper have been analyzed in periwinkles (22.1 mg/kg; see Appendix 31 of EIS). A sampling program for periwinkle has been proposed (see section 7.0 9.3.21 Human Health – Country Foods). However, bioaccumulation (BCF) has been found not to be a useful indicator of hazard for metals to aquatic organisms (Adams et al. 2000; Chapman et al. 2003). Many invertebrate organisms that could potentially be monitored (e.g., molluscs, crustaceans) are able to regulate and/or store copper (Bryan 1968; Dallinger 1977) with large differences in residues found in muscle (low) versus regulatory organs (high) such as the hepatopancreas (Bagatto and Alikhan 1987).

It is highly unlikely that any potential release from the site could be detected in the local biota. The proposed sampling program reflects a precautionary approach. Therefore, sampling of additional VEC's is deemed unnecessary at this time.

5.0 CONTAMINANTS

5.1 Panel

Provide information on the potential effects of copper on marine life. What are the normal range of levels and acceptable levels for marine sediments and waters? What organism could take up or accumulate copper and what organisms are particularly susceptible to the presence or effects of copper? What strategies may be applied to mitigate (a) the potential release of copper in the marine environment or (b) the effects of its release?

5.2 EIS Coverage

This information is not currently in the EIS. A summary of the fate and effects of copper in marine life is presented below in the response to panel questions.

5.3 Response to the Panel

Embryo-larval life-stages of bivalve mollusc represent the genera most sensitive to copper (USEPA 2003). By sensitivity rank, the genera are *Mytilus* (GMAV[1] = 11.5 µg/L) and *Crassostrea* (GMAV = 12.6 µg/L). No chronic toxicity data exists for these genera. Chronic data were available for the sheepshead minnow, *Cyprinodon variegatus*. In that study, the chronic value, based on growth as the most sensitive endpoint, was 249 µg/L. The 96-hour LC50 was 368 µg/L. The U.S. EPA is currently using an Acute to Chronic Ratio (ACR) of 3.1 to determine the chronic criterion. Data of acceptable quality pertaining to bioaccumulation of copper in marine or estuarine organisms are given for polychaete worms (BAF = 1,006–2,950), mussels (BAF = 2,491–7,730), and Pacific oysters (BAF = 33,400–57,000).

According to the ATSDR (2004), the concentration of copper in lakes and rivers typically ranges from 0.5 to 1,000 ug/L with an average concentration of 10 ug/L. The average copper concentration in groundwater is 5 ug/L. The average concentration of copper in tap water ranges from 20 to 75 ug/L. The concentration of copper in the oceans has been reported to be in the range of 1-34 ug/L at sites from Woods Hole, MA to the Bahamas (Galtsoff 1943). Jenkins (1981) reported it as 3 ug/L. Copper in samples of marine water from sample station 5 off of the Whites Point Quarry site ranged from 0.4 to 0.8 ug/L.

[1] GMAV = Genus Mean Acute Value

The current Canadian water quality guidelines (CCME 2006) for copper in freshwater range from 2 – 4 ug/L, depending on a hardness ($CaCO_3$) ranging from 0 to >180 mg/L. No guideline for copper in seawater is given. The guideline for copper in community water, based on an aesthetic objective, is ≤1000 ug/L. Water for agricultural use in irrigation is allowed to contain copper at 200 to 1000 ug/L and water for livestock, 500 to 5000 ug/L. The current U.S. EPA water quality criteria (USEPA 2006) for copper are as follows for freshwater (hardness dependent): Criterion Maximum Concentration (CMC) = 13 ug/L; Criterion Continuous Concentration (CCC) = 9.0 ug/L; For saltwater: CMC = 4.8; CCC = 3.1 ug/L. U. S. EPA notes that when the concentration of dissolved organic carbon is elevated, copper is substantially less toxic and use of Water-Effect Ratios might be appropriate. U. S. EPA has drafted an update to the copper criteria[2] which is available at the URL http://www.epa.gov/waterscience/criteria/copper/.

