RYAN S.D. CALDER

February 13th, 2018

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

Re: Effect of soil removal and capping on post-flooding MeHg concentrations in the lower Churchill River environment

Dear Dr. Reimer:

Please find attached an analysis of the impacts on post-flooding methylmercury (MeHg) concentrations and human exposures in the lower Churchill River environment further to two hypothetical soil removal/capping interventions proposed by the Independent Expert Advisory Committee (IEAC).

Do not hesitate to contact me if you require any clarification, or if you wish to schedule a presentation of these findings to the IEAC.

Sincerely,

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Encl.

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1 Introduction

Calder et al. (2016) forecasted post-flooding methylmercury (MeHg) concentrations in the Churchill River below Muskrat Falls and the low-salinity surface layer of Lake Melville relative to measured present-day seasonal average concentrations. This work assumed a flooded area of 41 km^2 (Nalcor Energy 2009) with surface soil organic carbon content of approximately 13% (ESDAC 2015).

The Independent Expert Advisory Committee (IEAC) has proposed two hypothetical interventions to reduce the production of MeHg following flooding of the Muskrat Falls hydroelectric reservoir:

A. Capping of fens and low-shrub bogs between 23.5 and 39 masl with organic carbon content (OC) <2%; and
B. Removal of all soils between 23.5 and 39 masl on land previously cleared of vegetation and accessible by roads and excluding slopes >30%, sensitive clays and riparian areas.

This analysis describes the impact of these interventions on post-flooding MeHg levels in the lower Churchill River environment and on human exposures relative to the baseline assumptions made by Calder et al. (2016), assuming all other factors are unchanged.

2 Scenario A: capping of wetlands

The IEAC provided four figures titled "Muskrat Falls – Ecological Land Classification – Wetlands" (1:50,000 scale) developed by Amec Foster Wheeler for Nalcor Energy. GIS analysis of these figures produces the wetland surface areas in Table 2.1.

Table 2.1: Targeted wetland surface area in Muskrat Falls reservoir area

Wetland type	Surface area (km^2)
Fen	0.229
Low shrub bog	0.127
Marsh	0.204
Unclassified	0.036

Scenario A contemplates capping fens and low shrub bogs, accounting for a total of 0.356 km^2, or roughly 0.9% of the total flooded area. The stated OC content of these particular wetlands, <2%, is <15% of the site-wide average considered by Calder et al. (2016).

Calder et al. (2016) considers that production of MeHg in the flooded reservoir is a function of, among other factors, surface area flooded and soil OC. Scenario A represents a small reduction in the surface area flooded (<1%), and this flooded surface area has substantially lower than average OC content (<15%). Furthermore, production of MeHg in flooded wetlands is known to be smaller than production in uplands with equal OC content due to likely sulfate-limitation in wetlands (Harmon et al. 2004; Hall et al. 2005; Jeremiason et al. 2006; Coleman Wasik et al. 2012). Together, these factors suggest that the intervention proposed in Scenario A would have a negligible impact on MeHg production in the Muskrat Falls reservoir relative to baseline parameters.

3 Scenario B: soil removal

Soils targeted for removal in Scenario B cover 10.3 km^2 ("Removal Scenario B_land area per ELC.xlsx"). A proposed removal depth of 50 cm would remove the vast majority of labile OC thereby effectively eliminating MeHg production potential over this surface area. Because no specific information is available on OC content of the soils targeted here relative to the site-wide average, they are assumed to have the same average OC content as the site as a whole.

Figure 3.1 illustrates the response of aquatic MeHg concentrations in the lower Churchill River environment as a function of area flooded, relative to measured seasonal averages, using the model developed by Calder et al. (2016). Values are plotted for the baseline assumptions made by Calder et al. (2016) and for the hypothetical intervention contemplated by Scenario B.

