RYAN S.D. CALDER

February 28th, 2018

Ken Reimer, PhD, Chair
Independent Expert Advisory Committee
PO Box 2129, Station B
Happy Valley – Goose Bay, NL
A0P 1E0
Canada

Re: Methylmercury exposure forecasts among Lake Melville Inuit under hypothetical scenarios for soil removal at Muskrat Falls and using certain updated and alternative model parameter inputs

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Dear Dr. Reimer:

Please find enclosed a summary of forecasts for MeHg values in the environment and of MeHg exposures among Lake Melville Inuit following development of Muskrat Falls. These forecasts are based on the Calder et al. (2016) model and incorporate updated Hg data for certain species of fish and seal and alternative habitat foraging fractions for certain species of fish as discussed in our conversation on February 22, 2018.

I look forward to speaking with you this coming Thursday, March 1st. In the meantime, please do not hesitate to contact me with any questions.

Sincerely,

Ryan Calder, ScD, MASc

1. Alternative model inputs

The Independent Expert Advisory Committee (IEAC) has requested an analysis of the effect of changing certain parameter values and distributions in the model developed by Calder et al. (2016) on methylmercury (MeHg) impacts from Muskrat Falls. These are:

a. updating present-day fish and seal Hg concentrations with measurements collected since 2016;
b. using alternative values for the lifetime-average habitat foraging fractions for certain species of fish for which no isotope data was available as well as adjusting the probabilities assigned for Atlantic salmon; and
c. evaluating the impact of certain hypothetical soil removal scenarios (Scenarios “A” and “B”) on forecasted MeHg impacts.

Table 1.1 summarizes the changes contemplated by (a) and (b) relative to the inputs retained in the model to date. Alternative fish Hg values were calculated by weighting, according to sample size, data presented by Calder et al. (2016) and supplied by the IEAC. For seal muscle, values are also aggregated by age range of the seal according to fraction in Inuit diet considered by Calder et al. (2016) (80% < 1 yr; 10% 1–4 yrs; and 10% >4 yrs). The data presented by the IEAC includes < 1 yr and ≥ 1 yr age ranges. The latter is assumed to account for 20% of the diet, following Calder et al. (2016). For fish and seal muscle, we can assume that MeHg ≈ THg. This assumption does not hold for seal liver (Dehn et al. 2005). In the absence of updated seal liver MeHg and given the similarity of new seal muscle data to previously used seal muscle data, the values for seal liver are not updated. The seal liver THg values presented by the IEAC are consistent with the MeHg values retained by Calder et al. (2016).

Table 1.1: Alternative vs. original model parameter inputs

	Calder et al. (2016)	Alterative values proposed by IEAC
Fish and seal THg, mean (SD), ppm		
Atlantic salmon muscle	0.07 (0.02)	0.07 (0.04)
Brook trout muscle	0.11 (0.03)	0.07 (0.04)
Lake trout muscle	0.99 (0.46)	0.75 (0.35)
Rainbow smelt muscle	0.11 (0.05)	0.06 (0.06)
Ringed seal muscle	0.16 (0.22)	0.16 (0.79)
Foraging fraction in Churchill River below Muskrat Falls		
Lake trout	100%	0%
Ouananiche	100%	0%
Foraging fraction in Lake Melville		
Atlantic salmon[1]	0–50%	0–20%

[1] Balance of foraging (i.e., 80–100% with IEAC values) is in outer marine layer

Scenario “A” represents capping of certain wetlands in the flooded area. Updated information provided by the IEAC suggests this area covers 0.8 km^2. Scenario “B” represents excavation of the vast majority of labile organic carbon (OC) over an area of 10.3 km^2.

2. Remediation scenarios "A" and "B"

In pristine environments, wetlands tend to produce more MeHg per unit area than upland soils (Rudd 1995; St. Louis et al. 1996). Meanwhile, flooded soils produce MeHg in proportion to their OC content (Mucci et al. 1995; Rolfhus et al. 2015; Meng et al. 2016). Previous investigations have revealed that production of MeHg in flooded wetlands is lower than would be suggested by their organic OC in comparison to flooded uplands (Hall et al. 2005). Other authors have proposed sulfate limitation in wetlands to explain this phenomenon (Harmon et al. 2004; Hall et al. 2005; Jeremiason et al. 2006; Coleman Wasik et al. 2012). Calder et al. (2016) summarizes available data to represent the widely acknowledged relationship between OC content of flooded soils and peak post-flooding MeHg levels across a wide range of values for OC, omitting wetlands because of the small fraction of the total area they represent.