Soil generally contains between 2 and 250 mg/kg copper, and in relatively clean sediment, the copper concentration is typically <50 mg/kg (ATSDR 2004). Canadian soil quality guidelines allow 63 mg/kg in agricultural and residential/parkland land uses. In commercial and industrial land use, 91 mg/kg is allowed. The Ontario Ministry of Agriculture and Food and Ontario Ministry of Environment (1992) allows up to 100 mg/kg in sludge amended soil. Canadian sediment quality guidelines for freshwater specify an ISQG of 35.7 mg/kg and Probable Effect Level (PEL) of 197 mg/kg. The ISQG for marine sediments is 18.7 mg/kg and the PEL is 108 mg/kg. The ISQG or SQG is defined as the level at which no biological effects occur. The PEL is defined as the level above which adverse biological effects are usually or always observed.

Loring (1979) sampled and analyzed for metals in the sediments of the Bay of Fundy and found copper concentrations in sediments averaged 19 mg/kg. Sediments were characterized by grain size and showed an increase in copper concentration with decreasing grain size, sand to mud, with a range of average copper concentration of 12 to 22 mg/kg. For the Whites Point Quarry EIS, analyses were performed for total copper in sediment samples collected from three sites in the waters offshore of Whites Cove. The total copper concentration ranged from 11 to 17 mg/kg.

According to the Province of Nova Scotia – Department of Mines and Energy, the Basalt Till Facies of the Beaver River Till Unit in the area of the quarry has naturally high levels of copper (NSDME 1982). Loring (1979) noted that copper concentrations in near shore

[2] *Freshwater*
The procedures described in the Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses indicate that, except where a locally important species is very sensitive, freshwater aquatic organisms an their uses should not be affected unacceptably if the 4-day average concentration of dissolved copper does not exceed the BLM-derived site-water LC50 (i.e., Final Acute Value (FAV)) divided by the final acute-chronic ratio more than once every 3 years on the average (i.e., the CCC); and if the 24-hour average dissolved copper concentration does not exceed the BLM-derived site-LC50 (or FAV) divided by two, more than once every 3 years on the average (i.e., the CMC).

Saltwater
The procedures described in the Guidelines for Deriving Numerical National Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses indicate that, except where a locally important species is very sensitive, saltwater aquatic organisms an their uses should not be affected unacceptably if the 4-day average concentration of dissolved copper does not exceed 1.9 µg/L more than once every 3 years on the average (i.e., the CCC); and if the 24-hour average dissolved copper concentration does not exceed 3.1 µg/L more than once every 3 years on the average (i.e., the CMC).

sediments are relatively higher as compared to offshore sediments due to detrital bedrock material derived from the underlying and coastal basalts. The geochemical analysis of the Beaver River Till showed a mean copper concentration of 131 mg/kg (n=5) and ranged from 80 – 218 mg/kg. In the two samples closest to the site (Whale Cove and West Mink Cove), copper concentration ranged from 80 to 107 mg/kg. In borehole samples of the basalt, average copper concentration was 101 mg/kg, with a range of 27 to 230 mg/kg at depths ranging from 5 to 61 meters. Basalt samples with copper concentrations ranging from 39 to 270 mg/kg were subjected to leachate tests (Maxxam Analytics Inc., *Atlantic CGSB Leachate + Metals (Leachate) 2006/07/20*, and *Atlantic CGSB Leachate+ Metals (Liquid)*, attached), using acetic acid at average final pH of 4.9. Average initial pH of the basalt samples was 9.8. The resultant leachates had copper concentrations ranging from non-detect (20 ug/L) to 480 ug/L, with an average percent leached of 0.078 % (range: 0.012 to 0.209%) of the basalt concentrations. Analysis of copper in ground water (pH = 7.4) was consistently below the EQL of 2 ug/L. Surface water samples (pH = 5.7 to 7.2) ranged from non-detect (EQL = 1.0 ug/L) to 3.0 ug/L.

Copper in natural water is predominantly in the Cu(II) state. In this form, copper is complexed or tightly bound to organic matter; little is present in the free (hydrated) or readily exchangeable - bioavailable form. Copper adsorbs to organic matter, hydrous iron and manganese oxides, and clay (Davies-Colley et al. 1984). Harrison and Bishop (1984) determined that, in water, a significant fraction of the copper is adsorbed within the first hour of introduction, with equilibrium usually obtained within 24 hours. Copper complexation capacity of waters controls copper toxicity by keeping the aqueous concentration of Cu(II) at nontoxic levels (Rivera–Duarte 2005). The chemical conditions in most natural water are such that, even at relatively high copper concentrations, these processes will reduce the free Cu(II) concentration to extremely low values (ATSDR 2004).

