Western Science

July 5, 2024

To: J. Esmonde, Cavalluzzo LLP
From: Dr. Brian Branfireun, London, Ontario, Canada

1 Introduction

I have been asked to review materials concerning the proposed Great Bear Gold Mine project, and provide an Expert Opinion concerning the potential for impacts on receiving and downstream water quality with a particular focus on mercury, and mercury methylation. The focus of this review of materials is on the technical adequacy of both ongoing and proposed approaches to manage water quality and avoid downstream impacts to aquatic habitat and degradation of aquatic resources. This memo is concerned primarily with the documentation from WSP Canada Inc./Kinross ("Proponents") associated with the proposed Advanced Exploration Program (AEX) Environmental Compliance Approval - Industrial Sewage Works (ECA – ISW). A complete list of the documents referred are provided at the end of this document.

2 Qualifications

I received my PhD in Geography from McGill University, Montreal, Canada in 1999 with a specialization in hydrology, mercury biogeochemistry, and wetland science. I was subsequently employed as a Professor at the University of Toronto Mississauga campus in Mississauga Ontario, Canada for 10 years, establishing an internationally recognized research program on hydrology and mercury in the environment. In 2010, I was recruited by the University of Western Ontario to the position of Professor and Canada Research Chair in Environment and Sustainability. The Canada Research Chairs program "stands at the centre of a national strategy to make Canada one of the world's top countries in research and development" (http://www.chairs-chaires.gc.ca/home-accueil-eng.aspx). I am considered an internationally recognized expert in the field of watershed biogeochemistry and the environmental cycling of mercury.

I have authored or co-authored over 100 peer-reviewed scientific papers and book chapters, and have made, or contributed to significant discoveries concerning the role of wetlands on the production and export of methylmercury (e.g. Branfireun et al., 1996; 1998; 1999; 2001; 2005; McCarter et al., 2017). I have been involved in high-impact state-of-the-science publications that have provided significant direction to the mercury research community (Harris et al., 2007; Munthe et al., 2007; Branfireun et al., 2020; Blanchfield et al., 2021). In addition to environmental biogeochemistry, research in my group has broadened to include the impacts of mercury on biota, including migratory birds (e.g. Ma et al., 2018a,b). This work has been supported by over ~$2M in research support over the last 5 years alone from primarily federal and provincial sources. I have served as an expert reviewer for the State of California and US Federal agencies on mercury related programs, and provided expert legal opinion to not-for-profit entities and In-

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digenous organizations in the the US concerning the impacts of mines water quality, mercury biogeochemistry and aquatic resources.

3 Summary of ECA-ISW Matters Concerning Mercury and Methylmercury

I am not an expert on the regulatory requirements for mining in Ontario and Canada, however I am surprised that Proponent claims the proposed AEX program “does not meet the requirements of the Physical Activities Regulations pursuant to the Impact Assessment Act. A Federal Impact Assessment is not required for the AEX Program” (ECA ISWApplication, p. 6). The extraction of up to 60,000 tonnes of ore, stockpiling of potentially acid-generating materials, the construction of what for all intents and purposes appears to be core mine infrastructure with a capacity to extract up to 60,000 tonnes of ore per day, the discharge of effluent to receiving waters, and the associated infrastructure required for this operation are substantial in scope and have the potential to impact aquatic resources. The statement that “The AEX Program will also improve the knowledge base to increase the confidence in environmental predictions associated with the Great Bear Project, if a decision should be made to proceed with full mine development.” (ECA ISW Application, 3.1) is worrisome rather than encouraging given the scope of the proposed exploratory work. The assumption is that the duration of the AEX program is the period of time during which baseline data will be collected, rather than prior to any discharges to the environment occurring which would be the more scientific approach to safeguard against impacts of the extensive AEX program itself. Indeed, the proposed data collection would be the only data of utility as the available baseline information that is provided in the ECA submissions pertaining to mercury, methylmercury and the processes associated with the formation of methylmercury in aquatic environments is inadequate.

In my opinion, there are concerning weaknesses and oversights associated with the ECA ISW Application that reveal a failure to properly address the environmental factors that contribute to methylmercury formation and uptake by biota. These oversights are of particular concern given that ultimately, receiving waters for the project flow into the most mercury-contaminated river system in Canada affecting the ecosystem and people that live there.

It is my opinion that:

1) The reliance on achieving on and off site water quality that complies with regulatory water quality guidelines for the protection of aquatic life is inadequate and inappropriate when considering mercury and methylmercury in water, and methylmercury uptake by biota that are consumed by humans (and other fish consuming organisms).

2) Baseline data for mercury and methylmercury in water and fish are inadequate and/or misinterpreted in the ECA ISW Application and associated documents.

