

1.0 BACKGROUND WATER QUALITY

Water quality is monitored at 19 stations within Kenogamisis Lake. Baseline data in the Final EIS/EA is based on data collected monthly between September 2013 and October 2016. From the data, total arsenic was the only parameter that exceeded the 75th percentile concentrations in the Outlet Basin, which represents the discharge point from Kenogamisis Lake to downstream receivers. Based on this, GGM understands and accepts MOECC’s determination that Kenogamsis Lake would be classified as a Policy 2 receiver.

The 75th percentile total iron concentrations in Kenogamisis Lake are above the PWQO in Barton Bay West and East, with all other basins of the lake well below the PWQO including the Outlet Basin. Total iron concentrations in the Outlet Basin are well below the PWQO of 300 µg/L with mean and 75th percentile concentrations of 109 µg/L and 125 µg/L, respectively. For iron we would see Barton Bay West and East would as Policy 2 receivers for iron, but the lake overall, based on the water quality at the point of discharge to the downstream receiver would be Policy 1. However, it is our understanding that MOECC is applying the Policy 2 classification for iron to Kenogamisis Lake in its entirety.

Table 1
Summary of Baseline Total Iron Concentrations (µg/L) in Kenogamisis Lake

Basin	Mean	75% Percentile
Barton Bay West	275	321
Barton Bay East	319	340
Southwest Arm	115	131
Central Basin East	145	191
Outlet Basin	109	125

Bold concentrations exceed PWQO

2.0 WATER QUALITY ASSESSMENT

The assessment of water quality effects on surface water is presented in Section 10.4.3 of the Final EIS/EA. The assessment was completed using a mass balance analysis, as described in Section 10.2.1.3, to evaluate the effects on water quality in various surface water features, including Kenogamsis Lake. The assessment was completed for 20 individual PoPCs identified for the Project (10 additional parameters were added from the Draft EIS/EA), including arsenic, iron and phosphorus.

The mass balance assessment evaluates the changes in mass loadings from all sources (surface water, groundwater, atmospheric deposition, historical tailings, and Project components) during operation and closure compared to baseline conditions. The change in mass loading considered both changes in concentrations and flows due to Project related activities based on the following equation:

$$\text{Mass Loading (kg/d)} = \text{Concentration} \times \text{Flow}$$

Changes in groundwater and surface water flow rates and quality from Project-related sources during operation and closures phases are predicted through comprehensive three dimensional hydrogeological modelling, hydrological analysis, and geochemical and water quality modelling using GoldSim for the Project. A summary of the method used to predict the water quality effects of these Project-related changes on Kenogamisis Lake follows:

- Surface water flows into Kenogamisis Lake were developed for each subwatershed using the mean annual flow from the regression equations developed in the hydrology assessment for the Project.
- Surface water loadings from each subwatershed into Kenogamisis Lake were calculated using baseline mean annual water quality and flow data.
- Groundwater discharge and loadings were developed using the three dimensional groundwater flow model (Hydrogeology Modelling TDR; Appendix F4) and the mean concentrations predicted through the GoldSim water quantity and quality modelling for each Project component as discussed in Chapter 9.0 (Groundwater VC).
- Baseline surface water quality in each sub-basin of Kenogamisis Lake was developed using Project water quality monitoring data. For each sub-basin the mean concentrations based on surface water quality data collected at all monitoring stations within the sub-basin were used.
- The resulting loading for iron was calculated for baseline, operation, and closure phases of the Project and the relative change from baseline conditions was determined during operation and closure phases. The relative change from predicted baseline conditions was then applied to the observed baseline conditions to estimate the operation and closure phase water quality concentrations for each basin.

Table 2 below presents a summary of the predicted changes in total iron concentrations for each basin modelled. There is no change in total iron concentration or loading for Barton Bay West as the Project is not predicted to result in changes to surface water or groundwater flows to this basin. The greatest change in iron loading and surface water quality occurs within Barton Bay East as a result of the reduction in loading due to the removal of historical MacLeod tailings and covering of the remaining historical MacLeod high tailings.

For the Central Basin and Southwest Arm, the greatest reductions in loadings are due to reduced discharge from the historical Hardrock tailings and to a lesser extent the historical MacLeod tailings.

Furthermore, the above assessment does not consider any benefits from the subsurface seepage collection system that is proposed for the MacLeod high tailings or the capture of any seepage around the new Project components.