Limited experimental data on MeHg production in wetlands suggests that the peak response may be comparable to the peak expected in the soils across the Muskrat Falls flooded area on average (St. Louis et al. 2004). Figure 2.1 reproduces Figure 1 from Calder et al. (2016) incorporating the wetland measurements from St. Louis et al. (2004). The data from St. Louis et al. (2004) suggests that it is reasonable to assume in Scenario "A" that the peak MeHg response from wetlands is comparable to the peak MeHg response in the non-wetland areas that account for the vast majority of site surface area.

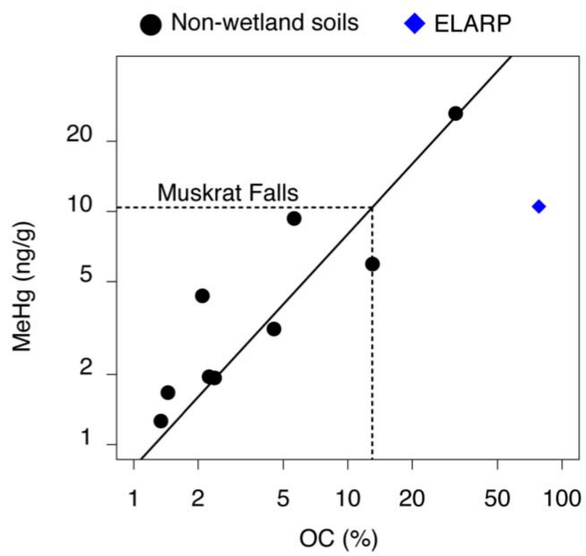

Fig. 2.1: Post-flooding peak soil MeHg v. soil OC for non-wetland sites as reported in Calder et al. (2016) with Experimental Lakes Area Reservoir Project data from St. Louis et al. (2004)

Therefore, Scenario "A" assumes removal of 0.8 km^2 from the area that contributes to post-flooding MeHg inputs using site-wide average values for OC and the associated peak soil MeHg forecasted by Calder et al. (2016).

Scenario "B" assumes removal of 10.3 km^2 of soil from the flooded area. Calder et al. (2016) forecasted post-flooding peak MeHg levels in the water column as a linear function of flooded area (among other variables). Based on this model, a reduction of 10.3 km^2 out of 41 km^2 assumed as a baseline design parameter would result in a proportionally smaller expected post-flooding impact as described in the memorandum submitted to the IEAC on February 13th, 2018 ("2/13 memo").

Table 2.1 below summarizes measured pre-flooding seasonal average and expected mean post-flooding MeHg levels in the aquatic environment for the baseline design parameters used in Calder et al. (2016) and for the hypothetical interventions made in Scenarios "A" and "B". This adds an evaluation of Scenario "A" to the table presented in the 2/13 memo.

Table 2.1: Pre-flooding seasonal average vs. post-flooding MeHg levels in lower Churchill River environment for baseline flooding parameters and for Scenarios “A” and “B”

Aquatic environment	Seasonal average MeHg (ng L^{-1})				Post-flooding MeHg reduction, vs. baseline	
	Pre-flooding	Baseline	Scenario A	Scenario B	Scenario A	Scenario B
Reservoir	n/a	0.22	0.22	0.17	2%	23%
River below Muskrat Falls	0.018	0.18	0.18	0.14	2%	23%
Lake Melville surface	0.017	0.043	0.043	0.037	2%	15%

3. MeHg exposure forecasts

The exposure model developed by Calder et al. (2016) has been re-run using the alternate parameter inputs summarized in Table 1.1 for the present-day, under post-flooding conditions assuming the original flooded area (“baseline”) and under the soil capping/removal scenarios “A” and “B” described in Table 2.1.

Alternative assumptions about habitat foraging and updated fish Hg data results in modestly reduced forecasts for peak post-flooding MeHg exposures among Lake Melville Inuit. For instance, Calder et al. (2016) forecasted a mean expected peak MeHg exposure increase of roughly 1.9x present-day exposures at the population-wide median level (i.e., half of increases are smaller than this and half are greater than or equal to this). Using the alternative model parameter inputs described in Table 1.1, this expected median increase is 1.6x present-day exposures. The parameter values retained by Calder et al. (2016) yield a mean expected peak MeHg exposure at the 95th percentile of the population of approximately 0.32 µg kg^{-1} day^{-1} (i.e., 95% of expected peak exposures are less than this). Using alternative model parameter inputs, the peak 95th percentile exposure is expected to be 0.28 µg kg^{-1} day^{-1}.

Scenario “A” has a negligible impact on exposure forecasts given the small impact on expected post-flooding peak MeHg levels in the water column. The effects of Scenario “B” using alternative model parameters are similar to those presented in the 2/13 memo. The exposures figure first presented in the 2/13 memo is updated and presented here as Figure 3.1.