In seawater, organic matter is generally the most important complexing agent (Coale and Bruland 1988). Copper has been shown to be subject to binding by dissolved organic carbon (Arnold, W.R. 2005). Iron oxides are also an important binding agent, particularly in estuarine sediments (Davies-Colley et al. 1984), and binding does not vary significantly with salinity reduced from 35 to 5‰.

Analysis of surface water at the site resulted in a mean total organic carbon content of 8.6 mg/L (N = 8), ranging from 2.7 to 16.6 mg/L. Iron was highly variable, ranging from 0.32 ug/L to 5.2 mg/L. Iron in marine water samples ranged from 25 to 120 ug/L. The total organic carbon in marine sediments offshore of the site ranged from 1.1 to 60 g/kg

Concern has been expressed about the potential effects that copper may have on marine life. As stated in section 4.3, for in many organisms, copper, an essential element, is regulated and/or stored. Bioaccumulation of copper in these organisms reflects this process and is not indicative of hazard. Based on (1) the mitigation proposed in the EIS, Sections 9.2.2.3, 9.1.2.3, 9.1.6.3 to minimize runoff into marine waters (i.e., drainage channels, sediment retention ponds, constructed wetlands, and an environmental preservation zone), (2) the potential binding capacity of the organic carbon and iron content in the surface and marine waters, and (3) the expected high pH of basalt slurry, it is highly unlikely that any marine organisms will have a significant exposure to copper from the site over and above background levels. The background concentration of copper in surface water at the site has been measured as high as 3 ug/L. Chronic effects from background concentrations are not apparent, probably due to environmental complexation and/or regulation by biota. As a precautionary approach Bilcon proposes that if dissolved copper concentrations in sediment retention pond effluents exceed 4.8 ug/L, samples of pond effluent will be submitted to a qualified contract laboratory for a toxicity screening test using a marine species known to be sensitive to copper. If significant mortality is observed, additional mitigation measures (e.g., treatment by coagulation, flocculation, filtration, adsorption or other appropriate methods) will be undertaken to reduce the copper to a non-toxic concentration prior to discharge.

6.0 HUMAN HEALTH – MARINE CONTAMINANTS (9.3.19)

6.1 Panel

9.3.19.2 The on-site sampling is not adequate to generate scientifically defensible information concerning copper concentrations. The Proponent argues that "implications to human health are uncertain". The Panel expects the Proponent to present current scientific information on the implications of copper on human health.

Given that periwinkles harvested for human consumption in the near shore environment on the site may be exposed to high concentrations of copper draining from the sediment ponds, this matter requires clarification.

6.2 EIS Coverage:

In EIS Section 9.3.19.2 Analysis, it is stated that copper levels in the soil at Whites Point was low (39 mg/kg at EQL 2). Also, copper levels in surface water entering the Bay from the Whites Point site is extremely low (2 – 3 ug/L at EQL 2). Likewise copper in the intertidal marine waters was extremely low (0.8 mg/L at EQL 0.1). Copper content in the basalt rock to be processed at the quarry site was also low (27 – 61 mg/kg, depending on depth at EQL 2).

On-site analyses as stated above are described in multiple sections of the EIS (e.g., Basalt bedrock and groundwater in 9.1.2.1 Research; Geochemistry of the Beaver River Till–Basalt Till Facies, soil, and pond sediments in 9.1.4.1 Research; surface water in 9.1.6.1 Research).

As stated in section 9.3.19.5 Impact Statement, Marine Contaminants – Human Health, background levels of metals are relatively low on-site. Surface water runoff and sediments from quarry operations will be contained in on-land environmental control structures, and sediments for future use during reclamation will be placed in diked disposal areas on-site. These precautionary measures will reduce the possibility of contaminants entering the marine environment and affecting marine organisms harvested for human consumption.

A review of scientific information on the implications of copper on human health is briefly presented below in the Response to the Panel. Fate of copper in the environment is reviewed in Response to the Panel in the section on Contaminants.

