Environment Canada
Environnement Canada

March 14, 2003

Mackenzie Valley Environmental Impact Review Board
Box 938, 5102-50th Avenue
Yellowknife, NT
X1A 2N7

Attention: Glenda Fratton, Environmental Assessment Coordinator

Dear Ms. Fratton:

Please accept the attached report from Environment Canada's submitted as an Addendum to it's February 14th Technical Report.

Please contact me if you have any questions or concerns.

Sincerely,

Mark Dahl
Contaminants Biologist
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Summary of Outstanding Environment Canada Issues

The Technical report submitted by Environment Canada (EC) on February 14, 2003 detailed EC's concerns regarding the De Beers Snap Lake development based on the information available to that date. Subsequent to the submission of that report the proponent provided a substantial amount of technical information for review. EC is submitting the attached Addendum Report (dated March 14, 2003) in order to address the information provided. The list below provides a plain language summary of the issues that remain unresolved after the review of the above noted technical information.

Issue numbers presented in this list correspond to the numbers used in Environment Canada's Addendum Report submitted March 14, 2003 (attached).

Issue #3 Water Quality - Treatment Options
EC is satisfied that several mine water treatment alternatives have been explored, however, it is difficult to compare the treatment options without reviewing the empirical data upon which the comparison is based. It also remains unclear if the treatment plant will be equipped to remove dissolved metals.
Why is this an issue?: In order to maintain a dry mine De Beers will have to pump large quantities of water out of the mine workings. The mine water will be composed of deep ground water, and water infiltrating from the lake. This water contains some materials that could damage the ecosystem in Snap Lake if they were not removed through water treatment. De Beers has examined several options for water treatment and has concluded that filtering out the suspended particles will produce water good enough to release to Snap Lake even though the treatment option selected does not effectively treat for dissolved metals. EC is concerned because the selection of the best suited treatment process was based on data that has not been provided for review and does not treat for dissolved metals which can cause environmental impacts.

Issue #7 Air Quality Monitoring - $PM_{2.5}$ and PM_{10}
Air Quality Monitoring is necessary to demonstrate that Ambient Air Quality Standards for $PM_{2.5}$ and PM_{10} are being met.
Why is this an issue?: The NWT has ratified the Canada-Wide Standards for Particulate Matter and Ozone (CWS). As part of the CWS many jurisdictions recognize that polluting "up to a limit" is not acceptable and that the best strategy to avoid future problems is to keep clean areas clean. EC concludes that De Beers needs to demonstrate, through monitoring, that the air quality impacts from the Snap Lake mine development comply with the NWT Ambient Air Quality Standards and Canada-Wide standards. In addition, ambient monitoring is essential to ensure that efforts are working to Keep Clean Areas Clean.

Issue # 8 Water Quality - Total Dissolved Solids Density Plume
The effluent discharged from the project will be denser than the water in Snap Lake and will therefore, sink to the lake bottom as it moves outside the turbulent mixing zone. The resulting plume will flow along the bottom and settle in deeper areas of the lake.
Why is this an issue?: When the plume finally settles in the deep spots it will resist mixing with the rest of the lake. This reduced mixing will result in pockets of water which have reduced dissolved oxygen concentrations and different chemical composition than the rest of the lake. If the plume does not break up as expected or if large portions of the lake are impacted by the it could the lake ecosystem could be significantly altered.

Environment Canada

Technical Report

De Beers Canada Snap Lake

Project

Addendum

March 14, 2003

INTRODUCTION

This report should be read in conjunction with Environment Canada's submission of February 14, 2003. In the interest of brevity issues that were listed as *Resolved* in Environment Canada's Technical Report dated February 14, 2003 are grouped as *Previously Resolved* and presented by topic only. *Recently Resolved Issues* were resolved on the basis of information received and reviewed post February 14. *Outstanding Issues* are issues that have not been resolved to the satisfaction of Environment Canada (EC) reviewers.

PREVIOUSLY RESOLVED ISSUES

Issue #1 Water management - Storage capacity

Issue #2 Ground Water - Impacts on North and Northeast Lakes

Issue #3 Water Quality - Treatment Options

RECENTLY RESOLVED ISSUES

Issue #4 Water Quality - Phosphorus

EC had concerns with the initial water quality modeling results, as they predicted a decrease in total phosphorus levels, when loadings were increasing as a result of project inputs. EC was also concerned that ortho-phosphorus was the only form included in eutrophication modeling, and that this may have lead to an underestimation of available phosphorus. De Beers was asked to re-run the phosphorus model to include other forms of phosphorus.