3) The proposed aquatic monitoring program is wholly inadequate to detect irreparable harm due to AEX project-induced changes in methylmercury formation, and fails to acknowledge the sensitivity of receiving waters. Stated trigger criteria, mitigation and contingency measures are moot – for change to be detected the impact would be so significant that downstream impacts would be irreversible.

4 Background on Mercury Cycling in Watersheds

Anthropogenic activities have resulted in anywhere from 200 to 500% more inorganic mercury being released to the atmosphere and deposited to ecosystems since ca. 1850. This is not the mercury that ultimately presents the direct risk to ecosystems and consumers. This inorganic mercury is converted to methylmercury (typically only a few percent of all mercury forms in the environment) in oxygen-free environments such as the sediments of aquatic environments and soils that support the activity of sulphate-reducing bacteria, principle methylators of mercury in freshwaters. The methylation process is an enzymatic by-product of the sulfate-reduction reaction. Thus, nutrient-limited anaerobic environments that have a supply of inorganic mercury, sulphate, and organic matter (required for microbial metabolism) are likely net sources of methylmercury, with sulphate and organic matter being limiting (usually in that order). Methylmercury loss in aquatic systems is through photodegradation by UV light and biotic demethylation. The amount of methylmercury that we measure in the environment is the net balance of all of these processes. Methylmercury is the only form of mercury that bioaccumulates and biomagnifies in aquatic biota and fish consumers, and comprises 80-100% of the mercury in an upper trophic level fish, and ultimately in humans and other fish consumers.

The amount of methylmercury that is found in fish is a function of **both** the environmental controls on methylation described above, and the characteristics of the aquatic food web and the organism's life history which regulates bioaccumulation and biomagnification. It is entirely possible to have a relatively high total mercury environment with fast growing, lower trophic level fish, resulting in relatively low concentrations of mercury in fish tissue. Conversely we can have remote, very low mercury environments and slow-growing higher tropic level fish with concentrations of mercury that can exceed consumption guidelines (a case typical of the majority of Canadian lakes). The absolute concentration of mercury in the environment is important, but is not the sole (and often not the most important) predictor of the amount of methylmercury in fish.

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5 Opinion 1: The reliance on achieving on and off site water quality that complies with regulatory guidelines for the protection of aquatic life is inadequate when considering mercury and methylmercury in water, and methylmercury uptake by biota

The Proponent outlines in both text and schematics the routing of water from materials stockpiles and underground operations to settling ponds, an Effluent Treatment Plant (ETP), a treated water pond, and then discharge to the Chukuni River. Despite language implying compliance with effluent water quality, it is wholly unclear what criterion and guideline values are being used to evaluate on-site (i.e. operational) effluent quality against. In section 3.1 of the ECA ISW surface water monitoring plan, on site monitoring methods and frequency are discussed but no effluent limits, and in Table 3-1 the only criterion being applied is a semi-annual acute lethality test which in no way can assess more concerning impacts of effluent discharges on the mercury methylation process. Confusingly in section 3.4 Trigger Criteria, the document states, "Three consecutive **final effluent** sampling results exceed 90% of the monthly average **effluent limit for any parameter,** with an associated increasing trend, based on application of the Mann – Kendall non-parametric test." (Emphasis mine). Since we do not know what the effluent limit is for the parameters measured, an Environmental Compliance Approval of this proposal as written is effectively a license to degrade Chukuni River water quality. If we assume that the guideline values are the same as for off-site then we are really no better off, given the largely irrelevant nature of the criterion with respect to sulphate, mercury and methylmercury.

In the ECA ISW surface water monitoring plan, the list of analytes and associated guideline values from various regulatory agencies for off-site monitoring locations are provided in Table 3-3. Given best available scientific knowledge today about methylmercury formation in the environment, there is no other way to characterize these guideline values as anything but useless, and even if discharges were a fraction of these guideline limits there would be significant potential for downstream impairments of aquatic resources. For example, the CCME Criterion for (Total) mercury is 26 ng/L, which is a 2003 value (developed from a 1991 protocol) for the **direct** protection of aquatic life. Despite being profoundly outdated, the CCME document provides valuable commentary that is all too frequently ignored when setting regulatory criteria based on this single value, including "*The protocol does not address exposure through food or bioaccumulation to higher trophic levels*", and "*if the ultimate management objective for mercury is to protect high trophic level aquatic life and/or those wildlife that prey on aquatic life, more stringent site-specific application of these water quality guidelines may be necessary*" (CCME, 2003, p.2). The latter statement appropriately invokes the complex controls on bioaccumulation and biomagnification outlined above but is ignored in the Proponent's surface water monitoring ECA submission. Interestingly, the Proponent fails to include the CCME criterion for methylmercury in freshwater, despite the fact that it is being (inadequately) monitored, and its obvious importance to downstream waters and fish consumers. An Environmental Compliance Approval of this

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guideline for mercury is effectively a license to impair downstream resources given the low concentrations of mercury identified by the proponent through limited baseline sampling – the guideline value for mercury in Table 3-3 is ~25x higher than the background mercury levels in the Chukuni River that the Proponent themselves report. Site specific criterion for mercury and methylmercury must be required here, and derived from **appropriate** baseline data – scant little of which currently exist (see Opinion 2).

