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May 22, 2018 Project No.: 180007

Mr. Stephen Lines
Environmental Assessment and Permitting Manager
Greenstone Gold Mines GP Inc.
steve.lines@ggmines.com

Dear Mr. Lines:

Re: Greenstone Gold: independent review of the analysis of mercury concentrations in surface water, sediment and groundwater in the vicinity of Kenogamisis Lake, and implications of these concentrations to human and ecological health

1.0 Introduction

Hutchinson Environmental Sciences Ltd. (HESL) conducted this independent third-party review of documents identified by Greenstone Gold Mines GP Inc. (GGM) and the Metis Nation of Ontario (MNO). The review was conducted to ascertain the validity and suitability of mercury-related studies in the documents to identify potential significant adverse effects from the Hardrock Project (the Project) in surface water, sediment and groundwater in the vicinity of Kenogamisis Lake, and ultimately, implications to human and ecological health from mercury.

2.0 Scope of Work

2.1 Scope Summary

The review was conducted to meet the objectives identified above, and generally consisted of a technical review of the supplied documents, communication with GGM on review findings and/or questions, and a draft and final report. The review was conducted based on the scope of work described in the following documents:

- Greenstone Gold Mines GP Inc. Terms of Reference for the Independent Review of Selected Water Quality Documents Related to the Hardrock Project, Geraldton, Ontario. January 22, 2018;
- Hutchinson Environmental Sciences Ltd. Proposal – Greenstone Gold Contaminant Model Review. February 2, 2018; and,
- Hutchinson Environmental Sciences Ltd. Greenstone Gold Contaminant Model Review – Summary of Concerns of Metis Nation of Ontario. February 28, 2018.

As the review progressed, it became beneficial to clarify preliminary questions on the technical work Stantec Consulting Ltd. conducted for the Project. As a result, the following information request was submitted to GGM:

- Hutchinson Environmental Sciences Ltd. Memorandum re: Greenstone Sold Contaminant Model Review – Questions and Information Requests. March 23, 2018.

GGM convened a call with HESL and Stantec on April 3, 2018 to discuss the questions and clarifications in the information request. Following the call, Stantec prepared documents that provided supplementary information, responses and clarifications to HESL's information request.

2.2 Documents Reviewed

The following background documents related to the Project and mercury in the vicinity of Kenogamisis Lake were identified by GGM, and reviewed by HESL:

- Damsa Integrated Resources Management Inc. (2017). Update – Technical Review on Impacts to Water from the Hardrock Gold Mine – Draft EA Review. December 22, 2017.
- Stantec Consulting Ltd. (2017). Hardrock Project Final Environmental Impact Statement / Environmental Assessment, Chapters 1.0, 2.0, 5.0, 6.0, 9.0, 10.0 and 11.0. June, 2017.
- Stantec Consulting Ltd. (2018a). GCM Hardrock Project – Mercury in Surface Water, Fish Tissue and associated Human Health and Ecological Risk Assessment. January 12, 2018.
- Stantec Consulting Ltd. (2018b). Hardrock Project, Responses to Comments Received on the Final Environmental Impact Statement/Environmental Assessment. February 9, 2018.
- Stantec Consulting Ltd. (2018c). Hardrock Project, Arsenic-Mercury Peer Review Water Workshop (presentation). February 14, 2018.

The following documents were provided by GGM in response to the information request, and were reviewed by HESL:

- Stantec Consulting Ltd. (2018d). Hardrock Project, Responses to Comments Received on the Final Environmental Impact Statement/Environmental Assessment (Comments Provided by Hutchinson Environmental Sciences Ltd.). April 19, 2018.
- Stantec Consulting Ltd. (2018e). Methylmercury Prediction in Fish Tissue. April 19, 2018.

2.3 Review Approach

The review approach consisted of a technical review of the background documents, to consider the following elements:

1. Overview to become familiar with the mine conditions, processes and environmental assessment work pertinent to identifying potential methyl mercury generation;

2. Identifying if the background information was sufficient to support the analysis and conclusions with appropriate documentation of sources, pathways, processes and receptors, thorough description and documentation of the affected areas and attention to detection limits and sampling program to support the subsequent assessments and modelling;

3. If the problem statement(s) and study objectives were clear, and addressed the concerns expressed by the MNO;

4. If the methods, models and analyses used were appropriate to the problem statement(s) with acceptable resolution, inputs, processes and outputs;

5. If the outputs and results made sense, and if they followed from the background documents, problem statement and analyses completed; and,

6. Whether the analyses were interpreted properly and the conclusions were relevant, clearly stated and addressed the problem statement(s).

