Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

Water Resources Division
3rd Floor Bellanca Building
PO Box 1500
Yellowknife, NT
X1A 2R3

**File: MV2003L2-0013**
BHP Billiton Diamond Inc.

February 12, 2007

To: Sarah Baines
Regulatory Officer
Wek'èezhìi Valley Land and Water Board

**Re: Aquatic Effects Monitoring Program Plan for 2007-2009 (Dec. 2006) - Comments**

The Water Resources Division, INAC, retained an independent expert to review only the water quality monitoring program components of BHP Billiton's suggested changes to the Aquatic Effects Monitoring Program Plan for 2007-2009. In order to conduct of this review, our consultant assessed all information according to 3 specific questions: 1) What effects are of interest to stakeholders? 2) How large of an effect is important to stakeholders? 3) What degree of uncertainty regarding AEMP-derived conclusions is acceptable to stakeholders?

The results of investigating the three questions above lead to the discussion regarding BHP's Environmental Impact Statement (EIS) and Aquatic Effects Monitoring Program. This review identified that key components to successful monitoring programs and environmental management were missing. As mentioned during the technical meeting in November, it is apparent that BHP has collected large amounts of data; however, effects of interest have been poorly defined and management plans are incapable of ascertaining significance of effects. The attached describes this assessment in more detail; Section 10 discusses the proposed changes to the AEM Program and ways to improve the AEMP.

INAC endorses the recommendations and conclusions in the attached review. Furthermore, the Division is concerned by the fact that BHP's AEMP lacks effect sizes, and that to date, an Adaptive Management Plan has not been submitted to the WLWB for approval. In the past few years, increases in 7 water quality parameters have been identified by BHP. Increases in one parameter have reached further downstream than predicted in the 1995 EIS, and the increases in the remaining 6 parameters were not predicted at all at that time (Environmental Impact Report 2006; p 5-34). This report goes on to say, "it has become clear that discharges from the LLCF are changing water quality in the downstream receiving environment and that the trend is for

increasing change in the future." Although none of these 7 parameters have yet exceeded CCME guideline for the Protection of Aquatic Life, the guidelines specifically state "For waters of superior quality, impairments to guideline concentration should not be acceptable".

Increases have been noted by BHP; the extent of the increases reaches further then predicted. These are concrete indicators that additional investigation, mitigation and adaptive management are required. Because of the lack of effect sizes and an Adaptive Management Plan (as required in the WL Part I, Item 2(h)) changes to the environment beyond what was predicted in the 1995 EIS have occurred. It is time to take action and limit the extent of such effects to be consistent with what was predicted and agreed to in the EIS. BHP has proposed that the results of any further investigations and evaluations regarding effects size could be prepared by February 1, 2008. INAC would like to note that establishing effects sizes will involve the cooperation of all stakeholders and that all involved will have to be in agreement. BHP also states that they will investigate and assess impacts and any potential mitigation options in the 2009 Environmental Impact Report; however, a number of years have passed since these increases were first detected. Work to address these increases should be done in the short-term; to help identify sources at the site and begin the appropriate mitigation activity.

The attached report and recommendations have been provided to help improve the plan and ensure that the environment is monitored sufficiently and is protected. INAC hopes that the above comments are useful both to the WLWB and to BHP. Any questions may be directed to Nathen Richea at richean@inac-ainc.gc.ca .

Sincerely,

Kathleen Racher, Ph. D.
Manager, INAC Water Resources

# Overview of the BHP Proposed AEMP

**Prepared by**
**Zajdlik & Associates Inc.**

**Prepared for**
**N. Richea**
**R. Chouinard**
**INAC**

**February 8th 2007**

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**Table 1: List of Acronyms**

| Acronym | Definition |
|---|---|
| AEMP | Aquatic Effects Monitoring Program |
| DOC | dissolved organic carbon |
| EIS | Environmental Impact Statement |
| EMP | Environmental Management Plan |
| LLCF | Long Lake Containment Facility |
| PCA | principal components analysis |
| TOC | total organic carbon |
| WLWB | Wek'èezhíi Land and Water Board |

# 1 Introduction

Zajdlik & Associates Inc. was retained to attend a meeting in November of 2006, where BHP presented an evaluation of the last three years of AEMP data and proposed changes to the current AEMP for consideration by the Wek'èezhíi Land and Water Board (WLWB). The purpose of my attendance was to evaluate how capable the AEMP is in detecting effects of interest. In order to conduct this evaluation from any perspective (not only statistical) three pieces of information are required. These are:

1. What effects are of interest to stakeholders?
2. How large an effect is important to stakeholders?
3. What degree of uncertainty regarding AEMP-derived conclusions is acceptable to stakeholders?

During the November meeting it became apparent that BHP has collected large amounts of data, considered previous reviewers comments and is engaged in a consultative process. It also became apparent that the latter two questions above were not discussed in the AEMP. This omission led to the investigation of background documents to determine what if anything, stakeholders had decided regarding these three questions. That investigation comprises sections 2 through 7 inclusive in the document below.

This document also investigates the Aquatic Effects Monitoring Program (AEMP) proposed by BHP (Rescan, 2006b), briefly examines the three-year AEMP review and comments upon the proposed AEMP for 2007-2009 that was revised following receipt stakeholder comments in December of 2006. The Baseline Study Plan for Future Developments of Rescan (2006c, section 4) was not reviewed at this time.

This document focuses on water quality monitoring following the Department of Indian and Northern Affairs interest in the BHP AEMP. Although this review necessarily focuses on reductions and limitations to the proposed AEMP and proposes some additional monitoring efforts, readers should also be aware that the BHP AEMP monitors many environmental components. It may be possible to reduce and / or refocus sampling effort without compromising environmental protection (Zajdlik, 2004).

This document includes the greater portion of another document entitled "Overview of BHP AEMP" by the same author in December of 2006. This earlier document was merged with the current document in order to provide all comments regarding the proposed BHP AEMP in a single document, prior to consideration by the WLWB.

## *1.1 Document Overview*

One of the issues that arose during the November 2006 AEMP technical meeting is the lack of objective numeric criteria for evaluating the AEMP. BHP is collecting large amounts of data, but has no criteria in place for assessing whether they have collected "sufficient" data, nor how to adaptively manage the project from the perspective of the

AEMP results. During the technical review meeting Chris Hanks (Rescan) candidly mentioned that the latter item has been discussed by BHP in the past.