Table 2
Summary of Measured and Predicted Mean Total Iron Concentrations (µg/L)

Basin	Baseline	Operations	Active Closure	Post-Closure
Barton Bay West	275	275 (0%)	275 (0%)	275 (0%)
Barton Bay East	319	233 (-27%)	233 (-27%)	266 (-17%)
Southwest Arm	115	98 (-14%)	90 (-21%)	95 (-17%)
Central Basin East	145	84 (-42%)	79 (-45%)	93 (-36%)
Outlet Basin	109	66 (-39%)	58 (-47%)	72 (-34%)

3.0 SUMMARY

The mass balance assessment completed as part of the Final EIS/EA considered 20 individual PoPC, including arsenic, iron, and phosphorus, that were identified by the MOECC as Policy 2 parameters for Kenogamisis Lake. Through the mass balance assessment, which we believed was supported by MOECC based on their May 31, 2017 Memo, iron was thoroughly analyzed and shown to have a net reduction in loading resulting in an improvement in water quality for Kenogamisis Lake.

The modelling results indicate that a net reduction in loadings and as a result reduction in total iron concentrations for sub-basins of Kenogamisis Lake affected by Project activities are expected through operations and post-closure, meeting the requirements of Policy 2 to demonstrate a net improvement in water quality. The most pronounced affect to water quality is in Barton Bay East where mean total iron concentratons are predicted to decrease below the PWQO, representing a significant improvement over baseline conditions.

As part of the Final EIS/EA, GGM has committed to implementing adaptive management and monitoring programs to document the changes and confirm model predictions through the construction, operation, and closure periods of the Project. The enhanced surface water and groundwater monitoring program developed for the Project is outlined in the Water Management and Monitoring Plan (Appendix M1 of the Final EIS/EA) and will be advanced through the permitting stage of the Project. This enhanced monitoring program was supported by MOECC as indicated in the attached Memo dated May 26, 2017.

We trust that this clearly summarizes the approach and results of the assessment of iron completed within the Final EIS/EA

Regards,



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May 31, 2017

MEMORANDUM

TO: Annamaria Cross, Manager, Environmental Assessment Services Section,
Environmental Approvals Branch

FROM: Brian Cameron, Water Resources Manager,
Technical Support Section, Northern Region

RE: Greenstone Gold Mines – Hardrock Gold Mine Project
MOECC Blue Book Receiver Policy 2

INTRODUCTION

As requested, surface water staff from Northern Region's Technical Support Section have reviewed the information provided before and during a technical workshop with MOECC, MNRF, MNDM, ECCC, Greenstone Gold Mines (GGM), and Stantec on March 24, 2017 in Thunder Bay. The intent of the meeting was for GGM and Stantec to provide an update on water quality, quantity, and management concerns to ministry and agency staff in regards to the proposed Hardrock Gold Mine project.

The purpose of this review is to provide advice on whether the assessment methodologies used to support how GGM intends to improve lake water quality as a result of its project activities appears to be sound; and, that all loadings and potential sources of contaminants to Kenogamisis Lake have been adequately identified. It is also to determine if the ministry is satisfied that GGM has provided sufficient information to demonstrate that it can meet the intent of the MOECC Blue Book Receiver Policy 2 as it relates to discharging treated mine effluent into the Southwest Arm of Kenogamisis Lake.

It should be noted that this review is solely based on information provided in a piecemeal fashion through draft memos and presentations. NR Technical Support Section has not reviewed any written final reports, and so comments are subject to change upon the submission and review of the final Environmental Assessment Report.

Summary of Studies Completed and Information Provided

At the March 24th meeting, information was presented by GGM and Stantec in regards to the following items identified as being of concern to ministry and agency reviewers:

- Water management plan for the mine site, including details of design criteria for project water management infrastructure;
- Groundwater model update including model approach and key assumptions, model results, particle tracking results and discharge estimates; groundwater quality predictions including loadings during baseline, operations, and closure;
- Assimilative capacity modeling and results for Kenogamisis Lake;
- Goldfield Creek realignment and methyl mercury predictions;
- Mass balance and contaminant loadings assessment and preliminary results including figures for baseline, operations, and closure;
- Stella model and results for sediment feedback modelling in Kenogamisis Lake; and
- Brief details were provided on the following:
 - Temporary sewage discharge from the mining camp; and
 - Waste management volumes,

The proponent's approach to modelling the various areas of concern appears to be sound; they have completed modelling for each of the areas for which concerns were identified as listed above. However, the details of modelling have not yet been provided in writing for review and results have been provided in a variety of smaller reports and presentations, and so it is not possible at this stage to comprehensively assess the project as a whole. As such, comments may change upon submission of the final EA report, which is expected to include a comprehensive explanation of the models used, their assumptions, and model results and their interpretation as they relate to anticipated impacts to the environment. However, at this stage of the process the proponent appears to have considered all of the areas of concern identified by the ministry, and their assessment methods appear to be sound.