6.3 Response to the Panel

Like iron and zinc, humans have developed a homeostatic mechanism with regard to copper exposure. Copper is an essential element for humans involved in aerobic enzyme function, hemoglobin synthesis, and gene transcription (Ralph and McArdle 2001). Many organisms have developed similar mechanisms for regulating copper levels at the biochemical and molecular levels (IPCS 1998), seeking to maintain their copper levels in a range that avoids deficiency and excess. Doses below the recommended daily allowance (RDA) can produce adverse developmental consequences and heart disease, while higher doses can produce toxic responses, including liver (primary organ for copper distribution in humans), kidney, cardiovascular, hematopoetic, and central nervous system effects (Georgopoulos et al. 2006; Ralph and McArdle 2001). In essence, the toxicity and essentiality of copper produces a U-shaped dose response curve, a hormetic response (Calibrese and Baldwin 2001; Calebrese 2004). The United States RDA for adult men and women is 900 ug/day; the median intake of copper in the US ranges from 1.0-1.6 mg/day, again, for adult men and women (global average is 1.5 mg/d for adults (Ralph and McArdle 2001)). IPCS (1998) lists the lower acceptable level of intake at 20 ug Cu/kg/day generally with a higher level of 50 ug Cu/kg/day for infants. The maximum daily allowances for various global regions ranges from 130 to 500 ug/kg/day (Ralph and McArdle 2001).

Chronic effects in humans are rare but may occur in individuals with Wilson's disease (1:30,000 live births) in which copper transport enzymes are inactive and copper accumulates in the liver and brain (Ralph and McArdle 2001). Also, the usually fatal Menkes disease (1:200,000 live births) resembles a copper deficiency in which Cu is not distributed past the gastrointestinal tract (IPCS 1998; Ralph and McArdle 2001). Based on the copper level required to produce liver damage, the tolerable upper intake level for adults is 10,000 ug/day. Additionally, acute, gastrointestinal upset often occurs at levels of 3 mg/L in water and above (Georgopoulos et al. 2006). This GI irritation usually is associated with copper in water and not in food where it is typically less bioavailable (i.e., complexed to proteins, lipids, etc. (Ralph and McArdle 2001)). In the US, the secondary maximal contaminant level (MCL) for drinking water based on taste and odor (aesthetics) is 1.3 mg/L. Under the Canadian Drinking Water Guidelines, the Canadian Guideline limit is 1 mg/L. IPCS (1998) lists the maximum level of intake around 2-3 mg/day.

Periwinkles are anticipated to be harvested for human consumption from the near shore tide pools, adjacent to and on the site. These sea snails, *Littorina* sp., have exhibited a maximum copper level of 22.1 mg/kg in pre-operation sampling. Periwinkles do not appear to be sensitive to the levels of copper already present in this environment. Given the potentially elevated background levels of copper and the fact that on-site operations are not expected to significantly elevate those levels, additional impacts to this harvested food source are not expected. ATSDR (2004) notes that individuals who regularly consume shellfish typically have higher copper intakes (an additional 2-150 mg/day) than those who do not consume shellfish. Research for this response did not identify current guidelines for copper content in marine organisms. Stewart and White (2001), in a review paper of contaminants on the Scotian Shelf, referred to a Health and Welfare Canada Guideline (circa 1996) of 100 µg/g in marine and freshwater animal products. According to the EIS (Section 9.3.19), levels above 800 ug/g (mg/kg or ppm) are considered excessive in aquatic food organisms. The current maximum levels found in periwinkles are over 30 times lower than that tissue concentration.

Country foods such as dewberry, raspberry and blueberry exhibit pre-operation levels of copper below 1 mg/kg. Health Canada recommends an upper limit dose of copper in adults (19 years and older) of 10 mg/day from drugs and health products (Health Canada 2004). Given the elevated background level of copper for this general vicinity, the fact that the berries do not show elevated levels of copper and the existence of homeostatic copper mechanisms in humans, the site is not expected to significantly elevate existing copper levels.

7.0 HUMAN HEALTH - COUNTRY FOODS (9.3.21)

7.1 Health Canada

Country Foods (Table ECM-2)

Health Canada recommends that raspberries and periwinkles be analyzed for metal following the first year of operation and then every subsequent five years. This would enable early detection of any elevated metals concentrations that may have been the result of quarry construction and early operations.