Water and sediment quality are important to MNO, but a key concern is fish tissue quality and the potential for mercury bioaccumulation from the project to affect fish and fish consumers (including humans). This review accordingly considered the potential impacts to surface water, sediment and fish tissue, as well as mercury-fish consumption risks to wildlife and fish consumers.

All methods, models, analyses and data reviewed by HESL for this work were examined at a 'presentation-level' – that is, HESL trusted that the data collection, manipulation, summaries and model computations as presented by Stantec were done correctly, unless it was clear or strongly suspected that they were not because the results of the work were unusual or unreasonable. Going back to source data and repeating the work that Stantec conducted was beyond the scope of this review, and our review findings accordingly are not a guarantee or endorsement of Stantec's work.

3.0 Review Findings

3.1 Document Overview

The background documents were reviewed to become familiar with the project and mercury assessment work conducted, and screen for information requiring further detailed review. A summary of the pertinent information in the background documents that informed review comments is provided in Table 1.

Table 1. Summary of document overview findings, and documents selected for additional detailed review.

Document	Section(s)	Summary of finding
Damsa Integrated Resources Management Inc. (2017). Update – Technical Review on Impacts to Water from the Hardrock Gold Mine – Draft EA Review. December 22, 2017.	Introduction and Mercury-related discussions	Damsa identified potential sources of mercury that could affect surface water quality: groundwater, sediment, ore, waste rock and tailings. Damsa identified several short-comings in the assessment of surface water quality including high analytical detection limits, potential mis-interpretation of the protection inferred by environmental quality and fish tissue guidelines for mercury, and failure to examine co-factors that encourage mercury methylation (e.g., increases sulphate and phosphorus).
Stantec Consulting Ltd. (2017). Hardrock Project, Final Environmental Impact Statement / Environmental Assessment Summary. June, 2017; amended August, 2017.	Chapter 1.0: Introduction and Overview	General project overview; no mercury-specific information requiring further review
	Chapter 2.0: Environmental Setting	Summary of general environmental conditions and setting; no mercury-specific information requiring further review
	Chapter 5.0: Project Description	General: Erosion and sediment controls during construction, operation and closure described appear to be reasonable to prevent erosion in disturbed areas and sedimentation in natural receivers. Construction and works-specific erosion and sediment control plans were not described, but this level of detail is not expected in the Project Description.
		Section 5.4.1: General description of the Goldfield Creek diversion; identified new water features that could lead to methyl mercury generation from permanent and intermittent flooding: the realigned Goldfield Creek (2.7 km long), reconstruction of the Southwest Arm tributary channel and construction of two valley-wide grade control structures within the existing Southwest Arm Tributary to impound and attenuate flows upstream. No mercury-specific information requiring further review.
		Section 5.4.22.2: Identified that pit dewatering from area S1 will be discharged to the Goldfield Creek diversion channel – this groundwater (overburden) may contain mercury concentrations greater than existing surface water (see Chapters 9.0 and 10.0, respectively), contributing to mercury in surface water. No mercury-specific information requiring further review.

Document	Section(s)	Summary of finding
		Section 5.4.8: Identified that Goldfield Creek will be diverted northeast and discharge to Kenogamisis Lake via the Southwest Arm Tributary. The increased flow to the Southwest Arm was not discussed. No mercury-specific information requiring further review.
		Section 5.4.19: Identified that 7.5 ha of new pond habitat will be created by impounding water at the confluence of the existing Goldfield Creek and new Goldfield Creek Diversion Channel, the new Goldfield creek channel will be 2.7 km long (6.58 ha of newly flooded land), the Southwest Arm tributary will be reconstructed to handle the higher combined flows, and grade control structures will be constructed across the Southwest Arm Tributary to impound and attenuate flows (up to 15 ha of newly inundated areas). The new channels will include riparian areas and floodplains, as well as permanently flooded fish habitat. The specific materials for the channel construction were not discussed, but organics will be part of the substrate to support the proposed habitat features. No mercury-specific information requiring further review.
		Section 5.6.2: General description of Goldfield Creek diversion water management; existing Goldfield Creek water will be diverted to the tailings management facility (TMF) while the new channel is constructed. No mercury-specific information requiring further review.
		Section 5.9.4: General description of the post-closure condition of Goldfield Creek, including the upstream Goldfield Creek diversion pond; identified that the permanent orientation of Goldfield Creek and the upstream diversion pond will remain the same as initially constructed. No mercury-specific information requiring further review.
	Chapter 6.0: Environmental Effects Assessment Methods	Summary of general environmental effects assessment framework. Did not include any mercury-specific information requiring further review.
	Chapter 9.0: Assessment of Potential Environmental Effects on Groundwater	Did not include a specific analysis of mercury impacts to groundwater, but did provide a summary of baseline mercury monitoring results, which identified mercury in groundwater in the Hardrock and MacLeod Tailings from <0.001 to 0.004 µg/L, in overburden in the Project Area from 0.003 to 0.007 µg/L and in project area bedrock from 0.003 to 0.004 µg/L, indicating possible mercury effects where groundwater (dewatering) is discharged to surface water.