As discussed above, the availability of sulphate is a critical limiting factor on the amount of inorganic mercury that is converted to methylmercury in freshwater environments. Temperate and boreal freshwater environments are typically sulphate-limited due to low concentrations of sulphate in the surface environment. The addition of sulphate stimulates the activity of sulphate-reducing bacteria (SRB), and as a consequence, increase the production of methylmercury. The guideline value for sulphate of 218 mg/L from the BC long-term exposure guidelines is both irrelevant and misapplied, as was the criterion for mercury. First, the guideline value is based on 30-day exposure lethal toxicity to early life stage rainbow trout in "soft to moderately soft" waters. For "very soft" waters like those of the boreal shield rivers and lakes in Ontario, the lethal toxicity value is only 128 mg/L (BC MoE, 2013). Lethal levels of a discharged pollutant should not be the kind of criteria that are being applied to "protect" aquatic life in any environment, in my opinion. That being said, the greater impact here is not via direct lethality but rather it is the impact on mercury methylation – even adhering to the lower limit would permit sulphate concentrations 25 times greater than the current concentrations in the Chukuni River. Sulphate discharge from the operating paper mill in nearby Dryden result in Wabigoon River sulphate concentrations that are in the range of the lower BC WQG guideline, and we have recently demonstrated that these kinds of levels dramatically enhance methylmercury formation (consistent with well-established science), even when considerably diluted to levels seen over 150 km downstream from the source. If sulphate concentrations are increased even modestly in the Chukuni River system and downstream receiving waters (let alone the guideline value), enhanced methylmercury formation can be expected. 2023 water quality sampling shows that summer average sulphate concentrations in both the upstream Wabigoon and Eagle Rivers are slightly less than 2 mg/L. The Proponents own data for the Chukuni River indicate a value of closer to 6 mg/L which is three times higher than the background concentrations of other rivers in the region. This suggests to me that upstream industrial and mining activities may already elevating sulphate in the receiving waters, meaning that any additional sulphate supplied to receiving waters by the proposed operations would be contributing to the cumulative effects of sulphate levels that are already above regional background. Arsenic concentrations in the Chukuni River that are already above guidelines strengthen the conclusion that this may already be an industrially-impaired ecosystem that should be protected from cumulative effects. In our recently released technical report, we found that increasing sulphate concentrations alone in river water from 1.3 to only 2.0 mg/L resulted in an average of 22% more methylmercury being formed in sediments.

Increasing that amount to 10 and 30 mg/L increased methylmercury concentrations by 62 and 115% respectively, clearly indicating that even small increases in sulphate concentrations can significantly affect methylmercury production at sites of methylation (See Branfireun Technical Report: Riverbank Mercury Methylation Dynamics Study, May 14, 2024).

As with the CCME guideline, the often in depth analysis that are provided in the Technical Appendices of WQGs is not considered, and in this case that technical appendix states that "*Further research is needed for better understanding of the indirect effects of elevated sulphate on … mercury mobilization.*" (BC MoE, 2013, p. 45). I would contend that the mercury science community was well-versed on the relationship between sulphate and mercury methylation in 2013, however the authors of this technical appendix may be excused for not being well-versed in that body of literature given their area of focus. The fact that the Proponent failed to address the role of sulphate on methylmercury formation in any part of this application cannot be similarly forgiven, given the extremely high level of awareness in Ontario in particular about mercury contamination in the downstream English-Wabigoon River system and the damage that it has caused to ecosystems and communities, and the link between mining activity, the release of sulphate, and subsequent increases in methylmercury in sediments, water and fish. The latter relationships were brought into sharp focus during late stage operation and closure of the DeBeers Victor Mine in the James Bay Lowland; a situation that the Proponents should be keenly aware of.

Finally, we have no evidence that the solutes that are relevant to mercury methylation in receiving waters will even be actively managed at all. The technical details of the Effluent Treatment Plant (ETP) do not appear to be elaborated on in available documents to the best of my knowledge. We do have some insight from a presentation to ANA on November 10, 2023 in which the ETP process is described, including "Ammonia Treatment – Moving Bed Biofilm Reactor (MBBR), pH adjustment, clarification, and Additional ultrafiltration". Other than ammonia, none of these processes target any of the potentially deleterious substances that are transferred to the ETP from site operations and stockpiles that are related to mercury methylation, the most concerning of which is sulphate. Although sulphate is the acid anion that is the underlying reason for acidic mine drainage, "pH adjustment" does not remove sulphate. For pollutants other than ammonia, the only process that reduces total loading is particle removal either through settling or filtration (and possibly pH adjustment depending on chemical conditions). Despite the impressive inference, "*ultra*-filtration" is simply the removal of smaller particles by filtration, and should not be confused with reverse-osmosis technologies or some other industrial scale ion-exchange/sorption technologies that could potentially address excess loadings. Table 1-1 in AEX PROGRAM ECA ISW AQUATIC RESOURCES MONITORING PLAN (Sept 18, 2023) states that the ETP will address " Removal of metals and potentially other contaminants from AEX effluent prior to discharge to the Chukuni River" yet the information available would suggest that this will only be done through particle removal (and possibly pH adjustment). Effectively, there