7.2 EIS Coverage:

EIS Section 9.3.21.4 Monitoring, states, in addition to monitoring air, water, and soil pathways as presented in previous sections of this EIS, Bilcon of Nova Scotia Corporation proposes to monitor country foods. Every five years, laboratory analysis of the metal content in wild raspberries and periwinkles will be conducted. A report comparing background levels to present levels will be compiled and made available to Health Canada if requested.

7.3 Response to the Panel

Considering the low background levels of metals (excepting copper in basalt and glacial till) in on-site soil, rock, and water, the proposed design considerations for spill containment, hazardous material handling, and proposed precautionary measures, the possibility of contaminants entering human food resources is extremely unlikely. However, Bilcon of Nova Scotia Corporation has proposed in EIS Section 9.3.21.4 Monitoring that wild raspberries and periwinkles be analyzed for copper following the first year of operation and then every subsequent five years; if the results are not substantially different between sampling events, the frequency may be decreased or even discontinued. In the unlikely event that the results are significantly higher, the potential hazard will be assessed, the mitigation processes re-evaluated if need be, and the monitoring frequency adjusted as appropriate.

8.0 SURFACE WATER QUALITY, REFERENCE: VOLUME IV APPENDICES, APPENDIX 45

8.1 Environment Canada

Information on the quality assurance/quality control program used by the laboratory analyzing water quality samples should be included. It is noted that the results for most sampling stations are for a single sample.

8.2 EIS Coverage

Environment Canada is correct in identifying this issue as a deficiency in the EIS.

8.3 Response to the Panel

Bilcon of Nova Scotia Corporation will provide the necessary information on the quality assurance/quality control program used by the laboratory.

9.0 CONTAMINANTS (SECTIONS 9.3.18 TO 9.3.20)

9.1 Fisheries and Oceans Canada

Page 127 – There is no proposal within this EIS for environmental effects monitoring of the commercially valuable species such as lobster, crab, and scallop that are sensitive to the toxic metal exposures, especially in the Bay of Fundy areas. The monitoring of water quality of outflow from the sediment retention ponds is insufficient to detect the possible problem of contamination associated with quarrying operation. In the study of the selection of bioindicators for monitoring marine environmental quality of the Bay of Fundy, Chou et al. (2003) reported that lobsters from Digby had elevated digestive gland copper (70 ug/g) in comparison to lobsters from Pubnico (10 ug/g). Chou et al. also reported the ineffectiveness of mussels and sediments as reliable indicators of contaminants. Mussels and sediments failed to reveal the problem of high toxic metals in the Bay of Fundy area. The EIS quotes the Gulfwatch results and states that heavy metal concentrations in blue mussels are near natural levels (Table MC-I, page 128). The report should include recent bioindicator studies by Chou et al. with regard to the contaminant levels in lobsters and crabs from the Bay of Fundy areas. The selection of bioindicators is key to revealing the toxic metal exposure in marine organisms.

9.2 EIS Coverage:

Section 9.3.18 Human Health - Drinking Water Quality; 9.3.19 Human Health - Marine Contaminants; 9.3.20 Human Health - Land Contaminants; 9.1.6 On-site Surface Water Drainage

In Section 9.1.6.4 Monitoring, it is stated that water quality monitoring of all outflows from sediment retention ponds will be conducted weekly for Total Suspended Solids (TSS) and pH and monthly for general chemistry. TSS will be maintained at less than 50 mg/L per grab sample or 25 mg/L monthly arithmetic mean while pH will be maintained within a range of 5 – 9 per grab sample or 6 – 9 monthly arithmetic mean at the sediment pond outlet. These TSS and pH limits correspond with those contained in the permit for the four hectare quarry on this site. The frequency of monitoring will be weekly for TSS and pH and a monthly summary of results will be prepared by Bilcon of Nova Scotia Corporation and be available to regulatory agencies.

In Section 9.3.19 Human Health – Marine Contaminants, 9.3.19.1 Research, it is stated that contaminants such as metals have been measured in scallop and lobster in the Bay of Fundy. Scallop from most of the Bay generally had metal levels comparable to those from uncontaminated areas (Bay of Fundy Ecosystem Partnership 2004, Ref. 99). Copper measurements in the tissues of lobster in the upper Bay of Fundy, **predominately in a non-industrialized area** (emphasis added), had levels as much as 30 – 100 times higher than industrialized areas.