Reference: TOR line #344 -350, 381 EAR section # 9.4.2.2.4

Background

De Beers has re-evaluated the input parameters to the model used to estimate phosphorus and algal productivity, and has also run sensitivity analyses and modeled a range of concentration scenarios.

Developer's Conclusions

De Beers re-ran the eutrophication model using a lower settling rate and negligible rate of P release from the sediments (recalibrated to observed conditions). This yielded a predicted P concentration of 12 ug/L in Snap Lake which is an increase of 4 ug/L from baseline conditions as well as an increase in chlorophyll *a* levels to 1.5 ug/L. This information was provided in a presentation made to stakeholders Feb. 10, 2003.

Further modeling was done to include various amounts of the dissolved phosphorus as available phosphorus, in addition to the orthophosphate. Predicted lake

mean concentrations were 13-23 ug/L for total phosphorus, and 1.5 - 2.3 ug/L for chlorophyll *a*.

Environment Canada's Conclusions and Rationale/Evidence

EC finds the results of the re-calibrated modeling to be more credible. EC notes that the total phosphorus value predicted by the re-calibrated model is likely to be associated with slightly increased productivity, but the phosphorus concentration would still fall within the range found in oligotrophic lakes (3.0 - 17.7 ug/L) as defined by Wetzel 2001[1]. Chlorophyll *a* concentrations predicted by the re-calibrated model remain below the mean for oligotrophic lakes under this classification system.

"Worst case" model results reached a maximum of 23 ug/L when 100% of dissolved phosphorus was considered to be available P. This would represent a significant increase in lake productivity, but is predicted using conservative premises. This would shift the lake towards mesotrophic status, but if model predictions of chlorophyll *a* are accurate the productivity response would remain within the oligotrophic range.

Recommendation

EC recommends that De Beers continue to refine their model calibration by monitoring the parameters which are used as model inputs. EC further recommends that this monitoring be carried out in the first years of mine operation to improve confidence in model predictions with respect to P loading over time. This will confirm whether the sediments act as a phosphorus sink (as predicted), and identify what proportion of the phosphorus is bioavailable.

Environment Canada's position: This issue has been resolved.

Issue # 5 Water Quality - Ground water impacts on Snap Lake

Water chemistry impacts of ground water from underground mine workings on Snap Lake.

Reference: TOR lines 344-355, 381, EAR section 9.4, Appendix IX.1

Developer's Conclusions

The impact magnitude of the hexavalent chromium in the effluent discharge was classified as low. This classification was based on the prediction that the concentration of hexavalent chromium in the discharge would result in chronic toxicity to zooplankton in less than 1% of Snap Lake. The predicted impact magnitudes for copper and cadmium were classified as negligible (p. 9-227). The TDS concentrations are predicted to increase from the median baseline of about 15 mg/L to a maximum average concentration of about 330 mg/L in Snap Lake. The major constituents of the increased TDS would include chloride, calcium, sodium, magnesium and sulphate. However, the impact on water quality could not be classified because there are no established general water quality guidelines or site-specific benchmarks for TDS and major ions (p. 9-229).

Environment Canada's Conclusions

On the basis of additional information and analyses provided in the Technical Memorandum titled "Snap Lake Diamond Project Mine Water Assessment and Variability", Environment Canada concludes that the estimated concentrations of total dissolved solids, chloride and other dissolved constituents in the mine water discharge (as presented in the EAR) are a reasonable representation of the conditions at the site. EC further concludes that the predicted impacts of the treated discharge on Snap Lake water quality are realistic.

Environment Canada's Rationale/Evidence

The proponent has included six additional ground water samples from the granite that were collected during the advanced exploration program. These samples were not included during preparation of the EAR but have been included in the calculations presented in the Technical Memorandum to support the estimates of baseline connate water chemistry presented in the EAR. The average chloride concentration for the 15 samples (9 original plus 6 new samples) is 299 mg/L. The new samples are, in general, collected from deeper bore holes than the original 9 samples. The chloride concentrations noted in these samples suggest that 330 mg/L as presented in the EAR was a reasonable (if slightly low) estimate of the chloride concentrations that will be found in the deeper parts of the mine.