The water license (MVLWB, 2005) does discuss such objective numeric criteria in the following sections:

- Part I, Item 2(e) "statistical design criteria, including a description of sampling frequencies for each parameter that ensures both accurate characterization of short-term variability and the collection of sufficient data to establish long-term trends"

- Part I, Item 2(g) "a description of evaluation criteria for the Aquatic Effects Monitoring Program and approaches to amend and refine the Aquatic Effects Monitoring Program"

- Part I, Item 2(h) "a description of how the results of the Aquatic Effects Monitoring Program will be incorporated in the overall adaptive management strategies employed by the Licensee"

Further discussion during the Nov. 21-22 AEMP presentation, revealed that the word "sufficient" used in the paragraph above has not been defined. Without a definition of this word, a reviewer cannot say that the AEMP is "good" or "bad" or that it meets it's stated goal or goals. Conversely BHP cannot say "We are collecting more samples than necessary" or demonstrate in a quantitative manner that the AEMP is "good".

BHP has noted changes in the receiving environment but without numeric criteria, reviewers or stakeholders cannot say that the proponent is having deleterious effects on the environment. Neither can the proponent say "the integrity of the ecosystem has not been affected by BHP activities"; a statement that reflects BHP's Environmental Policy (BHP, 1995).

*Defining criteria that allow the BHP AEMP to labelled as "good" or bad" is both necessary and beneficial for all stakeholders.*

The literature that comprises the background to the BHP AEMP was searched for discussions regarding:

1. BHP's general environmental policy;
2. the goal of the AEMP;
3. measurable targets set by reviewers; and,
4. absolute requirements of the BHP water license (MVLWB, 2005),

in order to define the requisite criteria. Note that only those portions of the documents pertaining to aquatic effects were investigated. All of the comments made in this document pertain to aquatic effects monitoring unless otherwise stated. The information obtained is summarized in section 2.

Sections 3 and 4 discuss concepts that have been used in developing assessment/action criteria for various Canadian environmental monitoring programs.

Section 5 reviews BHP's impact predictions to see whether the concepts of valued ecosystem components or measurement endpoints were used in the impact predictions.

Section 6 discusses effect sizes for measurement endpoints for specific valued ecosystem components that should form the basis of impact predictions.

Section 7 summarizes the background document review and review of associated concepts.

Section 8 reviews the structure of the proposed AEMP as necessary and section 9 reviews the proposed changes to the current AEMP.

Section 10 provides an overall summary and recommendations.

# 2 Background Document Review

## *2.1 Environmental Policy*

BHP's environmental policy (BHP, 1995 Volume 3, pg. 1) makes the following statements that are relevant from the perspective of setting criteria for an AEMP.

"Components of the policy specify the following:

- legal compliance, and, in the absence of adequate legal protection for the environment, application of standards that minimize adverse impacts from operations;

- establishment of management systems to identify, control and monitor environmental risks arising from its operation,

- etc."

The key concepts in these statements are:

- comply with legal standards: Legal standards are an absolute against which environmental performance can be assessed.

- If legal standards do not exist apply standards that minimize adverse effects: The phrase "minimize adverse effects" speaks to the standards that minimize risk and although not obvious, the degree of allowable risk of not detecting an effect using an AEMP.

- Management systems to control environmental risk: This item speaks to the purpose of an AEMP as an element of the management system.

## *2.2 Environmental Management Plan*

BHP makes the following statement regarding their environmental management philosophy. "It is the intent of the Proponent to develop the project so as to minimize negative impacts to the associated valued ecosystem components (VECs)." (BHP, 1995 Volume 3, section 3.1). The following statements regarding their environmental management plan are extracted from BHP (1995).

- "The Environmental Management Plan (EMP) contains the programs and policies that will be implemented to preserve ecosystem integrity as well as to prevent and mitigate any potential environmental impacts associated with all phases of project

development, operation, decommissioning and closure. The EMP is based on information obtained from baseline studies conducted on site (1993 to 1995), available regional data and traditional environmental knowledge. The plan takes into account the northern setting of the project within a tundra environment." (BHP, 1995 Volume 3, pg. 1).

- "The Environmental Management Plan (EMP) for the proposed NWT Diamonds Project is comprised of the integrated policies and programs that will be implemented to preserve the integrity of the claim block ecosystem. "(BHP, 1995 Volume 3, Section 1.3).

BHP makes the following statement in the context of environmental impact assessment:

"The NWT Diamonds Project has been designed to ensure that the residual effects of project activities will not cause any extensive degradation of the chemical or physical qualities of water, soils or the atmosphere of the ecosystems within the claim block. Therefore, the NWT Diamonds Project will not jeopardize ecological integrity through degradation of water, soil and air." (BHP, 1995 Volume IV, pg. 1.7).

The phrases "preserve ecosystem integrity" and "not jeopardize ecological integrity" are relevant from the perspective of setting criteria for an AEMP.

## *2.3 Purpose, Goals and Criteria for Environmental Monitoring*

BHP makes the following statement regarding the purpose of environmental monitoring:

- "The Environmental Monitoring Plan has been designed to determine compliance with government guidelines and permit requirements, the accuracy of predicted environmental impacts and the effectiveness of mitigative actions." (BHP, 1995 Volume 3, pg. 10, also section 10).

The goal of BHP's environmental monitoring program is stated below:

- "The monitoring plan is designed to provide adequate data for monitoring a range of water management parameters related to all phases of the NWT Diamonds Project." (BHP, 1995 Volume 3, Section 10.1.1).

Finally, criteria for environmental monitoring are mentioned in the following sentence:

- "Monitoring requires measurements that are statistically valid with adequate reference control to distinguish between project-related impacts and natural changes in the environment (such as cyclic changes in lemming abundance). (BHP, 1995 Executive Summary, pg. 46).

The statements relevant from the perspective of setting criteria for an AEMP are:

1. "designed to determine compliance with government guidelines and permit requirements, the accuracy of predicted environmental impacts and the effectiveness of mitigative action" While none of these statements are quantifiable they contain elements that when defined, may be used to assess the utility of the AEMP.

2. The phrases "adequate data" and "statistically valid" can be defined. There are many suitable conventions that describe "adequacy of data" and statistically valid". These might be adopted or serve as a basis for discussion.

### *2.4 Summary*

BHP has an environmental policy that discusses compliance with legal standards, minimizing environmental impacts where no such standards exist and managing the operation so as to control or mitigate environmental risks. The policy is translated into an environmental plan that is intended to follow the environmental policy in the context of the site-specific northern environment. The goal of the environmental plan is to "preserve the integrity of the claim block ecosystem".

While the statements themselves are admirable, they are not actionable because key phrases such as "minimize negative impacts" have subjective connotations. Other phrases such as "integrity of the claim block ecosystem" require that a concept such as "integrity" can be measured.