MOECC's Blue Book Receiver Policy 2: Areas with Water Quality Not Meeting the PWQOs

Upon determining that Kenogamisis Lake is a policy 2 receiver for arsenic, staff from Northern Region Technical Support Section worked with the proponent over the last few years to ensure that they complete the necessary supporting studies, and commit to project components and outcomes that will ensure that their project meets the intent of Blue Book Policy 2. The following points explain and summarize the ministry's approach to ensuring that the proponent's proposal to discharge into the Southwest Arm of Kenogamisis Lake, meets the intent of policy 2.

- Kenogamisis Lake has been impacted by historical mining activities which have resulted in elevated concentrations of some metals, in particular arsenic, in the water and sediment in the lake. Due to the particular locations of historic activities, some basins show more impairment than others;
- In Ontario, there is a PWQO value for arsenic (100µg/L), and an interim PWQO value (5µg/L) which is equal to the CCME value for freshwater. The interim PWQO value is based on newer science;
- Water quality samples taken from Kenogamisis Lake during baseline activities regularly exceed the interim PWQO value for arsenic, resulting in the lake being designated a policy 2 receiver for arsenic;
- As outlined in *Water Management Policies, Guidelines, Provincial Water Quality Objectives of the Ministry of Environment and Energy* (1994), a policy 2 receiver has water quality which presently does not meet the Provincial Water Quality Objectives and so it shall not be degraded further and all practical measures shall be taken to upgrade the water quality to the objectives;

- For the Hardrock project to proceed, GGM is proposing to discharge their treated mine effluent into the Southwest Arm of Kenogamisis Lake. While this basin appears to be the least impacted of the lake's basins, arsenic levels have exceeded the iPWQO in this basin at certain times of the year (i.e. seasonal variation in water quality). Water flows from the Southwest Arm into the Central Basin, which is much more impaired than the Southwest Arm. Any changes to the water quality in the Southwest Arm have the potential to move downstream and further compound the impairment in the Central Basin;
- The receiver policy designation is made on a lake scale, not a basin scale except in very specific and limited situations when lake basins are not hydraulically connected;
- Because of the hydraulic connectivity between basins in Kenogamisis Lake, the lake is considered a policy 2 receiver for arsenic as a whole; it is not appropriate to make a policy designation on a basin scale in this case;
- As such, the ministry is requiring that the proponent show that their proposed project activities will have a net benefit to water quality in order to meet the intent of policy 2. The proponent has indicated that by moving historical tailings to their new tailings management facility, and covering the remaining historical tailings with waste rock, that the arsenic loadings to the lake should decrease.
- In order to show this, the proponent determined the current arsenic loadings to the lake from all sources, and then modelled the predicted loadings during operations and closure to show that the proposed activity will improve the water quality of Kenogamisis Lake. This information was presented at the March 24th, 2017 meeting with ministry and agency staff;
- Arsenic loadings to Kenogamisis Lake will be reduced as a result of project activities. Historical tailings are the major source of arsenic to the lake, through groundwater seepage. The proposed undertaking will include moving a substantial volume of historic tailings into the new tailings management facility being constructed adjacent to the Southwest Arm of Kenogamisis Lake. These tailings will be essentially encapsulated in new tailings which are predicted to have much lower arsenic concentrations.
- By disposing of these historic tailings in the new TMF in the way proposed, GGM indicates that the loading of arsenic to Kenogamisis Lake at closure will be reduced by 52% of current loads, as reported at the March 24th meeting. Other metals found in groundwater seepage from the historical tailings will be reduced at similar magnitudes.
- GGM has also committed to employing water treatment technologies to their mine effluent that will result in effluent concentrations of arsenic in the range of the current PWQO for the metal.
- GGM has indicated that this baseline, operations, and closure loadings comparison has been repeated for other contaminants of concern that exceed PWQO values in the lake; however, these results have not yet been provided in any detail to the ministry.