If the samples with high pH and nitrate values are excluded, recalculation of mean major ion concentrations results in lower concentration estimates for all the major ions in the connate ground water when compared to the values used in the EAR. This outcome suggests that the effect including the contaminated samples in the calculation would increase, rather than decrease, the predicted major ion concentrations found in the connate water. This would result in an overestimation of connate water chloride concentrations in the EAR.

Re-evaluation of the upwelling of saline ground water was carried out using the FEFLOW model. The re-evaluation included re-examination of the TDS vs. depth and hydraulic conductivity vs. depth profiles used in the FEFLOW model for the Snap Lake area. The results indicate that upwelling of saline ground water would increase chloride concentrations in the mine water discharge to 280 mg/L or about 18% greater than the value presented in the Environmental Assessment Report (EAR).

The comparison of chloride concentrations calculated by the GoldSim model for the "Effective Lake Volume" and the lake water chloride concentrations computed by the RMA models has also been provided in the technical memorandum. Chloride concentrations in the "Effective Lake Volume" are, overall, higher than those computed by the RMA models for ice-free conditions but lower than those concentrations computed at the edge of the turbulent mixing zone created by the multi-port diffuser under ice-covered conditions (Table 9.4-19). Consequently chloride concentrations in lake water recharge flowing to the mine may be overestimated in the summer and underestimated in the winter.

During the review process intervenors requested that six variability scenarios be modeled to clarify TDS concentrations. The results of the reanalysis are presented in the technical memorandum. The increase in TDS concentrations in the discharge to Snap Lake ranges from 7% to 53% above the "EA Assessed" case depending on the specific scenario evaluated. The greatest increase results when "Expected plus one standard deviation" concentrations are used. For the "Depth Average" case the TDS values are similar to the "EA Assessed" case while the "Depth Average plus Upwelling" case results in a 27% increase with respect to the "EA Assessed" case.

The "Expected plus one standard deviation" case is a scenario meant to bracket some of the variability in the data rather than be considered a realistic scenario. This scenario was run to test the sensitivity of the mine water discharge to an arbitrary increase of one standard deviation in connate water concentrations. The upwelling of saline ground water is a physically-based scenario, but predictions of its effects are constrained by a lack of data on permeability and ground water geochemistry versus depth, and by assumptions that must be made during modelling of saline water upwelling. The proponent ensured that the "EA Assessed" case presented in the EAR was a "worst case scenario" by using conservative modeling assumptions. Since the results of the variability scenarios considered in the technical memorandum either do not differ significantly from the "EA Assessed" case or represent scenarios based on unrealistic input concentrations used to test the model, it is concluded that the quality of the mine water discharge as assessed in the EAR is reasonable.

Recommendation

It is recommended that the changes in mine water quantity and quality predicted in the EAR be verified by monitoring during the life of the mine. It is further recommended that the proponent institute management practices that incorporate the information generated by the monitoring program into their adaptive management approach.

Issue # 6 Water Quality - Total Dissolved Solids - Whole Lake TDS

De Beers estimates that TDS concentrations in Snap Lake will likely increase by an order-of-magnitude as a result of project inputs. EC sought substantiation of the prediction that higher TDS levels would have negligible to low effects on biota.

Reference: TOR lines 344-355, 381, EAR section 9.4, Appendix IX.1

Background

De Beers has provided a literature review titled "Potential Effects of Increased Total Dissolved Solids on Aquatic Communities in Snap Lake" dated February 2003. This report examines the body of literature on ecosystem effects and changes.

As discussed under Issue # 5 connate water forms a substantial part of the mine water discharge from the De Beers project. EC finds that predictions of connate water quality are reasonable, and accepts them as a basis for evaluating TDS effects.

Developer's Conclusions

De Beers concludes that effects on phytoplankton would be negligible, and those on zooplankton and benthic invertebrates would be of negligible to low magnitude. (EAR 9.5.2.2.3). This conclusion was substantiated through a comprehensive literature review presented in the technical memo dated Feb. 10, 2003 titled "Report on potential effects of increased total dissolved solids on aquatic communities in Snap Lake".

Environment Canada's Conclusions

Biological effects at the predicted levels of TDS (330 ppm maximum average concentration) would not be of high magnitude. EC anticipates that there may be minor species shifts within invertebrate communities and potentially a slight enhancement in productivity.