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are no technological mitigation measures in place that could mitigate exceedances of sulphate or mercury above guideline concentrations (even if they were applicable). Methylmercury is not even monitored as part of the on-site proposal.

Given that the proposed AEX operation will be exposing and stockpiling acid-generating waste rock, where the ‘acid’ is sulphate generated from oxidized sulphidic minerals, lack of clarity about both the direct effluent and the off-site exceedance limits that are being proposed mean that an enhancement of mercury methylation in receiving, downstream, and potentially onsite waters are certain if the inappropriate criterion stated in Table 3-3 are applied.

6 Opinion 2: Baseline data for mercury and methylmercury in water and biota are inadequate and/or misinterpreted in the ECA ISW Application and associated documents.

I am surprised by the degree of mishandling of mercury data in various media presented by the Proponents in the ECA ISW Application and associated documents, given the mercury contamination in the downstream English-Wabigoon River system and that damage that it has caused to ecosystems and communities. Instead of conveying confidence with mercury concerns at the forefront of their monitoring program through a transparent recognition of potential impacts and mitigation strategies, I find a submission that is rife with errors and misinformation.

SURFACE WATER MERCURY DATA: In WSP memo Daniel to MacDonnell, March 28, 2024 we find a number of re-directions and errors that highlight my concerns about the handling of background data. Despite providing some placating commentary about mercury and the project, no mention is made about the serious risk of enhancement of mercury methylation by sulphate addition to the environment. Instead we find reassuring statements that experimental leachate from mine rock and ore showed mercury at levels “below analytical detection limits”. We are not told what those mercury levels were, nor what the analytical detection limits were. I suspect that the detection limits are 5 ng/L which is the reporting level typically set by generic geochemical laboratories using ICP-MS to for aqueous metal analyses. This detection limit is unacceptable for environmental mercury monitoring and ICP-MS is an inappropriate technique for mercury analyses unless dedicated for such purpose. Given that surface water total mercury concentrations in major lakes and rivers are generally less than 1 ng/L in this region of Ontario (confirmed by the Proponents own low level mercury data for the Chukuni River), “below analytical detection limits” could be 4.99 ng/L, or 5 times higher than the reliably reported river water concentrations, which is problematic. Despite the fact that a greater supply of mercury increases the pool of available mercury for methylation , additions of mercury are unlikely to be the primary driver of mercury impairment of downstream resources – it is the addition of sulphate which will enhance the methylation of mercury that is already in the system.

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My speculation about analytical reporting/detection limits for total mercury are confirmed when we review Table 1 of this same memo which summarizes Chukuni River “baseline” water chemistry. Amazingly, the 25th and 75th percentile and average concentrations for mercury are invariant at 0.000005 mg/L (5 ng/L). The reason for this is that **these are not data** – these are just the detection limits reported by the laboratory. These are the same data that are reported in Table 2.10 of “Attachment 4 - Surface And Groundwater Technical Supporting Document” (March 2024). This document contains more information about detection limits, but instead of clarifying it leads to further confusion. Here, the detection limit for mercury is stated as 0.00001 mg/L (10 ng/L) – double the summary values reported in Table 2.10 of the same memo rendering them invalid. Given the importance of mercury data for the protection of the environment and fish consumers, I find this surprisingly inadequate. Regardless of which is correct, the existing ICP-MS mercury data are of no utility whatsoever because the high detection limits are unable to measure environmentally-relevant concentrations – this is confirmed by the limited ‘low level’ mercury analyses that was done on select samples.