Although GGM is proposing to discharge treated mine effluent containing arsenic into the Southwest Arm of Kenogamisis Lake (a policy 2 receiver for arsenic), they have completed a number of complementary studies and provided an overview of results to show that their proposed project is expected to meet the intent of Blue Book Receiver Policy 2; their project as a

whole is predicted to reduce the overall loading of arsenic to Kenogamisis Lake, thereby improving the water quality of the lake. The specific project activities that will contribute to the reduction in arsenic (and other metals) loading to the lake include the following:

- The disposal of historical tailings in the new TMF, and resultant reductions in arsenic in groundwater seepage to Barton Bay;
- Covering of remaining historic tailings to reduce infiltration of precipitation through the tailings piles;
- Collection ditches surrounding historical tailings and project infrastructure to intercept seepage; and
- The commitment to achieve monthly mean arsenic concentrations in their treated effluent that meet the current PWQO value (100µg/L).

SUMMARY

GGM's proposed Hardrock Gold project activities are anticipated to improve water quality in Kenogamisis Lake by reducing arsenic loadings, thereby meeting the intent of policy 2. The baseline studies and modelling approaches that they are completed appear to be sound. However, as discussed above, the details of modelling have not yet been provided in writing for review and results have been provided in a variety of smaller reports and presentations, and so it is not possible at this stage to assess the project as a whole or to fully understand how all of the various pieces fit together in a comprehensive manner. As such, comments may change upon submission of the final EA report, which is expected to include a comprehensive explanation of the models used, their assumptions, and the results and their interpretation as they relate to anticipated impacts to the environment.

Additional Studies

It should be noted that due to the proposed location for this project in an area impacted by historical mining activities, this project is not typical of other mining projects in the region. The historical impacts add a layer of complexity that is not yet well understood. So while the proponent has undertaken various studies to understand and consider the influence that historical impacts may have on the proposed project, there may be unforeseen circumstances and environmental effects that could require non-standard studies in the future as the project progresses and as more environmental data is collected and analyzed.

For example, the Stella model used to predict arsenic concentrations and availability in sediments in the various lake basins found that sediment quality is predicted to improve in several basins; however, arsenic concentrations in sediments could increase slightly from present day levels in both east and west Barton Bay. It is unclear how this may impact the arsenic bioavailability in the lake, and so additional studies may be required to understand potential environmental impacts.

The proponent's adaptive management approach to monitoring project effects will ensure that these types of studies are identified and carried out if required. Provincial approvals will be amended as required.

CLOSURE

If you have any questions regarding the above comments and recommendations, do not hesitate to contact me. The purpose of the preceding review is to provide advice to the Ministry of the Environment and Climate Change regarding the proposed discharge of treated mine effluent containing arsenic into Kenogamisis Lake, a policy 2 receiver for arsenic according to MOECC's Blue Book policies. The conclusions, opinions and recommendations of the reviewer are based on information provided by others, except where otherwise specifically noted. The ministry cannot guarantee that the information that has been provided by others is accurate or complete. A

lack of specific comment by the reviewer is not to be construed as endorsing the content or views expressed in the reviewed material.

Brian Cameron
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May 26, 2017

MEMORANDUM

TO: Gavin Battarino, Special Projects Officer, Environmental Approvals Branch

FROM: Brian Cameron, Water Resources Manager
Technical Support Section, Northern Region

RE: Greenstone Gold Mines – Hardrock Gold Mine Project
Enhanced Monitoring Program to Support Effluent Discharge

INTRODUCTION

As requested, technical staff from Northern Region's Technical Support Section have reviewed the memo submitted by Craig Johnson of Stantec on behalf of Greenstone Gold Mines entitled *Greenstone Gold Mines – Enhanced Monitoring Program to Support Effluent Discharge*, dated May 19, 2017. The purpose of the ministry's review is to assess whether the submitted monitoring program for the proposed undertaking adequately addresses monitoring requirements for anticipated project effects that have been identified throughout the ongoing Environmental Approval process for the proposed Hardrock Gold Mine project near Geraldton.

It is understood that monitoring requirements are expected to change as the project progresses through construction, operation, and into closure, and will be updated as required to meet regulatory requirements and in response to results from the adaptive monitoring program, as outlined in the memo.

Summary of Proposed Monitoring

The water management and monitoring program outlined in the memo includes both compliance monitoring and operations monitoring. Compliance monitoring will confirm compliance with regulatory approvals, whereas operational monitoring will support operational water management, and will compare predicted changes in groundwater levels and flow and quality, and changes in drainage patterns and surface water flow and quality, with those changes predicted through modelling during the EA process. Monitoring will also confirm the effectiveness of mitigation measures.