Environment Canada's Rationale/Evidence

Predicted chloride (and other constituent) levels are expected to remain below the protective guideline level as discussed in the TDS memorandum, and changes in TDS will be occurring gradually which will allow organisms and communities time to adapt.

Environment Canada's position: This issue has been resolved.

OUTSTANDING ISSUES

Issue #3 Water Quality - Treatment Options

EC is satisfied that several mine water treatment alternatives have been explored, however, it is difficult to compare the treatment options without empirical data. It also remains unclear if the treatment plant will be equipped to remove dissolved metals.

Reference: TOR line # 337-341, November 2002 Technical Sessions Day #3, Technical Memorandum entitled "Summary of Water Treatment Process Development, Selection and Comparison of Alternatives" dated Feb. 13, 2003.

Background

EC requested that De Beers elaborate on the treatment method(s) to be employed for treating mine water, specifically with respect to dissolved metals. EC focused on dissolved metals because the concentration of chromium in the effluent is predicted to be sufficiently high to cause chronic toxicity to zooplankton. During the technical sessions several treatment options were discussed, and EC sought clarification on which options will be employed and how incorporation of these options would affect the size of the impact area in Snap Lake. EC requested a commitment from De Beers that they would optimize treatment for metals to reduce the area impacted in Snap Lake, as well as the specifics of how and when treatment would be implemented.

EC also requested that De Beers provide a discussion of all the water treatment options examined in the search for optimal treatment of "parameters of concern". The requested discussion was to include options considered, effectiveness of each option, criteria used to select the preferred option and reasons for rejecting treatment options. Treatment options examined for nitrate were also requested.

Developer's Conclusions

Options for treatment were screened and refined using testing of bulk sample mine water to identify the most effective processes. Details of the treatment options examined and the process used to compare them are provided in the Technical Memorandum dated Feb. 13, 2003 referenced above. The water treatment process that was selected involves solids removal using a thickener and filtration, with provision for flocculation using lime and ferric sulfate followed by further filtration. However, pilot testing did not demonstrate that the addition of ferric sulphate and lime to the basic thickener filter system provided a clearly demonstrated benefit considering the inherent variability in the assay results which occurs when testing is conducted near detection limits. Testing of other reagent combinations and additional treatment through use of a high-density sludge circuit did not demonstrate consistent improvements in effluent quality.

In the evaluation process the use of ion exchange or reverse osmosis technology was rejected because the large mine water flow rates would result in a large brine waste stream. The system was also rejected because of extremely high life cycle costs. This is documented in the De Beers submission on TDS Removal Technology dated Feb. 10, 2003.

The water treatment plant optimization and operating strategy outlines monitoring activities and will be adaptive to dynamic process conditions to attain best treatment. This strategy will formalized in a long-term monitoring and optimization plan.

Unfortunately no feasible treatment options for nitrate are available.

Environment Canada's Conclusions and Rationale/Evidence

During discussions with De Beers representatives, both individually, and at the Technical Sessions (November 2002), it was indicated that lime and ferric sulphate would be added to the treatment process if necessary. Further, documents presented by De Beers imply that ferric sulphate and lime will be available as a contingency should they be required. However, De Beers does not appear to have committed to treating their effluent using this process. As stated in the *Developers Conclusions* section of this issue, pilot testing did not demonstrate that the addition of ferric sulphate and lime to the basic thickener filter system "provided a clearly demonstrated benefit considering the inherent variability in the assay results which occurs when testing is conducted near detection limits" (Feb. 13 AMEC Technical Memo). It is unclear whether this statement indicates that the treatment was ineffective or that the effectiveness of the treatment was masked by the variability in assay results which occurs when testing near detection limits. No

data are presented to substantiate this statement so reviewers were unable to assess the conclusion drawn by the proponent.

Environment Canada's position: This issue requires clarification.

Recommendation

EC recommends that the data generated during the comparison of treatment options be made available to allow reviewers to assess if treatment options were explored to their satisfaction. Should treatment be viable EC recommends that De Beers commit to treating mine water effluent to reduce the concentrations of dissolved metals in order to minimize impacts on Snap Lake. EC reiterates the recommendation that De Beers periodically re-evaluate available treatment technologies with a view to maintaining optimal effluent treatment and quality.