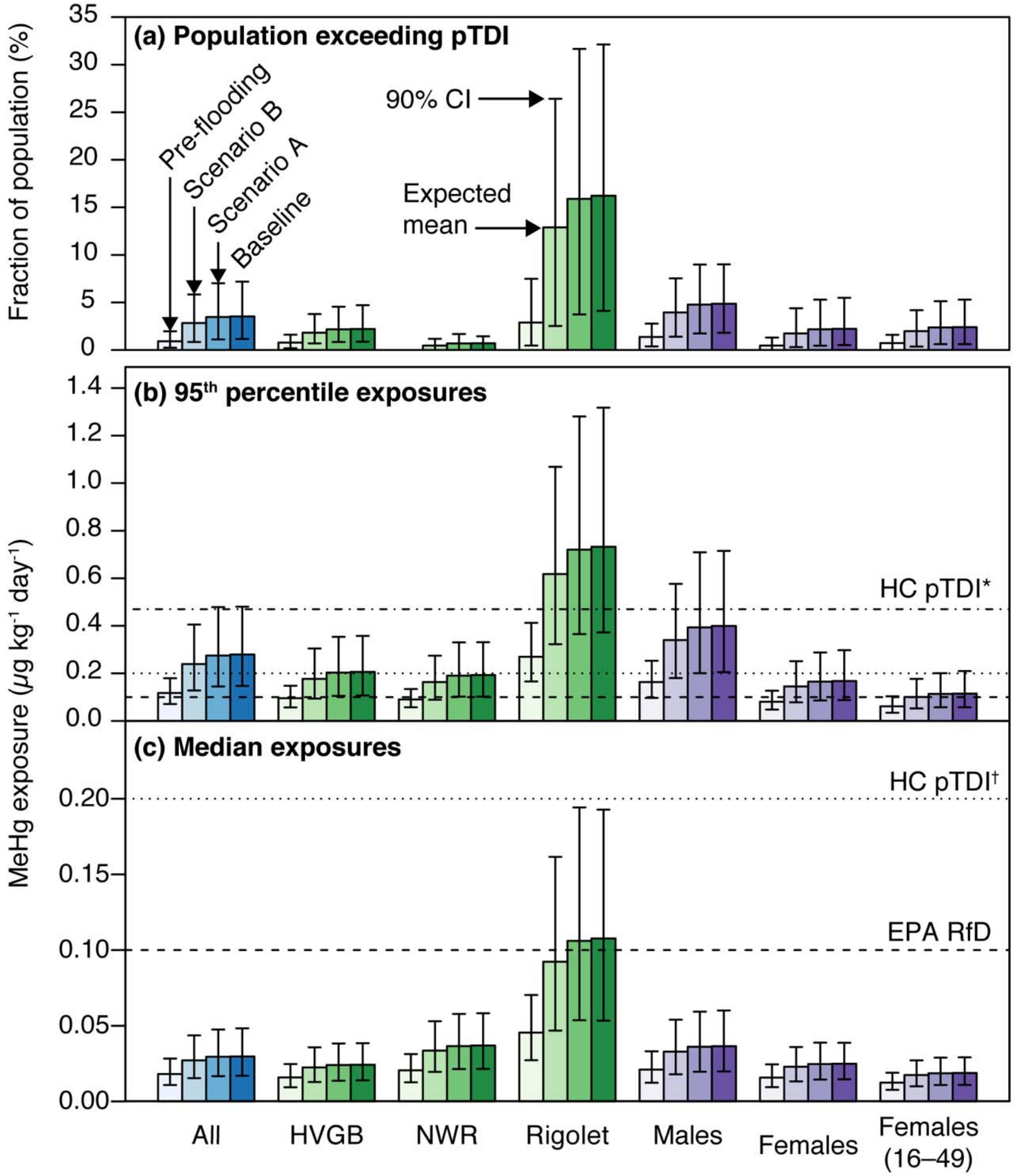

Figure 3.1: Impact of creation of Muskrat Falls reservoir using default design parameters ("Baseline") and under hypothetical remediation scenarios "A" and "B", as compared to measured pre-flooding conditions. Values presented for each scenario are the proportion of each demographic group exceeding Health Canada's pTDI levels (a), on the 95th percentile MeHg exposure in each demographic (b) and on median exposures in each demographic (c). Health Canada pTDI = 0.2 for women of childbearing age and children (†) and 0.47 for everyone else (*). HVGB = Happy Valley – Goose Bay (including Mud Lake), NWR = North West River.

4. References

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