# 3 Valued Ecosystem Components

When an ecosystem is being monitored it is not necessary to take measurements from every biotic and abiotic element of the ecosystem. Elements of the ecosystem to measure can be selected through a combination of criteria including, sensitivity to the contaminants of potential concern by virtue of either or both of habitat preference and toxicological sensitivity, social or political relevance, cost-effectiveness, etc. The elements so selected are known as valued ecosystem components (VECs). These concepts are thoughtfully articulated in section 1.3.2 (BHP, 1995 Volume II). Table 1.1-1 (BHP, 1995 Volume II) summarizes VECs. With respect to the aquatic environment specific reference is made to fish, water quality and aquatic habitat. It is not clear whether the VEC, biodiversity refers to the aquatic environment.

BHP discusses the following VECs in the aquatic environment.

- "Water quality has been identified as a valued ecosystem component due to its importance to aquatic and terrestrial ecosystems and to the human populations that depend upon them." (BHP, 1995 Volume IV, pg. 2.21).

- "Fish have been identified as a valued ecosystem component due to their intrinsic value as well as their importance as a food source, and to a lesser extent, for their associated recreation value." (BHP, 1995 Volume IV, Section 3.1, pg. 1). Specifically, "Lake trout and arctic grayling have been identified as valued ecosystem components." (BHP, 1995 Volume II, pg. 3.5).

This list does not include other components of the ecosystem that if adversely affected by the Project, will also affect fish. The list includes benthic macroinvertebrates, periphyton, zooplankton and phytoplankton. One or more of these ecosystem components should be explicitly labelled as a VEC as they provide an early warning system of potential effects on fish and may be more sensitive to project-related effects than fish. The exclusion of these components as explicitly named VECs could be construed as scientifically negligent. We do acknowledge that BHP is monitoring phytoplankton, zooplankton and benthos.

# 4 Measurement Endpoints

Measurement endpoints describe some measurement of a VEC. For example a measurement endpoint for fish might be the ratio of body size to weight or condition factor. Stressed fish may not be as heavy as unstressed fish, resulting in a change in condition factor due to the Project. Examples for water quality abound; each contaminant released to the environment may be measured and each measurement comprises a measurement endpoint.

Aside from the potential effect of angling in reducing the average size at age, no measurement endpoints are explicitly stated for fish, in the Environmental Impact Statement (EIS).

With respect to water quality, BHP, 1995 Volume IV, Section 2.4 discusses measuring sedimentation and suspended solids. Al and Ni are also identified as analytes that should be measured. Nitrates are discussed due their use as explosives but dismissed as a potential problem.

Despite the fact that measurement endpoints were not mentioned in the EIS it is clear that many elements of the aquatic ecosystem have been measured and will continue to be measured. (See for example, Rescan 2006b).

*The omission of measurement endpoints in the EIS is not critical in and of itself but coupled with a lack of effect sizes (discussed in section 6) does comprise a fundamental omission with respect to purposefully and effectively monitoring the aquatic environment.*

# 5 Impact Predictions

The water license (MWLB, 2005, Part I, Item 2(j)) requires "a comparison of effects in the aquatic environment to those predicted in the EIS and an assessment and rationale of how the results of this comparison are incorporated into revisions to the Aquatic Effects Monitoring Program." Sections 5.1 through 5.5 summarize the effects predicted in the EIS.

## *5.1 Water Quality*

### 5.1.1 Predictions

BHP (1995, Volume IV, pg. 1.6) made the following general statement regarding environmental effects: "In the majority of cases, the results of the environmental impact assessment for the proposed NWT Diamonds Project suggest that the residual effects on valued ecosystem components (VECs) will be negligible. This judgement is largely based on the fact that the local, unavoidable damages caused to terrestrial and aquatic habitats represent effects on a very small fraction of the affected habitat types within the claim block, and an even smaller impact on the Southern Arctic Ecozone."

Aside from this statement the only other prediction regarding water quality pertains to Al and Ni. Following a modelling exercise, Rescan (BHP, 1995 Volume IV, pg. 2.36) states: "Clearly, discharge from cell E during Years 1 to 18 can proceed without impact to the receiving environment. Moreover, conservative estimates of water quality within Cell E indicate that discharge of this water will not increase concentrations of Al or Ni (the only metals of environmental concern in the discharge) sufficiently to even approach applicable federal criteria for the protection of aquatic life for these parameters."

### 5.1.2 Mitigation

No mitigation was proposed for water quality following the predictions above. Note that strong efforts (not discussed here) to prevent the receiving environment from becoming contaminated were discussed in the EIS.

## *5.2 Aquatic Habitat Loss*

### 5.2.1 Predictions

Some loss is expected due to dewatering (BHP, 1995 Volume IV, Section 3.1.1).

### 5.2.2 Mitigation

Addressed through DFO no net loss policy and "establishment of a habitat fund for offsite enhancement of habitat and productivity" and creation of the Panda diversion channel.

## *5.3 Aquatic Habitat Modification*

### 5.3.1 Predictions

Some effects of sedimentation are expected during construction of bridges, roads, culverts and stream crossings, construction of diversion channel. BHP feels that effects will be temporary once losses due to these activities stop. (BHP, 1995 Volume IV, Section 3.1.2.1).

"The overall impact of turbidity and sedimentation will be minor, fairly localized and short term. From initial construction through the decommissioning phase, habitat may be affected at times by sedimentation and turbidity, but only in localized areas. However, wind and ice action will redistribute sediments and tend to return shorelines to their original condition as the finer fractions will be redeposited in deeper waters. As lake trout spawning habitat is abundant in most lakes, other areas will be available if one site is degraded through sedimentation." (BHP, 1995 Volume IV, Section 3.1.2.3)

### 5.3.2 Mitigation

Mitigation is through management of construction processes and monitoring. (BHP, 1995 Volume IV, Section 3.1.2.2).

## *5.4 Aquatic Habitat Degradation*

The likelihood of aquatic habitat degradation is "low". Training in spill response and contingency planning will be used to mitigate the effects of spills. Geotechnical inspections of dams will be used to ensure viability of dams. Monitoring will be used to assess effects of seepage at an early stage (BHP, 1995 Volume IV, Section 3.1.8).

## *5.5 Predictions of Cumulative Effects*

The only cumulative effect pertaining to water quality, hydrology, aquatic habitat or fish is "decreased fish productivity resulting from local habitat degradation" (BHP, 1995 Volume IV, Table 5.6-1). This effect was predicted to be "minor" (BHP, 1995 Volume IV, Table 5.7-1).

Potential cumulative effects will be assessed through monitoring (BHP, 1995 Volume IV, Section 5.8).

### *5.6 Summary*

The EIS makes only very general qualitative predictions regarding impacts to the aquatic environment. These qualitative predictions preclude comparison of impact predictions in the AEMP as required by the water license (part I 2(j)). These comparisons were not found upon examining Rescan (2002, 2006a) although Rescan (2006c, Appendix 3) states that such a comparison is made in the tri-annual Environmental Impact Report.