Issue # 7 Air Quality Monitoring - $PM_{2.5}$ and PM_{10}

Air Quality Monitoring is necessary to demonstrate attainment of $PM_{2.5}$ and PM_{10} Ambient Air Quality Standards

Reference: TOR lines 281-288 EAR section 2.6.1 Air Quality and Climate

Developer's Conclusions

In the Information Request Response 2.3.2, De Beers stated it would not implement PM monitoring because, at the time of writing the response, there were no NWT Ambient Air Quality Standards for $PM_{2.5}$ or PM_{10}. The NWT Ambient Air Quality Standards have been recently updated, December 2002, to include standards for $PM_{2.5}$. The following is an excerpt from the Information Request Response 2.3.2:

> *Future air quality monitoring at Snap Lake will not include PM10 and $PM_{2.5}$ monitoring. While De Beers acknowledges that the NWT is a signatory to the Harmonization Accord and has agreed to the recent Canada-Wide Standards for $PM_{2.5}$, these Canada-Wide Standards do not have any legal standing. Each jurisdiction participating in the Harmonization Accord will implement the standards under existing legislation, or by drafting new legislation. To date, the NWT has not implemented air quality regulations for $PM_{2.5}$. There are currently no Canada-Wide Standards and no NWT legislation for PM_{10}.*

During the MVEIRB Technical Sessions for Air Quality, Day 8, December 4, 2002, De Beers was again questioned about implementing $PM_{2.5}$ and PM_{10} monitoring. De Beers stated that it is committed to operating within existing standards and laws and would consider the suggestion of adding $PM_{2.5}$ and PM_{10} to its ambient air quality program. Below is response from De Beers (taken from the Technical Sessions transcripts).

> *De Beers is committed to operating within existing standards and laws. We are also committed to conducting consultations and*

developing resulting monitoring programs with the goal of confirming impact predictions. Basically you have highlighted your interest and we will consider the suggestion.

Environment Canada's Conclusions

The NWT has Ambient Air Quality Guidelines for $PM_{2.5}$ and has ratified the Canada-Wide Standards (CWS) for PM and Ozone. Ambient Air Quality Standards for PM_{10} from other jurisdictions, such as British Columbia, should be considered in absence of NWT standards. As part of the CWS development process the scientific review of PM_{10} has been completed and a report will be forwarded to the CCME in 2003. The report will present the findings of PM and ozone environmental and health science review, including recommendations on a PM_{10} CWS.

As part of the CWS, jurisdictions recognize that polluting "up to a limit" is not acceptable and that the best strategy to avoid future problems is keeping clean areas clean. The Keeping Clean Areas Clean (KCAC) commitment is aimed at minimizing the degradation of air quality in areas that currently have relatively clean air. The pollutants that should be included in the Snap Lake KCAC program in the ambient environment are $PM_{2.5}$ and PM_{10}.

EC concludes that De Beers needs to demonstrate that the air quality impacts from the Snap Lake mine development are in compliance with the NWT Ambient Air Quality Standards and Canada-Wide standards. In addition, ambient monitoring is essential to ensure that mitigation efforts are working to fulfill the Keeping Clean Areas Clean commitment by minimizing the degradation of air quality.

Environment Canada's Rationale/Evidence

Air quality modeling results presented in the Snap Lake Diamond Mine EAR indicate that the impact from mine emission of particulate matter will degrade regional air quality. Specifically, the model predicts that ambient air quality standards for total suspended particulate, PM_{10} and $PM_{2.5}$ will be exceeded.

Emissions from the BHP and Diavik diamonds will also impact regional air quality. Since Snap Lake shares a common airshed with the other mines, a cooperative regional air quality monitoring program may provide economic efficiencies and increase the understanding of environmental impacts.

Recommendation

EC recommends that De Beers include PM_{10} and $PM_{2.5}$ in the Snap Lake monitoring program to demonstrate they are meeting the Ambient Air Quality Guidelines.

EC encourages De Beers to investigate potential partnerships with BHP and Diavik in establishing a regional air quality monitoring program.

Issue # 8 Water Quality - Total Dissolved Solids Density Plume

The effluent discharged from the mine will have a higher density than the surrounding Snap Lake water and will sink to the lake bottom as it moves outside the turbulent mixing zone. Ultimately the plume will settle in the deeper areas of the lake this pooling may result in areas of meromixis on a seasonal basis.