Document	Section(s)	Summary of finding
	Chapter 10.0: Assessment of Potential Environmental Effects on Surface Water	Mercury was identified as having exceeded Canadian Water Quality Guidelines (Freshwater Aquatic Life – 0.026 µg/L) in 8 of the 924 surface water samples collected, as being below detection limits of 0.005 – 0.1 µg/L in the samples, as contributing to mercury methylation in the 15 ha new Goldfield Creek/Southwest Arm water impoundment, and as a concern to MNO. The Chapter included: mass loading estimates of mercury to various portions of Kenogamisis Lake water from different sources; predictions of mercury in water in the new Goldfield Creek (no change or decrease), Southwest Arm Tributary (increase, including post-closure), Mosher Lake (increase, to closure), Barton Bay (no change), Southwest Arm (increase), Central Basin (increase), and the Outlet Basin (increase). The mean annual flow in the Southwest Arm tributary was predicted to increase from 0.061 to 0.226 m^3/s during construction and remain about the same (0.224 m^3/s) during operations. The chapter also provided a description of surface water scope of assessment, methods, existing conditions, proposed project interactions with surface water, effects assessment, determination or significance and confidence in effects prediction.
	Chapter 11.0: Assessment of the Potential Environmental Effects on Fish and Fish Habitat.	This Chapter included a discussion of potential changes to mercury in fish tissue, which is a concern to MNO. It discussed the potential chronic toxicology of mercury on fish and fish-predators, baseline fish tissue and sediment mercury assessment. Mean mercury concentrations in sediment were below Ontario Sediment Quality Guidelines Lowest Effects Level (LEL: 0.2 mg/kg) in Kenogamisis Lake, Mosher Lake, Goldfield Lake, Wildgoose Lake, and small lakes in the LAA, except for elevated mercury in West Barton Bay (0.80 mg/kg) where previous studies had identified mercury up to 1.34 mg/kg. Mercury concentrations were also generally higher in the Central Basin of the Lake. Walleye and Spottail Shiner were identified as the fish species targeted for mercury-tissue assessment; mercury in Walleye were above the partial restriction guidelines for human consumption, and mercury was generally higher in Spottail Shiners where there was increased mercury in sediment in Kenogamisis Lake. The Chapter identified that there should be no increase of mercury in fish tissue, because water quality analyses had not identified any concerning increases of mercury in water.

Document	Section(s)	Summary of finding
	Chapter 19.0: Assessment of Potential Environmental Effects on Human and Ecological Health	The Chapter identified at a screening level, potential human health risk from methylmercury via fish tissue consumption under current conditions, as well as risks to Belted Kingfisher, Great Blue Heron and Mallard Duck from the same. However, when the potential risk was analyzed, it was suggested that there would be negligible increase in human health risk over current conditions from mercury ingestion based on hazard quotients (HQ) between 0.2 and 2.0, as well as negligible increased risks increases to the ecological receptors. In all cases, the negligible increased risk conclusion was based on the assumption that there would be no adverse effects on water or sediment by mercury from the project, and therefore no increase in fish mercury either.
	Appendix F.10 Draft Fisheries Off-site Plan	Identified the fish habitat off-set measures to be completed in the Southwest Arm tributary, including measures of success for fish habitat off-sets. Targets are to increase fish presence in the Southwest Arm tributary to meet the lost areas in former Goldfield Creek and its tributaries (further west in the Southwest Arm), the Golf Course ponds, tributaries contributing to the Southwest Arm and other small water courses that will be lost as a result of the Project. The reviewer interpreted the information to indicate a moderate increase in fish presence in the reconstructed Southwest Arm tributary.
Stantec Consulting Ltd. (2018a). GCM Hardrock Project – Mercury in Surface Water, Fish Tissue and associated Human Health and Ecological Risk Assessment. January 12, 2018.	All	The memorandum provides updates and clarifications on Stantec's evaluation of potential ecological and human health effects related to the Project, as well as on mercury levels in surface water and fish tissue in Kenogamisis Lake. The memorandum was prepared in response to comments on the Final Environmental Impact Statement (EIS) and Environmental Assessment (EA), and includes a summary of the methyl mercury generation in sediment modelling and transfer to surface water conducted by Stantec based on St. Louis et al (2004) and the FLUDEX study (Hall and St. Louis, 2005).
Stantec Consulting Ltd. (2018b). Hardrock Project, Responses to Comments Received on the Final Environmental Impact	Comments and responses related to mercury	The Ontario Ministry of the Environment and Climate Change (MOECC) reviewer discussed several concerns related to the potential for methyl mercury generation from proposed fish habitat off-set inundation, increased water circulation and sediment disturbance in the Southwest Arm of Kenogamisis Lake from the Goldfield Creek re-alignment, and co-parameters in seepage that may encourage mercury methylation (e.g., sulphate). The MOECC reviewer