## 6 Effect Sizes

The size of biological or chemical change that is significant from an ecological, sociological or political perspective is known as an effect size. Effect sizes are almost always driven by the best professional judgement of biologists, ecologists, etc. familiar with the general receiving environment. Effect sizes are often strongly debated by stakeholders before an agreement is reached.

The federal metal mining environmental effects monitoring programs (Environment Canada, 2002) provides effect sizes for various measurement endpoints in the aquatic receiving environment. These may or may not be applicable to the Ekati facility but are certainly a reasonable starting point.

Statistical hypothesis testing is often criticized because it tests for "statistical" significance which may or may not be ecologically, sociologically or politically significant. Statistical tests can be used with effect sizes to test, using statistical tools whether an allowable effect size has been exceeded. This approach marries the objective hypothesis test with a stakeholder-approved effect size and allows uncertainty to be acknowledged.

More importantly from the perspective of assessing environmental performance, statistical tools can be used to determine if the statement "no effect was observed" is a reasonable statement, given the data. Such a statement is reasonable if the probability that the environment really is affected, when a claim of no effect is made, is low. This probability, known as the Type II error rate, can be estimated using statistical tools.

The type II error rate is (along with other criteria) a statistical design criterion as required under MVLWB (2005, Part I, Item 2(e)[1]).

[1] "statistical design criteria, including a description of sampling frequencies for each parameter that ensures both accurate characterization of short-term variability and the collection of sufficient data to establish long-term trends;"

# 7 Summary: Assessing Environmental Performance

The environmental performance of the Ekati Diamond mine with respect to the aquatic receiving environment beyond the dilution zone has been assessed by comparing water quality measurements with CCME guidelines and comparing biological measurements with similar measurements from reference lakes. Some comparisons have been made over time and others over distance from the Long Lake containment facility.

None of the comparisons made refer to effect sizes. None of the comparisons made refer to type II error rates. As of 2005, no water quality parameters exceeded CCME guidelines (Rescan, 2006a) although increases in 8 water quality parameters were noted. One change was noted in sediment quality and one change was noted in a biological variable.

None of the changes noted were assessed in the context of ecological, sociological or political relevance; i.e. in the context of an effect size. None of the conclusions regarding lack of effects were couched in terms of type II error rates.

At the end of the day, this makes it very difficult to quantitatively assess the BHP AEMP. It is a comprehensive program, large amounts of data are being thoughtfully collected and there is a quality assurance program in place. Yet without the dual criteria of effect sizes and type II error rates all that can be said about the AEMP is:

*"The AEMP looks pretty good",*

or perhaps,

*"The AEMP doesn't look very good."*

Each of these statements can only be made by an expert or experts familiar with that receiving environment. Each of the statements is subjective in the sense that "good" has a subjective connotation. Neither statement is very helpful from the perspective of evaluating the redesigned AEMP or providing criteria for evaluating the revised AEMP.

The recommendations section, below discusses a way forward. Prior to making recommendations, changes proposed to the current AEMP are discussed (with the caveats noted in section 1). Those structural aspects of the proposed AEMP necessary for discussion purposes are also discussed immediately below.

# 8 AEMP Structure

This section provides comment on the proposed AEMP structure or summarizes the proposed structure for discussion purposes. At this time only water quality monitoring in lakes is discussed.

## *8.1 Level of Sampling Effort*

**Table 2: Summary of Lake Water Quality Monitoring Effort, August**

| Number of Locations | Depths (m) | Replicates | Sample Size | # Parameters | Source |
|---|---|---|---|---|---|
| 12 | 1 | 3 | 36 | 16 | Figure 3-1 2005 AEMP Summary |
| 12 | mid-depth | 3 | 36 | 16 | Figure 3-1 2005 AEMP Summary |

## *8.2 Analytes Studied*

The list of analytes evaluated in Rescan (2006a) is a subset of the analytes measured. The principal analyte classes of potential concern for the BHP facility are I believe, nutrients and metals. Particulates in various forms are also likely a potential issue in lakes immediately downstream of the Long Lake containment facility (LLCF). Key analytes falling into these classes are being measured and evaluated but the primary general toxicity modifying factors for metals as a class are not being evaluated. These three toxicity modifying factors are pH, hardness and dissolved organic carbon (DOC) or total organic carbon (TOC).

It is in the best interest of BHP to evaluate hardness and one of the forms of organic carbon due to their protective effects with respect to metal toxicity. This information is also useful for reviewers to better understand potential for toxicity in the context of the current benchmark for assessing metal concentrations; namely the CCME water quality guidelines.

# 9 Review of Proposed Changes

Rescan (2006b, c) has proposed various changes to the current BHP AEMP. Rescan (2006b, chapter 7) states that the changes are based on recommendations from the preceding chapters. These chapters are reviewed in the context of supporting the proposed changes.

Note that not all changes are reviewed at this time. Only those proposed changes comprising a reduction in the current AEMP with respect to water quality variables

## *9.1 Eliminate July and September Lake Water Sampling*

This is proposed change # 1. Rescan (2006b, c) have proposed to eliminate lake water sampling in July and September and increase sampling effort in August. I could not find any discussion in Rescan (2006b) on this topic. No comparison of July, August September water quality variables was found in Rescan (2006a).

It does not appear that the recommendation to eliminate 2/3$^{rd}$s of the summer temporal samples is substantiated. I recommend that the July and September water quality samples be retained until a defensible case overthrowing the original reason for collecting these samples is made.

## *9.2 Evaluate Critical Effect Sizes*

This is proposed change #16. Rescan (2006c) has proposed to evaluate critical effect sizes for selected parameters. It must be made very clear that critical effect sizes must be agreed to by all stakeholders. Moreover, critical effects sizes comprise a blend of scientific, political and sociologic issues. Critical effect sizes therefore should not (and likely cannot) be generated by any single organization. Section 6 of this document discusses effect sizes in a general way.

## *9.3 Use of Multivariate Statistics*

On Change # 18. In the past I have suggested that multivariate analyses are a useful method for examining the data generated by the BHP AEMP (Zajdlik, 2004, 2006). With respect to water quality parameters, multivariate methods such as ordination can show patterns of change that univariate analyses cannot. After reviewing the multivariate analysed conducted by Rescan (2006b) using the historical data I concluded that the multivariate analyses were in some ways more informative than the univariate analyses.

For example, examination of results in table 3.1-6 (Rescan 2006b) identifies a series of analytes that have increased due to the LLCF discharge. Despite the use of PCA where multiple sources of variability were present, more water quality variables exhibit an increase when using PCA relative to univariate analyses to interpret results. When reporting on univariate analyses results, Rescan does state for each analyte whether it is increasing or decreasing but highlights only a few analytes. The message that PCA gives is "a suite of 11 contaminant concentrations is increasing". Using the set of variables that were analyzed using both PCA and univariate analyses, the message that the univariate analyses gives is "a suite of 4 contaminant concentrations is increasing[2]".