Reference: TOR line #358-362, 395-397; EAR section 9.4.2.2.3; IR 2.1.6; IR 2.1.8

Background

The primary issue with discharge of a higher-density effluent stream is the potential for it to settle and flow along the lake bottom, possibly resulting in meromixis in the deeper parts of Snap Lake. This may occur if the increased TDS plume discharged into Snap Lake is not rapidly dispersed.

Developer's Conclusions

The EAR predicts that a denser plume will move beyond the turbulent mixing zone, and will sink back down to the bottom of the lake and flow downstream (Section 9.4.2.2.3). This phenomena is likely to continue until later in the mine life when ambient TDS concentrations are higher and the density gradient between the plume and the lake water is reduced. The response to IR 2.1.8 states that the portion of the lake affected by the discharge will depend on the rate at which mine water is discharged. During years of maximum discharge a large part of the main body of the lake below a depth of three to four metres could be affected. Wind-driven turbulence will ensure full mixing under ice-free conditions.

Environment Canada's Conclusions and Rationale/Evidence

The presence of "pockets" of higher-density water in the deeper areas of the lake may have some effect on dissolved oxygen levels within the pockets, as well as, producing relatively abrupt chemical gradients. Reductions in dissolved oxygen concentrations in these isolated pockets of water may result from several things: first, reduction of mixing and diffusion; second, decreased oxygen solubility with increased salt content; and third, increased oxygen demand for nitrification of ammonia, and possibly for metals oxidation reactions. The development of cohesive pools of dense water may occur on a seasonal basis (under-ice) and will need to be monitored. Some species of benthic invertebrates are tolerant of high TDS levels, and very low DO concentrations. It is likely that fish will avoid areas of low DO. Deeper holes are typically areas of the lowest productivity in the lake, but thresholds would need to be determined for these areas. These thresholds would be used to trigger remedial action to minimize environmental impacts. For example triggers could include the persistence of meromictic conditions into the open water season, or the development of a lake-wide winter chemocline. Either of these occurrences would likely result in a significant alteration to the lake ecosystem.

Recommendation

Environment Canada Recommends that De Beers develop an adaptive management strategy which combines monitoring with management through treatment and/or effluent diffusion modification if unacceptable effects appear likely to occur.

Environment Canada's position: This issue remains outstanding.

Summary of Recommendations

Issue # 3: Water Quality - Treatment Options

EC recommends that the data generated during the comparison of treatment options be made available to allow reviewers to assess if treatment options were explored to their satisfaction. Should treatment be viable EC recommends that De Beers commit to treating mine water effluent to reduce the concentrations of dissolved metals in order to minimize impacts on Snap Lake. EC reiterates the recommendation that De Beers periodically re-evaluate available treatment technologies with a view to maintaining optimal effluent treatment and quality.

Issue # 4: Water Quality - Phosphorus

EC recommends that De Beers continue to refine their model calibration by monitoring the parameters which are used as model inputs. EC further recommends that this monitoring be carried out in the first years of mine operation to improve confidence in model predictions with respect to P loading over time. This will confirm whether the sediments act as a phosphorus sink (as predicted) and identify what proportion of the phosphorus is bioavailable.

Issue # 5: Water Quality - Ground Water Impacts on Snap Lake

It is recommended that the changes in mine water quantity and quality predicted in the EAR be verified by monitoring during the life of the mine. It is further recommended that the proponent institute management practices that incorporate the information generated by the monitoring program into their adaptive management approach.

Issue # 7: Air Quality Monitoring - $PM_{2.5}$ and PM_{10}

EC recommends that De Beers include PM_{10} and $PM_{2.5}$ to its Snap Lake monitoring program to demonstrate they are meeting the Ambient Air Quality Guidelines. EC encourages De Beers to investigate potential partnerships with BHP and Diavik in establishing a regional air quality monitoring program.

Issue # 8: Water Quality - Total Dissolved Solids Density Plume

Environment Canada Recommends that De Beers develop an adaptive management strategy which combines monitoring with management through treatment and/or effluent diffusion modification if unacceptable effects appear likely to occur.

[1] Wetzel, R.G. 2001. Limnology Lake and River Ecosystems. Third Edition. Academic Press. 1006 pp.