9.3 Response to the Panel

Given the concern over the potential for high copper levels, it is proposed that all outflows from sediment retention ponds be sampled semi-annually and the samples analyzed for copper. This program would then be sunsetted if the levels of copper can be shown to be of no concern (see Response to Panel at section 4.3).

The use of bioindicators is said to be "key to revealing the toxic metal exposure in marine organisms". This is incorrect because it assumes there will be significant exposure to organisms in the marine environment, which is a false premise. As indicated in the response to the panel in the previous section on contaminants, copper exposure is expected to be extremely low due to the planned mitigation strategy and the physical/chemical processes acting upon the copper in the environment. Analysis of periwinkle has shown copper levels of 22.1 mg/kg, a consequence of the naturally occurring background levels of copper. Research for this response did not identify current guidelines for copper content in marine organisms. Stewart and White (2001), in a review paper of contaminants on the Scotian Shelf, referred to a Health and Welfare Canada Guideline (circa 1996) of 100 µg/g in marine and freshwater animal products. Bilcon of Nova Scotia Corporation, in good faith, has proposed to continue the sampling and analysis of periwinkles for copper. It is anticipated that any biomonitoring will not discern exposure due to the site activities nor show copper levels over and above that which is due to background exposure (refer to section 7.3).

The full range of elevated digestive gland copper in lobster as presented in Chou et al. (2003) include the following digestive gland (ug/g wet weight) copper concentrations from the Bay of Fundy:

Inner Bay of Fundy	–	Cobequid Bay	856 ug/g ± 40
		Minas Basin	405 ug/g ± 20
		Minas Channel	110 ug/g ± 25
New Brunswick Coast	–	Shepody Bay	637 ug/g ± 36
Nova Scotia Coast	–	Cumberland Basin	836 ug/g ± 17
Saint John Harbour	–	Dumpsite	317 ug/g ± 16
Annapolis Basin	–	Annapolis Basin	70.5 ug/g ± 2.8
Outer Bay of Fundy	–	Pubnico	10.4 ug/g ± 3.6

There are several issues against the use of lobster in a biomonitoring strategy. In Chou et al. (2003), there were high levels of copper in the digestive gland (hepatopancreas) of lobster, but edible tissues were not analyzed. It is expected that muscle tissue would likely have been much lower in copper concentration than the level determined in the hepatopancreas. This phenomenon has been observed in other decapod crustaceans that regulate metals (Bryan 1968; Bagatto and Alikhan 1987). Metals are sequestered in the hepatopancreas via metallothioneins, membrane metal transport proteins, and vacuolar sequestration mechanisms (Ahearn et al. 2004) and thus removed from circulation. The correlation of hepatopancreas copper and the copper concentration in the sediments in the Bay of Fundy was poor. The source of copper was unknown and could be from background sources. Lobsters appear to have a greater capacity for metal uptake and accumulation. Lobsters are also rather mobile, making it even more difficult to pinpoint a contributing source of contamination.

Metals have been measured in scallop and lobster in the Bay of Fundy. Scallop from most of the Bay generally had metal levels comparable to those from uncontaminated areas (Bay of Fundy Ecosystem Partnership 2004). Copper measurements in the tissues of lobster in the upper Bay of Fundy, predominately in a non-industrialized area, had levels as much as 30 – 100 times higher than industrialized areas.

These facts raise serious questions as to the suitability of lobster in a monitoring program. A periwinkle biomonitoring program has been proposed. Use of lobster in a biomonitoring program is not recommended.

10.0 INFORMATION REQUEST IR-3

10.1 Issue

The planned settling ponds will receive fine basalt that will contain an elevated copper content. The resulting sediments will leach into the overlying water which can then migrate into the ground water below or spill into the nearby intertidal zone.

10.2 Information Request - IR-3

Provide the details and results of leaching tests on finely ground basalt (grain size equivalent to the material in the settling ponds) with a composition typical of the quarried material and dissolution rates of metals (particularly copper) for this material to allow the potential for the transfers outlined above to be quantified. Propose mitigation measures to minimize the risks of adverse effects.

10.3 EIS Coverage

The sediment retention ponds (settling ponds) are addressed in several sections of the EIS (e.g., 7.0; 9.1.2; 9.1.4; 9.1.6; 9.3.19). The issue of contamination of groundwater is addressed in Section 9.1.3 of the EIS.