It is important to realize that the two statements are not directly comparable. The multivariate analysis identifies increases in the suite of analytes, the univariate approach

[2] Note that Rescan does report on each analyte separately but not all increases are reported as such. The reason for this exclusion was not investigated.

identifies increases for a single analyte at a time, based upon specific Type I error rates[3] and spatiotemporal comparisons.

One of the reasons Rescan (2006c) makes for not using multivariate analyses within the AEMP is that the incremental benefit of adding one year of data to a dataset and repeating a multivariate analysis is negligible. This is likely correct if no substantive changes in water quality occur within a single given year.

I am however suggesting that multivariate analyses be conducted on the within-year data. This analysis focuses on the spatial changes in water quality variables as a group. The analysis can highlight spatial patterns occurring in the suite of substances released by BHP that univariate analyses cannot. I concluded this after examining the AEMP structure with respect to water quality monitoring (please see section 8). This useful analysis is possible given the number of evaluated water quality variables relative to the number of stations.

Within-year multivariate analyses may also be possible for raw benthic community measurements depending upon the number of taxa collected; alternatively a suite of summary metrics could be used in a multivariate analysis.

## *9.4 Use of BACI Analyses*

This section refers to proposed changes # 19 and # 20. Comments made regarding BACI analyses in Zajdlik (2004) relative to Rescan (2002) are still relevant here. These are re-stated / summarized below.

- Rescan (2002) ignores the potential year effect by lumping all data collected between 1994 and 1997 into the "before period'. However variation from year-to-year can obscure differences. Blocking on the year effect prevents year-to-year variability from obscuring spatial differences and may also allow results from an unusual year (i.e. the inexplicable turbidity in 1997) to be incorporated into the data set as the effect of year is removed by blocking. Note that Rescan (2002a) pg 3-5, bullet 4 acknowledges that they assume that the "pooled data from these (1994 to 1997, inclusive) were representative of the "Before" period in the analysis". However it is not clear that the assumption was ever checked.

- The use of subsamples as replicates[4] and lack of control of confounding variables affects the validity of BACI conclusions.

[3] The type I error rate is lower than that used in other environmental monitoring programs. All other things being equal the degree of environmental protection afforded by an AEMP decreases as the type I error rate decreases. This is further discussed in section 9.4.

[4] The issue of subsamples has been acknowledged by Rescan in the November, 2006 AEMP technical meeting. If subsamples are no longer treated as replicates this point will have been addressed.

- Of lesser concern but still an issue is the use of the Kolmogorov-Smirnov test (an historical curiosity D'Agostino and Stevens, 1986) for testing normality. Alternative methods should be used to test the assumption of normality required for highly defensible conclusions following the BACI analyses used by Rescan.

- The BACI interpretation paradigm used by Rescan is conservative from the perspective of protecting the discharger due to the choice of level of significance. Rescan (2002, section 3.3.2.1) rationalizes the choice of a type I error rate of 1% rather than the generally accepted 5% for the BACI interaction term. This in effect "raises the bar" for detecting environmental effects. An increase in the type I error rate increases the level of environmental protection whereas a decrease lessens the level of environmental protection.

It is critical that the issue regarding Type I error rates in BACI analyses be addressed. It is not clear from examining the 2005 AEMP summary document (Rescan, 2006a) whether this issue was addressed subsequent to the 2004 review. It is also not clear from examining the 2005 AEMP summary document (Rescan, 2006a) whether the other issues described above were addressed subsequent to the 2004 review.

## *9.5 Stepwise Elimination of Biotic Variables*

I do not clearly understand proposed change # 21.

# 10 Recommendations

## *10.1 AEMP Background and Underpinnings*

The evaluation and redesign of an AEMP must be made in the context of what is acceptable to stakeholders. The EIS written in 1995 fails in this regard because the amount of change that was acceptable to stakeholders was not defined. Change (from the perspective of the aquatic receiving environment) includes the magnitude of change and the spatial extent of the change.

Perhaps large changes within a very short distance are acceptable (for example, draining a lake). Perhaps small changes over a very large distance are unacceptable. In any case, words such as "short" and "large" must be defined so that an AEMP can be evaluated and if necessary redesigned. Clearly defined statements regarding what is acceptable and what is not also provides clear guidance to the proponent. This allows the proponent to take timely mitigative action if necessary, to point out the success of their mitigative actions if appropriate or to take no mitigative action at all.

Therefore, I suggest that the EIS be updated from the perspective of aquatic effects monitoring[5]. At least one EIS for a Diamond Mine in the NWT, written since 1995 includes a discussion of measurement endpoints and what changes in a measurement endpoint reflects a deleterious change. This EIS also includes a quantifiable discussion of the spatial extent of expected changes. The combination of spatial extent and magnitude of change was used by stakeholders to clearly define what effects are acceptable and what effects are unacceptable. These discrete criteria allow reviewers to asses whether the AEMP is "good" or "bad". The proponent is also able to say unequivocally, "We are doing a good job in protecting the environment" if all measurement endpoints fall within the criteria. Stakeholders can feel comfortable that the environment is being protected to the level agreed upon.

Updates to the EIS should include:

1. Additions of benthos to the list of VECs.

2. An explicit list of measurement endpoints.

3. A list of effect sizes.

[5] An update for other environmental programs may also be required.

4. Acceptable Type I and II error rates. The recommendation to include acceptable Type I and II error rates addresses Part I, Item 2(e) of the water license (MVLWB, 2005) with respect to statistical design criteria. The adjective "acceptable" dictates that these values be obtained through consensus.

   Rescan (2006c, Appendix 3) addresses this license requirement by pointing to sampling frequency and critical effect sizes as addressing design criteria. Sampling frequency, even when coupled with number of locations is only one statistical design criterion (sample size). Critical effect size is not a design criterion; it is a design objective that is not within the purview of the proponent to develop alone (discussed in section 9.2).

The combination of items 3 and 4, above are consistent with MVLWB (2005, Part I, Item 2(g)): "a description of evaluation criteria for the Aquatic Effects Monitoring Program and approaches to amend and refine the Aquatic Effects Monitoring Program". These updates should be included in the following sections of the AEMP, although perhaps only at the three-year review stage:

1. **Experimental design:** These concepts rationalize the experimental design and allow reviewers to critically evaluate the design and the proponent to strongly defend the design.

2. **Conclusion:** The conclusion of "no effect" is strengthened when changes fall within the limits agreed upon by stakeholders.