Document	Section(s)	Summary of finding
Statement/Environmental Assessment. February 9, 2018		also identified that additional baseline fish sampling consistent with guidance in Ontario Waterpower Association (OWA - 2014) was needed to define the pre-development mercury conditions in fish. Stantec, on behalf of GGM, provided responses to the Ministry comments and included a copy of the Stantec 2018a clarification memorandum.
Stantec Consulting Ltd. (2018c). Hardrock Project, Arsenic-Mercury Peer Review Water Workshop (presentation). February 14, 2018	All slides related to mercury	The presentation provided an overview of groundwater and surface water quality; discussed the rationale, conservative factors and conclusions of the mercury-in-surface water mass balance modelling; and identified pre-construction mercury methylation mitigation (clearing and grubbing of organic material from flooded areas), flow management to possibly reduce methylation (e.g., high flushing rates and lack of shoreline erosion).
Stantec Consulting Ltd. (2018d). Hardrock Project, Responses to Comments Received on the Final Environmental Impact Statement/Environmental Assessment (Comments Provided by Hutchinson Environmental Sciences Ltd.). April 19, 2018.	All responses related to mercury	The information request response addressed questions that arose from HESL's initial review. HESL's questions included: what were the effects of high mercury detection limits on potential predicted mercury increases from the project, how were mercury impacts to sediment quality and the possibility of methylmercury generation from co-parameters (e.g., sulphate) considered, and why was a toxicity-based approach used to assess post-development mercury in fish when fish mercury is a bioaccumulation concern? Stantec provided detailed responses to these questions which clarified or supplemented the mercury-related information in the other reviewed Stantec documents.
Stantec Consulting Ltd. (2018e). Methylmercury Prediction in Fish Tissue. April 19, 2018.	All	Stantec predicted the potential post-development mercury conditions in 400 mm long Walleye and 550 mm long Northern Pike, according to the OWA (2014) guidance.

3.2 Background Information Sufficiency to Support the Analysis and Conclusions

The purpose of baseline data collected as part of an Environmental Assessment (EA) and/or Environmental Impact Statement (EIS) is to define the conditions that may be impacted by the Project to a level of detail that is appropriate to estimate environmental sensitivities and potential impacts to them by the project. In addition to the predictions of impact, an important outcome is preparing mitigation and management plans for potential impacts – baseline data must also support this outcome.

For Greenstone Gold, the EA and EIS (Stantec, 2017) and follow-up studies (Stantec, 2018a) appeared to have identified most potential mercury sources and receivers that could be impacted by the Project. The supporting assessment information was thorough in many regards and supported Stantec's impact predictions in general, but there was also room for improvement. The following sub-sections discuss the strengths and potential gaps in the baseline (background) information reviewed, pertinent to protecting human and ecological receptor health from mercury related to the Project.

3.2.1 Surface Water

Surface water quality was sampled over several seasons and years of baseline studies since 2013, to establish existing conditions and assess relative change for potential future conditions. The detection limits for mercury were generally high (0.005 – 0.1 µg/L) which may have masked potential seasonal and water-body specific sensitivities, but this was partially compensated for by considering ½ of the lowest detection limits to represent baseline conditions (see discussion in Section 3.4.1).