10.4 Response to the Panel

The results of leaching tests for basalt samples from the site, as performed by Maxxam Analytics, Inc., are attached in Section 4.1 Proper Scientific Standards. The following is a summary of the results for copper:

Sample ID	Initial Cu (mg/kg)	Initial pH	Final pH	Leached Cu (ug/L)	Percent Leached
N03377	170	10	4.8	21	0.012
O87412	39	9.7	4.9	ND	0.051
O87419	230	9.7	4.9	480	0.209
O87421	91	9.6	4.9	35	0.038
Average	132	9.8	4.9	139	0.078

ND: not detected at RDL = 20 ug/l, used in calculating average.

Mitigation measures (e.g., treatment by coagulation, flocculation, filtration, adsorption or other appropriate methods) have been proposed based on the results of additional sampling, analysis, and toxicity studies as described above in section 5.3.

11.0 REFERENCES

Adams, W. J., Conard, B., Ethier, G., Brix, K. V., Paul R. Paquin, P. R., and D. M. DiToro. 2000. The challenges of hazard identification and classification of insoluble metals and metal substances for the aquatic environment. Human and Ecological Risk Assessment. 6: 1019 – 1038.

Ahearn, G. A., Mandal, P. K., and A. Mandal. 2004. Mechanisms of heavy-metal sequestration and detoxification in crustaceans: a review. Journal of Comparative Physiology B: Biochemical, Systemic, and Environmental Physiology. Volume 174, Number 6 / August, 2004.

Arnold, W. Ray. 2005. Effects of Dissolved Organic Carbon on Copper Toxicity: Implications for Saltwater Copper Criteria. Integrated Environmental Assessment and Management – Volume 1, Number 1 – pp. 34-39. 2005.

Bagatto, G. and M. A, Alikhan. 1987. Copper, Cadmium, and Nickel Accumulation in Crayfish Populations Near Copper-Nickel Smelters at Sudbury, Ontario, Canada.
Bull. Environ. Contam. Toxicol. (1987) 38:540-545.

Bay of Fundy Ecosystem Partnership. 2004. "Contamination Concerns: Heavy Metals and the Bay of Fundy". Fundy Issue #25. Spring 2004.

Breslin, V. T. 1999. Retention of metals in agricultural soils after amending with MSW and MSW biosolids compost. Water Air Soil Pollut 109:163-178.

Brown, B. E. 1982. The form and function of metal-containing 'granules' in invertebrate tissues. Biol Rev 57:621-667.

Calabrese, E. J. 2004. Hormesis—Basic, Generalizable, Central to Toxicology and a Method to Improve the Risk-assessment Process. Int J Occup Environ Health. 10:466–467.

Calabrese, E. J. and L. A. Baldwin. 2001. The Frequency of U-Shaped Dose Responses in the Toxicological Literature. Toxicological Sciences 62: 330–338.

CCME. 2006. Canadian Environmental Quality Guidelines. Canadian Council of Ministers of the Environment, 1999, updated 2001, 2002, 2003, 2004, 2005, 2006.

Chapman, P. M., Feiyue Wang, F., Colin R. Janssen, C. R., Richard R. Goulet, R. R., and C. N. Kamunde. 2003. Conducting Ecological Risk Assessments of Inorganic Metals and Metalloids: Current Status. Human and Ecological Risk Assessment: Vol. 9, No. 4, pp. 641-697.

Chou C.L., L.A. Paon, J.D. Moffatt, T. King. 2003. Selection of bioindicators for monitoring marine environmental quality in the Bay of Fundy, Atlantic Canada.
Marine Pollution Bulletin 46 (2003) 756–762.

Coale KH, Bruland KW. 1988. Copper complexation in the Northeast Pacific. Limnol Oceanogr. 33:1084-1101.

Composting Council of Canada. 2006. Setting the Standard: A Summary of Compost Standards in Canada. www.compost.org/standard/html . Accessed Sept 25, 2006.

Dallinger, R. 1977. The flow of copper through a terrestrial food chain. I I I . Selection of an optimum copper diet by isopods. Oecologia (Berlin) 30:273-276

Davies, P.H. 1986. Toxicology and chemistry of metals in urban runoff. In B. Urbonas, T. Barnwell, D. Jones, L. Roesner, and L. Tucker, eds., Urban Runoff Quality, American Society of Civil Engineers, New York, NY, pp. 60-78.