3. **Adaptive Management:** Inclusion of quantifiable changes that indicate adaptive management is necessary or not, helps the proponent in managing the process, demonstrating due diligence and provides assurance to stakeholders. Moreover, the link between these quantifiable changes and adaptive management are required under MVLWB (2005, Part I, Item 2(h)[6]). This work has not yet been conducted although Appendix 3 of Rescan (2006c) states that this work is forthcoming[7]. Since effect sizes are not currently part of the BHP AEMP, they should be in the Adaptive Management Plan. It is clear that an adaptive management plan has yet been created for the Ekati facility. (N. Richea (INAC, pers. com.)

4. **Comparison to EIS Predictions:** It is not clear how comparisons to EIS predictions are possible or useful given the ambiguity of the EIS (discussed in section 5, above). Rescan (2006c, Appendix 3) refers to Rescan (2006b, Figure 9-1) to demonstrate how the revised AEMP is in compliance with (MWLB, 2005, Part I, Item 2(j)) the requirement to compare with EIS predictions. Figure 9-1

[6] "a description of how the results of the Aquatic Effects Monitoring Program will be incorporated in the overall adaptive management strategies employed by the Licensee"

[7] "The forthcoming Watershed Adaptive Management Plan will describe how AEMP data will be used within the framework of adaptive management, and how the results of adaptive management will be reported in the AEMP." Rescan (2006c, Appendix 3).

does not contain any comparisons nor does it point to any comparisons. Figure 9-1 only states this work will be done in 2006.

Pg. 4 of Rescan (2006c, Appendix 3) does point to the tri-annual Environmental Impact Report that addresses item 3(e) of MVLW (2005). In this report 6 water quality analytes are reported as continually increase since 1997 (Rescan, 2006d, section 5.4.3.2); the original EIS predicted negligible residual effects. Special effects studies have been commissioned to assess these findings.

The statement opening this section describes the EIS predictions as ambiguous. While this is true, it is possible to compare an observed change to no predicted change (negligible effects) and conclude that a change has occurred. What cannot be concluded is whether the change is unacceptable with respect to total loadings to the environment, concentration in the environment or spatial extent of elevated concentrations. At this point in time I do not know whether the current bases for comparison (CCME water quality guidelines) were acceptable to stakeholders as concentrations that BHP could approach. This should be investigated along with stakeholder acceptable limits for spatial extent of elevated concentrations, etc.

Note that Rescan (2006c, Appendix 3 in reference to Section 7.2, bullet 1 and Figure 9-1 of Rescan, 2006b) does mention MVLWB (2005, Part I, Item 2(g)) on evaluation criteria. They state that multivariate statistical tools comprise evaluation criteria. The two references to the re-evaluation report (Rescan, 2006b) refer to the use of multivariate analyses on a three year cycle (Section 7.2, bullet 1) and a schedule stating that the AEMP will be evaluated in 2006 (Figure 9-1).

Multivariate analyses may be used to test hypotheses or make predictions regarding the effect of the mine; however multivariate analyses are not a criterion to evaluate the AEMP. A criterion is a standard by which something is judged or evaluated. One criterion tied to multivariate analyses is the ability of the proposed multivariate analyses to detect effects deemed “critical”, i.e. the critical effect sizes. This ability or “statistical power” is a criterion that could be used to evaluate the AEMP. The ability or statistical power required to detect a given change must again be, consensus driven.

## *10.2 On Proposed AEMP Changes*

Rescan (2006c) proposes numerous changes to the AEMP. Comments regarding the changes reviewed (please refer to exclusions in section 9) are summarized below.

- Rationalize omission of July and September lake water samples before omitting.
- The proponent can and should participate in the discussion regarding critical effect sizes, but the final decision should arise following consensus among stakeholders.

- Multivariate analyses provide insights into patterns in data that univariate analyses cannot. Multivariate analyses should be used at least for the within-year lake water quality dataset on an annual basis.

- I did not clearly understand proposed change # 21.

## *10.3 Recommended Changes to Proposed AEMP*

Rescan (2006c) has made changes to the AEMP some of which have been reviewed and discussed above. I recommend the following additional changes to the AEMP.

- The list of water quality analytes being evaluated[8] should be reviewed. This list was compiled after an examination of the data collected to date in 2002 or thereabouts. One criterion for evaluation and reporting in the AEMP was whether the analyte was demonstrably increasing (Rescan, 2003, section 1.6.1). If a change was observed, 5 additional criteria were applied before including the analyte in the list of evaluated parameters. Given that approximately 5 years have passed, and that the initial screening criterion is an increase in analyte levels, I suggest that the list of evaluated analytes be re-examined. Similar arguments may apply to analytes in other matrices such as sediment. The following analytes should be included in the list of evaluated analytes.

    - DOC, TOC and hardness as they are critical with respect to assessing metal toxicity. (discussed in section 8.2).

    - Stack losses in the form of chlorinated organic compounds and polycylic aromatic hydrocarbons (PAHs) will ultimately reside in the fatty tissues of top level predators. Some of the cumulative forms of these analytes (total PAHs, total PCBs, etc.) should be added to the list of analyses conducted in lake trout livers and edible tissue. Detection in an intermediate environmental component such as sediment and/or a bait fish would allow BHP to predict whether these compounds will accumulate to unacceptable levels in edible fish tissues.

- The type I error rate used in the BACI analyses must be examined. A value of 1% sets the bar for declaring a change higher than any other environmental program I have been involved with. The value should be changed to at least 5% and possibly 10%. All other things being equal the degree of environmental protection afforded by an AEMP decreases as the type I error rate decreases.

[8] BHP analyzes water samples for a large number of analytes. Only some of these are "evaluated". Evaluation comprises statistical analysis, presentation and discussion in AEMP reports.

## *10.4 Recommendations Zajdlik 2004*

Zajdlik (2004) reviewed the 2002 BHP AEMP report and made various recommendations at that time. Those recommendations are reviewed to see if changes have been made.

**Table 3: Checklist of Whether Previous Recommendations were Adopted**

| Section (Zajdlik, 2004) | Topic | Recommendation | Recommendation Adopted? |
|---|---|---|---|
| 9.1 | List of Analytes | Investigate flocculants | I believe so. |
| 1.7.1 # 1 | BACI Analyses | Use control lakes as a pool rather than one – at – a time for BACI analyses. | Unable to ascertain after reading Rescan (2006c). |
| | | Multiple sources of variability (depth, season, year) | Examined section 4 of Rescan (2006c) and could not find details of BACI analyses. Section 2, changes 19 and 20 of Rescan (2006c) state that the current BACI related practices will be retained unless data are available for more than 3 years in which case a temporal-spatial analysis will be used. |
| | | Use of subsamples as replicates | This recommendation is being studied. Rescan (2006c) proposes to collect 3 replicates for the August lake water quality study. Other aspects of the AEMP were not examined. |
| 1.7.2.3 | AEMP Context | Definition of receiving environment | It is not clear whether this recommendation was addressed. |
| 1.7.1, # 2 | Interpretation Paradigm | Flaws in logic | The only mention of the interpretation paradigm in the 2005 AEMP summary only states: "conduct an evaluation of effects using historical and baseline data" (Figure 1.1-2 Rescan, 2006a). This is insufficient to understand what was done. At this point it is not possible to determine if recommendations were adopted or not. |