3.2.2 Groundwater

Groundwater quality was sampled over several seasons and years of baseline studies in the different potential mercury source areas identified by Stantec, to establish existing conditions and groundwater inputs to surface water. The detection limits for mercury were generally high (0.005 – 0.1 µg/L); Stantec addressed this by assuming that groundwater mercury concentrations were ½ of the highest detection limits which may have conservatively over-estimated the potential loadings to surface water from groundwater.

3.2.3 Sediment

The existing sediment quality was described to generally identify mercury conditions and elevated areas in the water features around the Project for post-development comparison and identifying current sensitivities. Erosion and sediment control (ESC) general descriptions appeared to be reasonable to protect surface water receivers during work in and near water. Work-specific ESC plans will be required in later detailed planning phases of the project but are not appropriate to expect at this stage of development.

3.2.4 Mercury bioaccumulation in fish

A key concern that our review identified was the potential for the proposed newly inundated areas in the Goldfield Creek diversion and Southwest Arm tributary to generate methyl mercury, which can bioaccumulate in fish, starting with benthic invertebrates in sediment where the methyl mercury would be

generated. Stantec (2017) proposed fish compensation in the newly flooded areas which would attract fish to the potential sources of methyl mercury, possibly increasing the effect of bioaccumulation by exposure to a greater number of fish.

The proposed inundated surface areas that could generate methyl mercury from flooding in the Goldfield Creek diversion and Southwest Arm tributary were quantified, which is necessary for predicting methyl mercury generation potential and bioaccumulation (see discussion in Section 3.4.4). Fish tissue samples for mercury were collected throughout the Project area during the baseline studies. The species, size, age and number of fish collected did not specifically meet the guidance in OWA (2014) to define baseline fish mercury in small proposed inundated areas, but there appeared to be sufficient fish tissue samples to reliably estimate baseline fish-tissue mercury conditions and make predictions for possible future increases due to bioaccumulation (see discussion in Section 3.4.4).

A target catch per unit effort (CPUE) was used to evaluate the success of new fish habitat off-set measures proposed for Goldfield Creek diversion and Southwest Arm tributary, but no increases in fish abundance or fish residency were provided in the initial documents; Stantec (2018e) subsequently clarified fish residence and bioaccumulation potential.

3.3 Clarity of Problem Statement(s) and Study Objectives

The Problem Statement(s) and Study Objectives as they relate to assessing mercury in surface water, groundwater, sediment and fish tissue, as well as the risk of mercury to wildlife and human fish consumers, were sufficiently defined to identify the potential impacts and risks, in the documents reviewed. The overall objective of the baseline studies and predictive work that relied upon the data collected was to protect human and environmental receptor health from potential mercury-related Project impacts.

3.4 Appropriateness of Methods, Models and Analyses

3.4.1 Surface Water

Stantec used a mass balance approach to assess the potential impacts to surface water quality from the various mercury sources of the Project. The exception was the potential for methyl mercury impacts to surface water in the newly inundated Goldfield Creek and Southwest Arm tributary impoundments from methyl-mercury generating sediments, in which case Stantec applied literature values from St. Louis et al (2004), and Hall and St. Louis (2005), to estimate the amount of mercury that may migrate to surface water from sediment. Both approaches appeared to be appropriate, and for the Goldfield Creek and Southwest Arm tributary impoundment predictions, the inputs and outputs were also reasonable.

Model inputs for the mass balance approach may have underestimated the relative change in mercury after development for surface water receiving mercury, but would have over-estimated the final mercury concentration for the following reasons:

a) Stantec had relatively high mercury detection limits in the surface water samples collected in their earlier baseline sampling programs (resulting in regular ‘non-detect’ concentrations) and

compensated by assuming baseline mercury concentrations were ½ of the highest detection limits in a dataset.

- The approach over-estimated the amount of mercury in surface water at baseline, meaning the relative predicted increases showed little to no difference over baseline. Had lower assumed baseline concentrations been assumed, relative increases in surface water mercury may have been more apparent.
- However, when the potential increase in mercury was added to the potentially elevated baseline concentration, it resulted in a higher post-development concentration, which is precautionary.
- Ultimately, the final potential concentration is the concern, and although the approach did not allow for an accurate assessment of relative change, it was protective by assuming higher post-development mercury concentrations than may actually occur.

b) Stantec used the average mercury concentration observed for each basin modelled, as the baseline concentration, and assumed that Lake Kenogamisis was fully mixed when conducting the modelling (Chapter 10, Stantec, 2017). The approach may have masked seasonal and/or basin-specific mercury trends. The MOECC reviewer made a similar comment about baseline data averaging in their review (Stantec, 2018b) in which Stantec directed the reviewer to Appendix E4.2 of the EIS/EA to clarify. The Appendix included descriptions of the sampling program and summary statistics on the measured parameters, but did not provide additional insight or rationale for the averaging approach.