This lack of attention to the quality of baseline data is even more evident in Appendix A (Water Quality Data) of Attachment 4. Here we can scroll through the dozens of tables of element concentrations to find mercury data that is sometimes equal to the stated detection limit of 10 ng/L, but most often is fixed 5 ng/L, which is not data but a substituted value for samples that are at or less than the detection limit. But then, we sometimes find some samples that are half of this value (2.5 ng/L, which may be the undocumented detection limit for the laboratory on a good day), but if they are not, then they are and below the stated detection limit and should not be reported. Sometimes we find values that are clearly errors. For example, Table B-2 on PDF page 66 of Attachment 4, we see three values that are flagged as ‘exceedances’ of the meaningless CCME guideline of 26 ng/L; values of 70, 30 and 50 ng/L. These values are actually impossible in an uncontaminated freshwater system such as, and if there were a contamination source, the signature would be much more persistent. These values are almost certainly a calculation error, contamination in the sample handling/analytical process, or simply poor instrument calibration/operation at the analytical laboratory used by the Proponent. We find instances of this throughout these data tables for mercury. The fact that these values were flagged as ‘exceedances’ by the Proponent rather than errors and even used in the calculation of the statistics (which themselves are meaningless) reveals to me a technical team overseeing water quality considerations with insufficient experience reviewing environmental water quality data. I am of course focussing on mercury, however other data may be equally unreliable and there is evidence of this with inconsistencies, rounding errors, and lack of precision evident in the reporting of other elements and solutes such as sulphate. For the Proponent to not be aware of this is concerning and reveals a lack of attention to the data provided by the analytical laboratory, a lack of understanding of natural water chemistry, and a lack of attention to numerical calculations that don’t make sense. This does not lend confidence in the Proponent’s ability to conduct acceptable

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quality control and assurance associated with the monitoring program, the interpretation of data, and reporting.

Although a justification for doing so is not provided , the Proponents submitted a very small number of samples for "low level" mercury analyses, listed separately as if it is detecting some different form of mercury. All that is different is the analytical technique which is more sensitive, and is the one that should have been used for all mercury analyses (consistent with EPA Method 1631). In Table 2.10 this lower detection limit is noted, however it is stated that the detection limit is 1 ng/L; it is actually typically at least half of this in a laboratory with good quality assurance and quality control. Regardless, the results of these analyses should have flagged the results by ICP-MS as unacceptable for mercury, however this was not done. There are no statements concerning the method detection limits for methylmercury (US EPA Method 1630) which is also an 'ultra-trace' technique.

In Table 2.10 of Attachment A (reproduced as Table 1 in Daniel to MacDonnell) we see reasonable and expected values for total mercury ranging between 0.8 and 0.9 ng/L. When closely examined, we see that this was for only **3 samples** reported here for the Chukuni River. Three samples does not constitute a baseline dataset, and yet another indication of generating meaningless statistics (25th and 75th percentiles are meaningless with n=3). Interestingly, when reviewing the actual data in Table B-6 of Attachment 4, I find **8 samples** reported (for Chukuni River downstream only), with an average of 1.13 ng/L and 25th and 75th percentiles of 0.705 and 1.67 ng/L, respectively. The 75th percentile is **double** the value that is reported in summary Table 2.10 and Table 1 in Daniel to MacDonnell from WSP to Kinross (and approximately 25x higher than the CCME guideline value proposed in the Application). At best, this is again evidence of inattentiveness to the data; at worst is it selective reporting where due diligence and transparency are, instead, needed.

The conclusion that the Proponent is selectively presenting favourable surface water mercury data in the ECA ISW application is unfortunately reinforced when the low level total mercury and methylmercury data is considered for the other sampling sites. At these select locations inorganic and methylmercury data present a very different story than the 3 samples openly discussed from the Chukuni River. I extracted just the mean values and calculated the percent of total mercury that is methylmercury, a good indicator of the methylmercury production potential of the waterbody/watershed. In surface waters, %MeHg over 1% would indicate a high methylmercury production potential.

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Table 1: Data extracted from Tables B in Attachment 4 of the ECA ISW

Location	Sample #	Average MeHg (ng/L)	Average THg (ng/L)	%MeHg
Dixie Creek Upstream	9	0.103	2.45	4.2
Dixie Creek Downstream	11	0.231	3.43	6.7
Dixie Creek Far Field	2	0.434	3.02	14.4
Dixie Creek Tributaries	9	0.404	4.80	8.4
Rice Lake	4	0.043	2.16	2.0
Rice Lake Tributaries	4	1.015	8.80	11.5
Teardrop Lake	1	-	4.22	-
Genessee Lake	7	0.030	0.60	5.0

It is clear that the proposed project area already has very high methylmercury production potential and much higher concentrations than those highlighted by the Proponent. The Dixie Creek Far Field value of over 14% is actually one of the highest %MeHg I have ever seen for surface waters, yet these less 'favourable' mercury and methylmercury values are not described anywhere in the Application other than buried in the 'wall of numbers'. The Proponents statement that "Most of the mercury in the environment is in the form of inorganic mercury which tends not to accumulate in the food chain, such as in fish." (Memo Daniel to MacDonnell) is perhaps numerically true in that MeHg is less than 50% of total mercury, however is misleading given the very high methylmercury concentrations in creeks and lakes in the Project footprint. Indeed with percentages of total mercury as methylmercury of even less than 1% in surface waters, higher trophic level fish can have mercury levels in tissues that exceed consumption guidelines, so this point is not relevant. This is a methylmercury sensitive landscape with extraordinarily little reliable mercury data, and the high levels of mercury in fish that are reported in the Application Appendix C are confirmatory.