| Section (Zajdlik, 2004) | Topic | Recommendation | Recommendation Adopted? |
|---|---|---|---|
| 1.7.1 # 3 | | Hydraulic gradient | Rescan (2006c, change # 27) will present graphics showing spatial arrangement of stations. It is not clear that the spatial information among stations will be used in the temporal-spatial analyses proposed by Rescan (2006c, changes 19 and 20). I do not believe this recommendation has been adopted. |
| 1.7.1 # 4 | Multivariate analyses | Use for temporal and gradient relationships for zooplankton, phytoplankton, benthic macroinvertebrates, sediment chemistry and aquatic chemistry | The multivariate analyses conducted by Rescan (2006b) and summarized in Table 4 partially address this recommendation. However, the analyses collapsed data over watershed, time and space. The consequences of this data treatment are discussed in Appendix 2: The 3-Year AEMP Review. |
| 1.7.1 # 5 | Data Interpretation | Use one-sided tests. | After examining Rescan (2006a, c) it is not clear whether this recommendation was adopted. |
| 1.7.1 # 6 | | Report effect sizes. | Rescan (2006c) has adopted this recommendation. |
| 1.7.1 # 7 | | Integrate analyses. | Rescan has only integrated some of the analyses when using multivariate analyses for the first time in the 2006 data review (Rescan, 2006b). Given that Rescan's position is that multivariate analyses will be conducted only every three years and that multivariate analyses are the only tool used thus far to integrate results, it is doubtful that Rescan intends to adopt this recommendation. |
| 1.7.3.1 | Quality Assurance | | The quality assurance recommendations seem to have been adopted. |

## *10.5 Miscellaneous*

- Rescan (2006c, Appendix 3) disagrees with the requirement to address potential effects within Lac de Gras. INAC should be aware of this disagreement and decide what steps to take. If the AEMP must consider effects within Lac de Gras, additional monitoring will be required.

- The synthesis provided in BHP (2007, Appendix 2 pg. 1 and 2) entitled "Summary of Stakeholder Comments on the November 2006 AEMP Re-evaluation" is incomplete (discussed in Appendix 1, below). The summary should be corrected and the addendum to BHP (2007) should be officially posted lest the summary provided stand as a complete and accurate summary of reviewer comments.

# 11 Citations


Burd, B.J. 2002. Evaluation of mine tailings effects on a benthic marine infaunal community over 29 years. Mar. Env. Res. 53(5):418-519.

D'Agostino, R.B. and M.A. Stephens. 1986. Goodness of Fit Techniques. Marcel Dekker Inc., New York.

Environment Canada. 2002. Metal Mining Guidance Document For Aquatic Environmental Effects Monitoring, June 2002.

Rescan. 2002. 2002 Aquatic Effects Monitoring Program (AEMP) Technical Report.

Rescan. 2003. AEMP Re-Evaluation and Refinement Report: Proposed Program for 2003 – 2007. Prepared for BHP Billiton, January, 2003.

Rescan. 2006a. Ekati Diamond Mine Aquatic Effects Monitoring Program (AEMP) Summary Report. July 2006. Project #696-7

Rescan. 2006b. Ekati Diamond Mine AEMP Re-evaluation and proposed program for 2007-2009. Prepared for BHP Billiton, November, 2006.

Rescan. 2006c. Ekati Diamond Mine Aquatic Effects Monitoring Program Plan for 2007-2009. EKATI Diamond Mine, BHP Billiton Diamonds Inc. December, 2006.

Rescan. 2006d. Environmental Impact Report. Prepared for BHP Billiton Diamonds Inc. April, 2006.

BHP. 1995. NWT Diamonds Project Environmental Impact Statement.

MVLWB. 2005. BHP Ekati Facility Water License #MV2003L2-1616.

Zajdlik, B.A. 2004. Review of the Ekati Diamond Mine 2002 Aquatic Effects Monitoring Program. Prepared for the IEMA Steering Committee.

Zajdlik, B.A. 2006. Overview of the BHP Proposed AEMP. Prepared for R. Chouinard, INAC. December 14th, 2006.

# Appendix 1: Comments on Rescan (2006c) Appendix 2

The synthesis provided in BHP (2007, Appendix 2 pg. 1 and 2) entitled "Summary of Stakeholder Comments on the November 2006 AEMP Re-evaluation" is incomplete.

For example:

- Some of the summarized statements do not include dissenting positions. For example the North Slave Métis Alliance was not in favour of eliminating July and September sampling.

- Some critical comments were omitted.

    - The Independent Environmental Monitoring Agency suggested that multivariate analyses be conducted on a yearly basis.

    - Zajdlik (December, 2006) makes suggestions to be included in the adaptive management plan but this does not appear in the summary table.

    - etc.

The summary should be corrected and the addendum to BHP (2007) should be officially posted lest the summary provided stand as a complete and accurate summary of reviewer comments.

# Appendix 2: The 3-Year AEMP Review

This section briefly reviews the 3-Year AEMP review conducted by Rescan (2006b) and is NOT comprehensive. The goal of assessing the 3-Year AEMP review is to better understand the BHP AEMP so that constructive comments can be made as BHP submits an updated AEMP to the Wek'eezhii Land and Water Board.

## *Interpretation Tools*

The following investigations were conducted by Rescan (2006b):

**Table 4: Summary of Investigations Conducted by Rescan (2006b)**

| Investigation | Zooplankton | Lake Benthos | Stream Benthos | Lake Cladocera Only |
|---|---|---|---|---|
| Abundance versus Year by location | ✓ | ✓ | ✓ | |
| Richness versus Year by location | ✓ | ✓ | ✓ | |
| Richness versus 1st principal component using water or sediment quality data as appropriate (all years) by location | ✓ | ✓ | ✓ | |
| Richness versus 2nd principal component using water or sediment quality data as appropriate (all years) by location | ✓ | ✓ | ✓ | |
| Bray-Curtis Dissimilarity versus 1st principal component using water quality data (all years) by location | ✓ | ✓ | ✓ | ✓ |
| Bray-Curtis Dissimilarity versus 2nd principal component using water quality data (all years) by location | ✓ | ✓ | ✓ | ✓ |
| Cluster analysis on Bray-Curtis Dissimilarities | ✓ | ✓ - by depth | ✓ | |
| Bray-Curtis Dissimilarity cumulative densities | ✓ | ✓ | | ✓ |

All investigations conducted by Rescan (2006b) described above (with the possible exception of the cluster analyses) present results on a per station basis. No analyses of yearly phytoplankton data were presented. No analyses of fish-related data were presented although this may be due to the availability of data as fisheries data is collected only on a 5-year cycle.