   Although the reviewer does not completely agree with the approach, in the context of high detection limits over-estimating the potential post-development mercury conditions and the low predicted mercury bioaccumulation risk (Section 3.4.4, below), the approach likely did not underestimate or overlook potential mercury risks for the project, and accordingly is not a concern.

3.4.2 Groundwater

Mercury concentrations in groundwater were considered relative to their potential effect on surface water in this review. Stantec assumed that mercury concentrations in groundwater below the detection limits were ½ of the higher detection limit for a dataset, which tended to overestimate the mercury in groundwater. Therefore, when groundwater contributions to surface water were considered, the effect of groundwater mercury on surface water tended to be overestimated.

The approach did not allow the actual increase in surface water to be accurately predicted, but was protective of human and ecological receivers given that contributions to surface water tended to be over-estimated. The approach and inputs were therefore acceptable.

3.4.3 Sediment

Potential changes to mercury in sediment were assessed by Stantec in two principal ways:

1) In Kenogamisis Lake, potential mercury changes in sediment were considered via inputs from surface water and groundwater. Stantec did not predict problematic increases of mercury in surface water or groundwater from the Project, concluded that there would be no concerning changes to mercury in sediment either, and committed to monitoring mercury in sediment after development to confirm that the predictions were correct. Stantec also considered potential sediment migration from the proposed Goldfield Creek diversion and Southwest Arm tributary reconstruction to the lake, and concluded that based on the design of the water features which are intended to attenuate flows and resist erosion, sediment contributions from the features to the lake would be negligible. Methyl mercury in sediment of the newly flooded areas may increase (discussed below) and contribute to new mercury in the Southwest Arm of the lake if it migrates. The approaches were simplistic, but valid considering that surface water is a more sensitive receiver than sediment and that sediment is not expected to migrate from the newly flooded areas, so if there is no concerning impact to water or sediment migration, there should not be an impact to sediment in the lake either. However, the lack of potential impact to surface water and sediment must be confirmed through monitoring after development, especially to validate the assumption of negligible sediment migration from the newly flooded areas.

2) For the proposed Goldfield Creek diversion and Southwest Arm tributary reconstruction, Stantec concluded that the flooding related to the tributary diversion would not create a methyl mercury human or ecological health concern, although methyl mercury in sediment could increase from a baseline of 0.121 µg/g to 0.134 µg/g (an increase of 0.013 µg/g) as a result of existing mercury methylation in newly flooded soils. The prediction was based on literature values from Eckley et al (2017). Stantec considered key factors that could increase mercury methylation (anoxia and methylating bacteria stimulated by sulphate) and found that the co-factor conditions in the newly flooded areas did not support additional mercury methylation. Stantec reasoned that dissolved oxygen concentrations would remain near the baseline of 10.76 mg/L because of the turbulent flow through the diversion channel and increased surface water areal exposure to the atmosphere, and anoxia was therefore not a concern. Sulphate was predicted to increase to 3.2 mg/L (from the existing of 1.6 mg/L), which is less than the optimal range for mercury methylation (20 – 50 mg/L) as predicted Ulrich et al (2001). The reviewer agrees with both lines of reasoning in general, but cautions that diurnal oxygen sags from aquatic plant growth in the summer months and marginal sulphate increases can still stimulate methylating bacteria, and post-development monitoring programs should check the predictive conclusions carefully. Stantec highlighted that the predicted methyl mercury concentration (0.134 µg/g) in newly flooded areas was far below the MOECC LELs (1993), and was not a concern, and that post-development monitoring would confirm methyl mercury concentrations.

   Stantec's approach for predicting methyl mercury concentrations in sediment (i.e., considering percent newly flooded areas and modifying factors) is reasonable and consistent with recent guidance on potential effects from small-scale flooding as recommended by the OWA (2016). Comparison of mercury sediment conditions to MOECC LELs was not necessarily protective of bioaccumulation risk, but Stantec did subsequently address fish mercury bioaccumulation through additional modelling (see Section 3.4.4).