FISH MERCURY DATA: Concentrations of mercury and methylmercury in fish tissue are reported in Appendix C of Attachment 4. My concern is with the Proponent's interpretation of guideline criterion to which the data are compared because such interpretation could place fish consumers at risk if the interpretation were propagated beyond this document.

The document states that:

> "The total mercury concentrations measured in large-bodied fish tissue were compared to the provincial consumption guidelines (Ministry of the Environment, Conservation and Parks [MOECC] 2015) and federal food and nutrition standards (Health Canada 2011). Concentrations of methylmercury were compared against the Canadian Council of Ministers of the Environment (CCME) Canadian Tissue Residue Guideline for the Protection of

> Wildlife Consumers of Aquatic Biota – methylmercury (CCME 2000).". Appendix C, p.4).

The fish tissue contaminant data are nearly impossibly buried in a poorly structured and excessively long report. Many of the sampled locations have fish tissue mercury concentrations that are highly elevated, as one would expect based on species, and water methylmercury concentrations that were discussed above. Despite this, one particular statement (with minor variation) is copied and pasted for data for nearly every location where fish mercury is reported:

> "… all concentrations were less than the Ontario consumption guideline developed for the general population (1.8 mg/kg). Most samples were also less than the guideline for women of child-bearing age and children (0.5 mg/kg) and the Health Canada maximum contaminant concentration (0.5 mg/kg)."

This statement is dangerously misleading. The Ontario consumption guideline is presented to the public as a "meals per month" recommendation, based on a mercury tissue concentration – body size model generated on a species-by-species and lake-by-lake basis. This function is then compared against a Tolerable Daily Intake value that is used to calculate the number of meals per month. Ontario has no numerical concentration-based consumption guideline. The value of 1.8 mg/kg is the fish tissue concentration where the model generates a zero meals per month output. In other words, this is the concentration at which no fish should be consumed by anyone, at any time. The language used in the Report implies is that fish are safe to eat if they are less than "1.8 mg/kg consumption guideline". Further, the stated value of 0.5 mg/kg being a "guideline" for women of child-bearing age and children is untrue for the same reasons – this is the "do not eat" mercury level for this group. Concentrations less than this may result in highly restricted consumption recommendations, but with recommended meals per month being a function of the concentration.

In the interest of transparency, here is the actual section of the Ontario Guide from 2015, which is cited by the authors of this report:

> For women of child-bearing age and children under 15, an advisory changes from 32 to 16 meals per month at a mercury concentration of 0.06 parts per million (ppm), from 16 to 12 meals per month at 0.12 ppm, from 12 to 8 meals per month at 0.16 ppm, from 8 to 4 meals per month at 0.25 ppm, **while complete restriction (i.e., do not eat) is advised for levels above 0.5 ppm**. For the general population, an advisory changes from 32 to 16 meals per month at mercury concentration of 0.15 parts per million (ppm), from 16 to 12 meals per month at 0.3 ppm, from 12 to 8 meals per month

> at 0.4 ppm, from 8 to 4 meals per month at 0.6 ppm, from 4 to 2 meals per month at 1.2 ppm, while **complete restriction is advised for levels above 1.8 ppm**. (emphasis mine).

This is an explanatory section of the guide that simply identifies how the consumption guideline is arrived at.

The Health Canada value of 0.5 mg/kg is not a "maximum contaminant concentration", but the level at which fish cannot be commercially sold at all in Canada (with certain "luxury food" exceptions). Health Canada's consumption guidelines are also not concentration-based. That being said, 0.5 mg/kg is often used as a rule of thumb "do not consume" level for the general population, and 0.2 mg/kg is similarly recommended as a **maximum** concentration for routine consumption by subsistence fishers and consumers in Canada. The US EPA uses an even lower maximum concentration for subsistence fish eaters. All of these guidelines consider steady lifetime exposure and do not take into account people who have already experience very high exposure as fetuses, children, or earlier in their adult lives and who may have already exceeded their lifetime exposure limit.

Being "less than" some guideline "do not eat" value does not mean fish are safe to consume. Many of the fish mercury levels reported in the Application are high by objective standards, and would present a significant risk to consumers if eaten with any frequency. Combined with the 'below detection limit' water concentrations, presenting fish mercury data like this implies an aquatic environment that is free from risk to consumers, and one that will not be materially impacted by the AEX project or full mine development, which in my opinion is not the case. Given the high profile of mercury contamination in fish in this region and the prevalence of both Indigenous communities exercising their rights to harvest and consume fish and well as an active recreational fishery, this presentation of worrisome fish mercury levels against complete restriction cut off concentrations so that it can be stated that they are 'less than' some value is inexplicable.