The following sub-sections discuss the two major efforts by Rescan (2006b) with respect to augmenting the yearly data interpretations.

## Principal Components Analyses on Abiotic Variables

The 3-year AEMP review by Rescan (2006b) used a multivariate data interpretation tool – principal components analysis (PCA) to further investigate the data collected to date. This departs from the tools (univariate statistics, visual gradient analyses and best professional judgment) used to interpret the data on an annual basis.

Rescan (2006b) accepts the ancillary comments in articles not written for the purpose of evaluating ordination methods to justify their treatment of missing values. The option used by Rescan is to delete observations where a dataset is not complete. The effect of this is to lose much of the early data. The loss of this information must be borne in mind when accepting or rejecting Rescan's conclusion with respect to the utility of ordination relative to univariate methods.

Rescan (2006b, pg. 3-2) found that PCA on lake and stream water quality variables produced similar results. It would be helpful to see these results so that the reader can decide if they agree with the conclusion[9].

DOC and TOC are two critical variables (with respect to mitigation of potential metal toxicity). These variables were not included as ordination variables, (Rescan 2006b Table 3.1-1). These variables were omitted as they were not available for all years and inclusion of these variables would have resulted in the loss of substantive amounts of data (B. Friesen-Pankratz, Rescan, pers. comm. at BHP Meeting Nov. 22).

Data were combined across watersheds. I believe that data were analyzed separately by watershed and then combined following the similarity of results for each separate analysis. Again it would be helpful to see these results so that the reader can decide if they agree with this conclusion.

Data were also combined across years and seasons. There are clearly yearly effects (see for example Figure 7.4-2, Rescan, 2006b) and very likely seasonal effects.

PCA attempts to describe the major patterns of variability in a data set. The major pattern of variability of interest is the variation and co-variation of analytes across the exposure and reference lakes. The sensitivity of a PCA to this source of variation will be blunted by including other major sources of variability (yearly and seasonal) and minor sources of variability (potentially watersheds, streams and lakes). It is surprising that the PCA performed as well as it did, given these extra confounding sources of variability.

Rescan (2006b) concluded that the univariate analyses performed on a yearly basis and PCA performed on the accumulated data provide the same insights for water quality variables. I disagree with this conclusion for the following reason.

[9] A brief discussion with B. Friesen-Pankratz (Rescan at BHP Meeting Nov. 22) indicates that this statement is likely reasonable.

Examination of results in table 3.1-6 (Rescan 2006b) identifies a series of analytes that have increased due to the LLCF discharge. Despite the blunted PCA, more variables are shown an increase using PCA relative to univariate analyses. When reporting on univariate analyses results, Rescan does state for each analyte whether it is increasing or decreasing but highlights only a few analytes. The message that PCA gives is "a suite of 11 contaminant concentrations is increasing". Using the set of variables that were analyzed using both PCA and univariate analyses, the message that the univariate analyses gives is "a suite of 4 contaminant concentrations is increasing[10]".

Rescan (2006b) states that the univariate sediment analyses performed on a yearly basis and PCA performed on the accumulated sediment quality data are in general agreement. However, the ratio of analytes flagged by PCA versus univariate sediment quality analyses is almost identical to that for water quality variables. The multivariate analysis highlights a larger suite of contaminants whose concentrations are increasing in the receiving environment than the univariate analyses, at least as summarized.

Rescan's (2006b) conclusions about the relative merits of univariate versus multivariate analyses must also be examined in the context of:

1. Potential insensitivity of the ordinations due to the inclusion of sources of variability that at least obscure the comparisons of interest;

2. Potential confounding of conclusions due to the inclusion of multiple sources of variability; and,

3. Failure to extract some of the information contained in the ordinations.

## Analyses on Biotic Variables

Cluster analyses were used to investigate biotic data but were dismissed by Rescan (2006b) as being uninformative. The cluster analyses have not been reviewed at this time.

The Bray-Curtis dissimilarity measure is used to summarize the biological communities. The authors acknowledge the influence of the sensitivity of this measure to the most abundant species but do not discuss this sensitivity when interpreting results.

Bray-Curtis dissimilarity measures are relative. Rescan (2006b) used all data from all reference lakes averaged over years to represent the "mean overall reference condition". Rescan (2006b) states that "this step is necessary in order to differentiate between "effects" from mining operations and natural shifts due to external factors".

[10] Note that Rescan does report on each analyte separately but not all increases are reported as such. The reason for this exclusion was not investigated.

An independent reviewer (C. Schwarz) was retained by BHP Billiton to "review and provide comments on the EKATI AEMP documents" (Rescan, 2006b). One recommendation was to use a Temporal-Spatial Level-by-time design. This recommendation is adopted in section 7.2 of Rescan (2006b). Rescan (2006b) states: "This approach (Temporal-Spatial Level-by-time) will improve the ability of the AEMP in detecting gradual increasing trends over time".

I agree with the recommendation made by C. Schwarz on this topic and the conclusion made by Rescan (2006b). It is important to acknowledge changes over time. The analysis advocated, makes spatial comparisons indexed by time, rather than collapsing over time.

The Bray-Curtis dissimilarities estimated by Rescan (2006b) do not adhere to this concept, collapsing the reference data over both time and space to estimate the "mean overall reference condition" and collapsing exposure data over time to create location-specific dissimilarities with the mean reference condition. This averaging procedure should not be used as it has the potential to obscure meaningful differences.

### *Summary*

Rescan (2006b) concluded that:

- PCA performed on the accumulated data provide the same insights for water quality variables;

- the univariate sediment analyses performed on a yearly basis and PCA performed on the accumulated sediment quality data are in general agreement.

I cannot support these statements at this time due to the inclusion of numerous known sources of variability that potentially confound results.

The Bray-Curtis dissimilarity index is only one of many and provides only part of the picture. Its particular attributes can influence interpretation of the dataset; the influence of the choice of metric on conclusions should be discussed.

Use of the Bray-Curtis index suffers from collapsing data over time. Collapsing data over time contradicts the rationalization behind the temporal-spatial comparisons recommended by another reviewer and adopted by Rescan (2000b).

When the Bray-Curtis index is used to produce cumulative distributions following Burd, (2000) the effect of time, particularly for those lakes closest to the Long Lake Containment Facility is not included. Examination of Burd (2000) shows that the assumption of homogeneity is the "most important[11]" when applying this method.

[11] "The most important assumption in this method is that biotic factors for a given area (near-field, mid-field and far-field) were relatively homogeneous over time during mining or after mine closure, and therefore could be combined as described." Burd, (2002).