Davies-Colley RJ, Nelson PO, Williamson KJ. 1984. Copper and cadmium uptake by estuarine sedimentary phases. Environ Sci Technol 18:491-499.

Galtsoff, P. S. 1943. Copper Content of Sea Water. Ecology, Vol. 24, No. 2 (Apr., 1943), pp. 263-265.

Georgopoulos, P.G., S.W. Wang, I.G. Georgopoulos, M.J. Yonone-Lioy, P.J. Lioy. 2006. Assessment of human exposure to copper: A case study using NHEXAS database. J. Exposure Science and Environmental Epidemiology. 16: 397-409.

Harrison FL, Bishop DJ. 1984. A review of the impact of copper released into freshwater environments. U.S. Nuclear Regulatory Commission. Livermore, CA: Lawrence Livermore National Laboratory. NUREG/CR-3478.

Health Canada. 2004. Monograph. Copper. Draft. Health Canada Drugs and Health Products. Natural Health Products. Applications and Submissions. Product Licensing. Compendium of Monographs. July 5, 2004. Last Updated: 2004-05-01. Accessed: 31 October 2006.

Hooper, P., Rehacek, J., and Morris, G. 1999. 10. Data Report: Major and trace element composition, strontium, neodymium, and oxygen isotope ratios, and mineral compositions of samples. In: Larsen, H.C., Duncan, R.A., Allan, J.F., Brooks, K. (Eds.), 1999. *Proceedings of the Ocean Drilling Program, Scientific Results,* Vol. 163. Ocean Drilling Program, Texas A&M University. National Science Foundation and Joint Oceanographic Institutions, Inc. 18 September 1999. http://www-odp.tamu.edu/publications/163_SR/chap_10/chap_10.htm

International Programme on Chemical Safety (IPCS). 1998. Environmental Health Criteria. 200. Copper. WHO. Geneva, 1998. http://www.inchem.org/documents/ehc/ehc/ehc200.htm

Jenkins, D. W. 1981. Biological monitoring of toxic trace elements.

EPA Report 600/S3-80-090, pp. 1-9.

Loring, D. H. 1979. Baseline levels of transition and heavy metals in the bottom sediments of the Bay of Fundy, Nova Scotia, Canada. Proceedings of the Nova Scotia Institute of Science, Volume 29, number 4, pages 335-346.

NSDME. 1982. Province of Nova Scotia – Department of Mines and Energy. "Pleistocene Geology – Southwestern Nova Scotia". Sheet 7. 1982.

Ontario Ministry of Agriculture and Food and Ontario Ministry of the Environment. 1992. Guidelines for sewage sludge utilization on agricultural lands. Sludge and Waste Utilization Committee, OMAF and OME, Toronto, Ont. 32 pp.

Ralph, A. and H. McArdle. 2001. Copper Metabolism and Copper Requirements in the Pregnant Mother, her Fetus, and Children. A Critical Review. International Copper Assoc., Ltd. New Your, NY. 198 pp.

Rivera–Duarte, I., Rosen, G., Lapota, D., Chadwick, D. B., Kear-Padilla, L., and A. Zirino . 2005. Copper Toxicity to Larval Stages in Three Marine Invertebrates and Copper Complexation Capacity in San Diego Bay, California. Environ. Sci. Technol. 2005, 39, 1542-1546.

Stewart, P. L. and L. White. 2001. A Review of Contaminants on the Scotian Shelf and in Adjacent Coastal Waters:1970 to 1995. Canadian Technical Report of Fisheries and Aquatic Sciences 2351. Oceans and Environment Branch. Maritimes Region. Department of Fisheries and Oceans. Bedford Institute of Oceanography. Dartmouth, Nova Scotia, Canada.

United States Environmental Protection Agency. 2006. National Recommended Water Quality Criteria. Office of Water. Office of Science and Technology. (4304T)

Webber, M. D. and S.S. Singh. 1995. Contamination of Agricultural Soils. Chapter 9 in The Health of our Soils: Toward sustainable agriculture in Canada: D.F. Acton and L.J. Gregorich (editors). Centre for Land and Biological Resources Research. Research Branch. Agriculture and Agri-Food Canada Publication 1906/E