The surface water monitoring program includes the following components:

- Pumping rates and water quality of various contact water collection facilities;
- Discharge rates and treated effluent water quality from the STP and ETP;
- Surface water levels and flows in Southwest Arm Tributary, Goldfield Creek Tributary, Mosher Lake, and Kenogamisis lake; and
- Surface water quantity and quality in the receiving environment to confirm the extent of the mixing zone within the Southwest Arm of Kenogamisis Lake, and to confirm the overall improvement in water quality within the lake due to the reduced discharge from historical tailings.

This surface water monitoring program will confirm the effectiveness of the planned mitigation measures on water quality within Kenogamisis Lake.

The groundwater monitoring program includes the following components:

- Dewatering rates from aggregate source area and historic underground workings and the open pit;
- Groundwater levels in monitoring wells to document changes in response to dewatering historical underground workings, the open pit, and aggregate source areas, and to document changes in recharge from project components (WRSAs, ore stockpiles, overburden storage areas, TMF); and
- Groundwater quantity and quality to document changes associated with the historical McLeod and Hardrock tailings and project components.

This groundwater monitoring program will confirm the effectiveness of the seepage collection systems and the groundwater quality discharging to the receiving environment. The monitoring locations down gradient of the project components and seepage collection system will be used as trigger monitoring locations to identify the need for adaptive management actions.

Surface water and groundwater monitoring locations will be reviewed at regular intervals and locations may be added or removed from the program in accordance with their utility in monitoring the effects of the project on the environment. Sites required as part of a regulatory approval that are deemed no longer be required will only be removed once the required amendments are approved.

Limits and Triggers

Results of compliance monitoring will be compared to limits set out in project-specific regulatory approvals and follow-up actions will be required if approval limits are exceeded. As well, results from operations monitoring, and where appropriate compliance monitoring, will be compared to water quality and quantity predictions made as part of the assimilative capacity study, the groundwater modelling study, the GoldSim water balance and water quality modelling, and the Stella mass balance sediment model, all to be included in the final EA report. Deviations from predicted values will be investigated and additional studies may be required to determine the appropriate response(s).

Reporting

The proponent suggests that elements relevant to compliance monitoring will be assembled into a formal report and be provided to regulators on an annual basis during construction and operation and during closure in years when monitoring is carried out. Further details will be developed as project planning continues and will be included as requirements in regulatory approvals.

Adaptive Management Approach

GGM will apply an adaptive management approach to the proposed monitoring program to continuously improve environmental management practices by learning from their outcomes. This will allow them to address and accommodate new circumstances, to adjust monitoring, to implement new mitigation measures, or to modify existing measures. They will identify and correct incidents with appropriate measures aimed to prevent reoccurrence and/or similar occurrences.

GGM is committed to the continual improvement of its environmental management and performance.

Conceptual Aquatic Management and Monitoring Plan

The memo includes a table that lists a variety of monitoring activities that will be carried out at the frequency required by ECCC's EEM to evaluate the performance objectives committed to in the EA, which will include maintaining or improving the overall productivity of CRA fisheries, avoiding lethal or sub-lethal effects on fish, avoiding an increase in parameters of potential concern in fish tissue, and maintaining the abundance and diversity of benthic invertebrates.

These monitoring activities include: Kenogamisis Lake fish community monitoring; fish tissue sampling; benthic community monitoring; sediment sampling; aquatic vegetation monitoring; plankton and periphyton monitoring; and toxicity monitoring.

SUMMARY

GGM is proposing an enhanced, comprehensive monitoring program that covers the four pillars of information used in aquatic assessments: sediment, fish, benthic invertebrates, and water. Their overall guiding principles and approach are consistent with ministry expectations, and they acknowledge and understand that the monitoring program is likely to change as the project progresses and as more information becomes available.

Given the complexity of the system and the historical impacts to the system, additional and more complex studies could be required to adequately understand and adapt to potential changes in the system as the project develops through construction, operations, and closure. The adaptive management approach proposed by GGM will enable them to develop these studies should they be required.

CLOSURE

If you have any questions regarding the above comments and recommendations, do not hesitate to contact me. The purpose of the preceding review is to provide advice to the Ministry of the Environment and Climate Change regarding the proposed groundwater, surface water, and aquatics monitoring program based on the information provided in the above referenced document. The conclusions, opinions and recommendations of the reviewer are based on information provided by others, except where otherwise specifically noted. The ministry cannot guarantee that the information that has been provided by others is accurate or complete. A lack of specific comment by the reviewer is not to be construed as endorsing the content or views expressed in the reviewed material.



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