3.4.4 Mercury Bioaccumulation in Fish

In the documents that supported the EA/EIS, Stantec used a toxicity-based approach (using the low potential mercury increases in water to estimate changes in fish mercury and considering the relationship to CWQGs or Ontario Provincial Water Quality Objectives - PWQO) to assess the significance of increased methyl mercury, and identify the risk to fish consumers. Stantec also assessed the risk to human and ecological receptors via toxicity-based Human Health and Ecological Risk Assessments, based on the predicted changes of mercury in surface water. Bioaccumulation-based mercury predictions as recommended by OWA (2016) tend to be more robust predictors of mercury change that could affect human and wildlife health from fish consumption. Therefore, in the HESL (2018) information request, the reviewer recommended Stantec conduct bioaccumulation-based mercury predictive modelling as recommended by OWA (2016) to test the findings of the toxicity-based modelling conducted in the EA. Subsequent to the information request, Stantec:

- Conducted mercury-in-fish-tissue predictive modelling to consider bioaccumulation. They considered the uptake pathway starting with sediment which is the primary source of bioaccumulative mercury in newly flooded small areas like the ones proposed for the Project;
- Considered fish residency in the newly flooded areas as a percent of fish life in a given year to address possible concerns regarding new fish in the newly inundated areas;
- Predicted peak mercury concentrations in fish as recommended by the OWA (2016); and,
- Compared peak mercury concentrations to fish consumption guidelines.

The approach and input data were appropriate to estimate peak mercury and subsequent risk, although monitoring and management-response plans for increased mercury in fish tissue were not discussed.

3.5 Sensibility of the Outputs and Results, and Ability to Answer the Problem Statement(s); and Analyses Interpretation and Relevant Conclusions?

3.5.1 Surface Water and Groundwater

Overall, Stantec's approach to assessing the potential impacts of mercury from the project on groundwater and surface water and their conclusions, were protective of human health and ecological receptors and were sensible. Based on the rationale and findings presented by Stantec, it does not appear that any changes to mercury in surface water from the project will be a concern to human or ecological receptor health, which our review findings agree with. The elevated detection limits in the project baseline definition work and Stantec's practice of averaging baseline results masked subtle potential changes of mercury in groundwater and surface water, but these changes are unlikely to affect the health of receptors.

3.5.2 Sediment

Stantec's approach to assessing the potential changes to sediment were sensible. Their findings that the project was unlikely to effect mercury in the sediment of Kenogamisis Lake in a problematic way also appeared to be reasonable and protective of human health and environmental receptors based on no significant mercury inputs to sediment from groundwater or surface water, and negligible sediment

migration from the Goldfield Creek diversion and Northwest Arm tributary reconstruction. Our review findings agree. However, Stantec's assumptions that support the conclusions of no significant impacts should be monitored post-development to validate impact predictions and ensure that no negative effects occur.

Stantec's approach to estimating the potential increases of mercury in the sediment of the Goldfield Creek Diversion and Southwest Arm Tributary reconstruction were sensible and in keeping with the supporting literature. The predicted methyl mercury increase in sediment of the Creek and Tributary are a potential concern for mercury bioaccumulation in fish, and the risks were assessed by Stantec using a toxicity-based approach in the EA and by the bioaccumulation-based methods recommended by OWA (2016) subsequent to the HESL (2018) information request.

3.5.3 Mercury Bioaccumulation in Fish

Stantec completed an assessment of potential changes to mercury bioaccumulation in fish as recommended in the information request. The MNO (Damsa, 2017), were concerned that bioaccumulation had not been adequately considered. Stantec's bioaccumulation-based assessment followed the approach recommended (OWA, 2016), was sensible, and protective of human and environmental health. Stantec found that mercury bioaccumulation in fish would occur as a result of new flooding in the Goldfield Creek diversion and Southwest Arm tributary reconstruction: an increase of 0.008 µg/g for a total of 0.213 µg/g was predicted in 400 mm long Walleye, and an increase of 0.035 µg/g for a total of 0.126 µg/g was predicted in 550 mm long Northern Pike. The increases will not result in a change of MOECC fish consumption guidelines for either species, and as a result Stantec concluded that there would not be any incremental increased risk to human consumers of fish which the reviewer agrees with. Note that MOECC fish consumption guidelines are already in place for Walleye and Northern Pike in Kenogamisis Lake, based on the mercury concentrations that Stantec measured in fish.