All of the evidence from reliable data included by the Proponent (both low level mercury and methylmercury and fish concentrations) objectively point to a mercury-sensitive landscape, which is quite expected for the this region of Ontario given watershed characteristics, water chemistry and aquatic food web structure. As a consequence, fish mercury concentrations will be impacted by any development that changes hydrology, water levels, and sulphate concentrations, as is the case here. It is surprising to me that the ECA ISW Application and the supporting documents that I reviewed were silent on all of these matters.

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7 Opinion 3: The proposed aquatic monitoring program is wholly inadequate to detect irreparable harm due to AEX project-induced changes in methylmercury formation, and fails to acknowledge the sensitivity of receiving waters. Stated trigger criteria, mitigation and contingency measures are moot – for change to be detected the impact would be so significant that downstream impacts would be irreversible.

WATER MONITORING: The proposed monitoring of surface water quality and biota for mercury and methylmercury are inadequate to detect irreparable harm for several reasons. As previously discussed, the reliance on mercury concentration data generated by ICP-MS with high detection limits are of no utility now, or in the future. Therefore any monitoring plan that indicates "ICP-MS metals" must be discounted for mercury, and by definition does not include methylmercury. The only data that are currently in hand are the small proportion of samples that were submitted for "ultra-trace" analyses of mercury and methylmercury. As written in the ECA ISW Application, there are no plans to expand the application of these appropriate measures as part of the AEX project or future mine expansion. In fact, the Application indicates that these data, which are the only water mercury data of utility to ensure the protection of downstream fish consumers, will be sampled at fewer locations during the AEX project, and at such a low frequency that meaningful change detection will be nearly impossible.

Table 3.1 of Attachment 6 (ECA ISW Monitoring Plans) reveals that no measurements of appropriate low level mercury (and no measurement of methylmercury at all) are to be made in on site waters that are ultimately directly discharged to the Chukuni River. It will therefore be impossible to undertake a definitive root cause analysis if elevated levels are detected downstream in the Chukuni River because one of the potential sources (operations effluent) is not being monitored.

Table 3.2 describes the off site sampling locations and parameters which do include appropriate low level mercury and methylmercury at some locations, including Pakwash Lake which is of notable importance. This is the first lake downstream of the proposed effluent discharge, and already has five fish species that have restricted consumption advisories due to mercury contamination (https://www.ontario.ca/page/fish-consumption-report?id=50459330) indicating that any further loading of methylmercury, or enhancement of the methylating process either in the lake or upstream would amplify an existing environmental degradation. Appropriate low level Mercury and methylmercury measurements are only proposed at 50% of the monitoring locations (11 out of 22), and other than the obvious locations in the receiving water and downstream, the justification is unclear, particularly given the level of of methylmercury production that was reported in other baseline data that will not be monitored in the future. The absence of sufficient mercury and methylmercury data to date means that there will be no baseline record for mercury and

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methylmercury in water to refer to prior to the beginning of the AEX program. Based on what would appear to be elevated levels of sulphate and arsenic that are above regional background due to upstream sources, it is also likely that the upstream Chukuni River sampling location is not a 'reference' site at all, because it is already impaired.

Appropriate low detection level mercury and methylmercury samples at sites that are specified are only to be taken quarterly. This low frequency of sampling is insufficient to statistically detect change until that change is so substantial that its effects would be irreversible. These samples should be taken at minimum monthly. Simply put, for a program such as this, low level mercury and methylmercury samples should be taken at all sites, for all water quality samples.

Even if monitoring were improved, the trigger criteria would never be invoked given the application of meaningless criterion for mercury and sulphate concentrations (see Opinion 1). As stated in section 3.4, triggers would only be invoked if "Three consecutive final effluent sampling results exceed 90% of the monthly average **effluent limit** for any parameter, with an associated increasing trend…", or "such that there is a likelihood of **applicable water quality guidelines for the Protection of Aquatic Life** being exceeded in the receiving environment". Independent of the meaningless criterion, as written this statement would suggest that there could be three exceedances that do NOT show an increasing trend and that would not result in a trigger? These kinds of statements should not have any aspect of them that are subject to interpretation, in my opinion.

There is no guideline criterion stated for methylmercury; therefore there is no associated trigger criteria for this water quality parameter which in my opinion is the most important for the protection of downstream aquatic resources and fish consumers. As there is no guideline included in the application for methylmercury in water, this parameter will be unregulated.

BIOTIC MONITORING: My primary concern is the frequency of monitoring, and the inadequacy of that monitoring to detect change and prevent irreparable harm. The AEX Program ECA ISW Aquatic Resources Monitoring Plan Draft (Sept, 2023) outlines, biotic sampling that is proposed.

Biotic monitoring is proposed to begin one year after the initiation of the AEX program, and then inexplicably only every three years after that. There is no mercury or methylmercury analysis specified for benthic organisms, despite their high utility as rapidly responding bioindicators. Large bodied and forage fish are proposed to be sampled at the same frequency and analysed for mercury and methylmercury.

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Stated trigger criteria for mercury in fish are:

> *Fish tissue mercury and/or methylmercury are statistically different from and higher than the concentration of total mercury and/or methylmercury in fish tissue that is taken in the reference area (if applicable) and/or baseline condition.* (Table 3-2)

Given the extremely small sample sizes that are currently reported and that are proposed, it is unlikely that statistical significance would ever be possible. However, even if it was, the trigger action stated is:

> *Review results of multiple years to confirm difference. Based on discussion with MECP develop a mitigation plan, or offset measure if Required.* (Table 3-2).

It is unclear what is meant by "review results of multiple years to confirm difference", however since sampling is proposed for every 3 years, the action will lag a minimum of 6 years behind any detectable change in fish mercury concentrations, during which time whatever operational process was increasing fish mercury concentrations will continue to degrade the aquatic environment irreparably and impair aquatic resources for downstream consumers. Moreover, the effect will have 6 years to propagate further downstream. At minimum, young-of-year/small-bodied fish should be sampled annually at the end of the growing/exposure season as these fish are the most likely sentinels of changes in methylmercury in the aquatic environment in that year. For any given year, differences between young-of-year fish mercury concentrations and a suitable reference location should result in an immediate trigger for more in-depth investigation before irreparable degradation occurs.

8 Concluding Remarks

The Great Bear Projects Advanced Exploration ECA ISW Application and associated documents are silent on the direct role of sulphate in the formation of methylmercury, and that sulphate release from the AEX or full mine project present the greatest risk to the local and downstream aquatic environment via the enhancement of the process that produces methylmercury.

- Water quality guidelines that are associated with the protection of aquatic life are not appropriate when addressing potential impacts on methylmercury production and uptake by biota, and are not protective of fish consumers.

- Despite assertions to the contrary, there is scant useful data about mercury in the proposed project area and receiving waters because the majority of the data that is available is either not data or is not usable. Usable low level mercury and methylmercury data that exists but is not discussed in the ECA ISW application reveals a landscape with very high potential for methylmercury production – a landscape that will be very sensitive to changes in hydrology and sulphate loading. This is supported by high fish mercury level data that is deeply buried and not elaborated upon in the Application.

- Proposed monitoring for mercury and methylmercury in water and biota is insufficient to detect change and avoid impairment of downstream aquatic resources due to increased methylmercury production. Appropriate low-level analyses for mercury and methylmercury are not proposed at all stations, temporal frequency of water and fish sampling is insufficient, and guideline concentrations and trigger criteria are inappropriate.

Taken together, the existing data, water quality guidelines, effluent treatment, and proposed monitoring are not protective of biota in the waters in the project area, in the receiving Chukuni River, or further downstream with respect to methylmercury production and uptake. As a consequence, the existing data and proposed monitoring are not protective of fish consumers, including humans. Combined with the Proponent's inexplicable discounting of the Project's potential impact on methylmercury formation and uptake by biota, it is my opinion that there is a very high risk of irreversible harm to ecosystems and fish consumers if the ECA Application documents that I have reviewed are accepted.

9 Materials Referred

Great Bear Project AEX ECA ISE Aquatic Resources Monitoring Plan
(Aquatic Resources Monitoring Plan - Sept 18 2023.pdf)

Great Bear AEX Program Attachment 4 – Surface And Groundwater Technical Supporting Document
(Attachment 4_GBR_AEX_ECAISW_April2024.pdf)

Great Bear Advanced Exploration Program ECA ISW Application
(GBR_ECA ISW_Application_GRB_AEX Program_11Apr2024 (1).pdf)

Great Bear Project Proposed Underground and Open Pit Gold Mine. Presentation by Kinross to Grassy Narrows First Nation November 10, 2023
(PowerPoint Presentation by Kinross to ANA - Nov 10 2023.pdf)

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WSP Memo: S. Daniel (WSP) to Aaron MacDonnell (Kinross) Marsh 28, 2024 (GBR_AEX_WSP Memo_to_GNFN_(March28.24).pdf)

Canadian Council of Ministers of the Environment. 2003. Canadian water quality guidelines for the protection of aquatic life: Inorganic mercury and methylmercury. In: Canadian environmental quality guidelines, 1999. Canadian Council of Ministers of the Environment, Winnipeg. (mercury-inorganic-mercury-and-methylmercury-en-canadian-water-quality-guidelines-for-the-protection-of-aquatic-life.pdf)

Ministry Of Environment Province Of British Columbia Ambient Water Quality Guidelines For Sulphate Technical Appendix Update April 2013
(bc_moe_wqg_sulphate.pdf).

Branfireun Technical Report: Riverbank Mercury Methylation Dynamics Study May 14, 2024.
(Riverbank Mercury Methylation Dynamics Study Technical Report May 14.pdf)

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