Stantec did not complete a Wildlife Exposure Assessment (described in OWA, 2016) because there was no change in fish consumption guidelines from the predicted peak mercury increases, which is consistent with OWA (2016) recommendations and which the reviewer agrees with. Post-development monitoring plans to monitor the increase, peak and decrease of mercury in fish over time, as well as contingency management plans, were not provided for review but should be prepared.

Damsa (2017) cited concerns with post-development mercury concentrations in fish being greater than the CCME Tissue Residue Guideline of 0.033 µg/g (for methyl mercury), based on the toxicity work Stantec completed prior to the HESL (2018) information request. From the bioaccumulation-based assessment that Stantec completed, in the case of both Walleye and Northern Pike, the baseline total mercury concentrations were greater than the CCME guideline (0.205 and 0.091 µg/g, respectively). Although Stantec predicted that concentrations in fish would increase slightly in response to the project, there would be no change in consumption advice relative to the CCME guideline after mine development because the guideline is already exceeded at baseline. The predicted increased mercury in fish does not therefore change the guidance for human or wildlife consumption relative to CCME or MOECC consumption guidelines and does not represent additional incremental risk as indicated by Damsa, but fish consumers should be aware of a modest predicted increase of mercury in Walleye and Northern Pike.

4.0 Conclusions

Stantec's conclusions that mercury related to the Project will not affect the human and ecological health of receptors in or using the surface water and sediment of Kenogamisis Lake, the Goldfield Creek diversion and Southwest Arm tributary reconstruction, or consuming fish in the same water features, appeared to be reasonable based on the information reviewed (i.e., the EA/EIS documents and supporting information, and the responses provided to HESL's information requests). Concerns to human and ecological health from the Project were the subject of this review. As with any theoretical predictions that have the potential to effect human and/or ecologcial health, the predicted conditions must be monitored during the potential effects period (in this case after mine development and closure) to ensure that the predictions were correct, detect unacceptable change and mitigate impacts if change occurs.

5.0 Recommendations

Post-development and post-closure monitoring programs should be prepared and/or reviewed and amended if necessary, to accurately monitor mercury in surface water and sediment in Kenogamisis Lake, the Goldfield Creek diversion and Southwest Arm tributary reconstruction, as well as monitor predicted mercury concentrations in fish over time. Specifically:

- Surface water should be monitored for total and methyl mercury as per the spatial and temporal recommendations in OWA (2014), to measure potential changes of mercury in Project-effected surface water features relative to representative upstream and baseline references;
- Surface water and groundwater should also be monitored more broadly to confirm that the predictions of mercury changes in those media temporally and spatially are valid;
- Sediment should be monitored to detect and quantify changes in total and methyl mercury possibly related to the project, especially in the Goldfield Creek diversion and Southwest Arm tributary reconstruction features, and the area(s) of the Kenogamisis Lake Southwest Arm that may receive sediment from the features. Sediment sampling should be conducted in areas most likely to be affected by early methyl mercury generation and methyl mercury changes over time (i.e., newly flooded areas after the first year of flooding) and in sediment deposition areas within the new features and Kenogamisis Lake. Methyl mercury in the biologically active layer of newly flooded areas, and newly deposited (i.e., upper) sediment in settling areas, should be discretely sampled to accurately assess temporal and spatial changes. Sampling should be conducted on an appropriate interval over time to detect change and until a new stable methyl mercury condition is established;
- Fish mercury sampling in Walleye, Northern Pike and forage fish should be conducted as recommended in OWA (2014) to detect short- and long-term change and consumption risk in large fish likely to be consumed by humans, and forage fish as early indicators of change; and,
- Contingency plans and feasible mitigation strategies should be prepared for responding to and managing higher-than-predicted mercury concentrations in surface water, sediment and/or fish for consumption, to protect human and ecological receptors. OWA (2016) offers advice on risk managing potential consumption risks from fish containing mercury. It may not be necessary to prepare the monitoring and contingency plans prior to EA approval, but the plans should be a part of post-approval EA conditions.

It is conceivable that the conditions that supported the mercury fish tissue risk predictions in the EA/EIS and following the HESL (2018) information request may change during the course of the Project's development, and modelling will accordingly need to be updated. If this is necessary, the bioaccumulation-based predictive modelling recommended in OWA (2016) should be used to predict potential fish consumption risks as it tends to be a more robust predictor of bioaccumulation risks than toxicity-based approaches.

6.0 Closing

Thank you for the opportunity to conduct this review. Please contact me at your earliest convenience if you have any questions or concerns related to this report.

Sincerely,

Per Hutchinson Environmental Sciences Ltd.

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