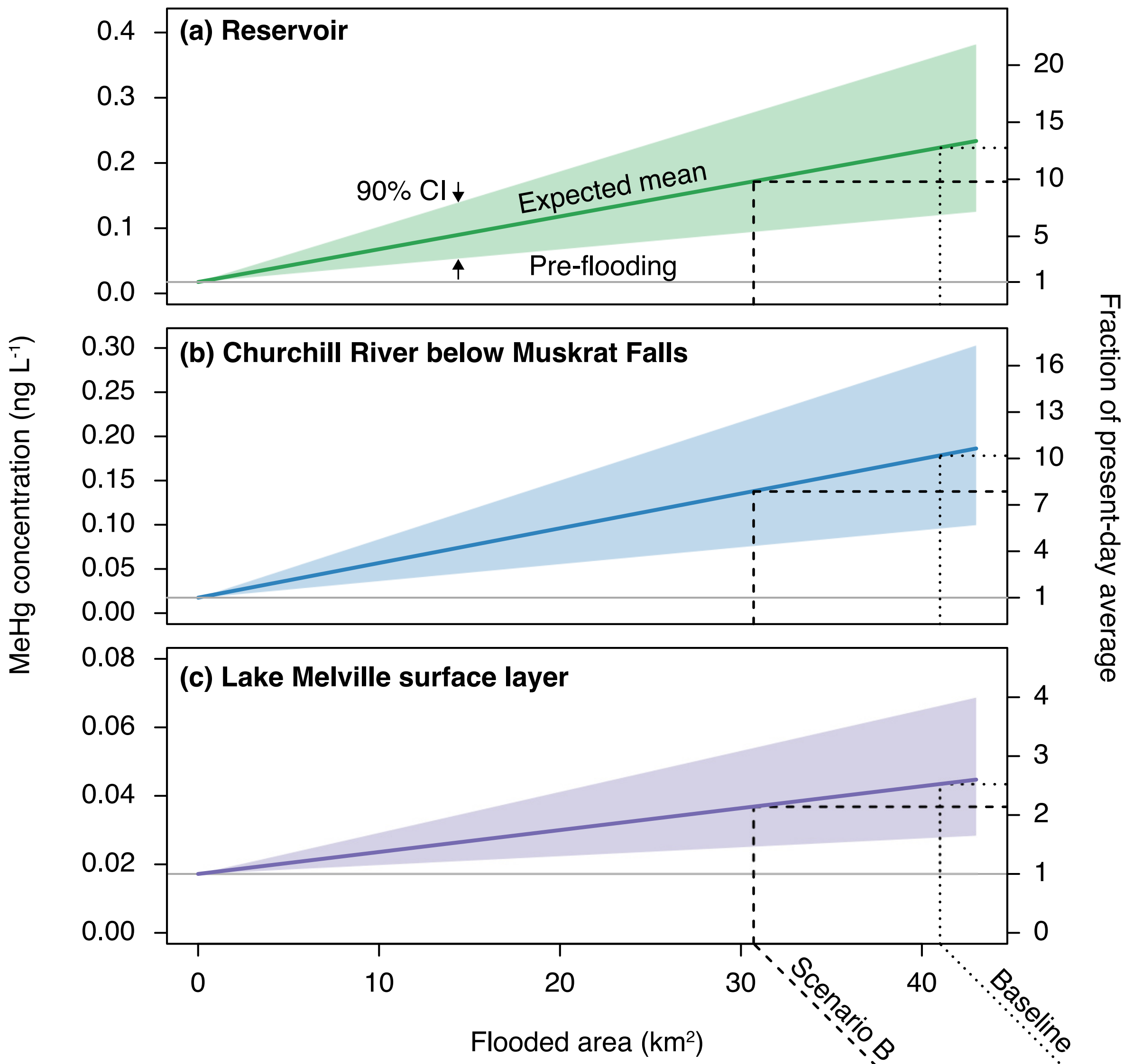

Figure 3.1: Post-flooding MeHg production as a function of flooded area for Muskrat Falls reservoir (a), the Churchill River below Muskrat Falls (b) and the surface layer of Lake Melville (c). Expected mean and 90% confidence interval of post-flooding MeHg levels are shown and result from probabilistic modeling described by Calder et al. (2016). Hatched lines demonstrate the effect of the Scenario B intervention relative to the baseline parameters considered by Calder et al. (2016). Effect of flooding is compared to easured pre-flooding seasonal averages in grey.

Soil removal carried out under Scenario B would reduce peak MeHg levels in the lower Churchill River environment relative to the baseline parameters by 23% in the reservoir and river below Muskrat Falls and 15% in the surface layer of Lake Melville, as summarized in Table 3.1.

Table 3.1: Pre-flooding seasonal average vs. post-flooding MeHg levels in lower Churchill River environment for baseline flooding parameters and for Scenario B

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

Calder et al. (2016) forecasted the effects of environmental MeHg increases on Inuit MeHg exposures based on a baseline MeHg exposure assessment and dietary survey that enrolled 1,145 Inuit and their families from Happy Valley – Goose Bay, North West River and Rigolet. This modeling framework can be adapted to explore the effect of reducing the increases of MeHg inputs into the Churchill River following development of the Muskrat Falls reservoir as outlined above.

Scenario B would reduce exposure increases following flooding and reduce the proportion of the population expected to exceed regulatory references doses relative to the baseline reservoir design considered by Calder et al. (2016). For example, median MeHg exposures are projected to increase from roughly 0.018 $\mu g\ kg^{-1}\ day^{-1}$ at present day to 0.035 $\mu g\ kg^{-1}\ day^{-1}$ after flooding, assuming no change to diet. Under Scenario B, this modeling framework suggests the new population-wide median would be approximately 0.031 $\mu g\ kg^{-1}\ day^{-1}$. Human exposures vary sublinearly with respect to the magnitude of MeHg fluxes in the reservoir because a large proportion of MeHg exposures derive from species that forage substantially in the marine or estuarine environment (e.g., salmon) and whose MeHg levels are influenced less by reservoir creation than substantially riverine species.

Figure 3.2 presents modeling estimates for the proportion of the Lake Melville Inuit population exceeding Health Canada provisional tolerable daily intake (pTDI) levels (0.2 $\mu g\ kg^{-1}\ day^{-1}$ for women of childbearing age and children and 0.47 $\mu g\ kg^{-1}\ day^{-1}$ for everyone else) (Health Canada 2004), for median MeHg exposures and for the 95th percentile exposures. The probabilistic modeling approach developed by Calder et al. (2016) allows for expected mean modeling estimates and a statistical confidence interval around this estimate to be expressed for these quantities, as presented in Figure 3.2. These values are presented for the pre-flooding condition, for the projected peak using baseline reservoir design plans as described above and under Scenario B, each for various segments of the Lake Melville Inuit population.

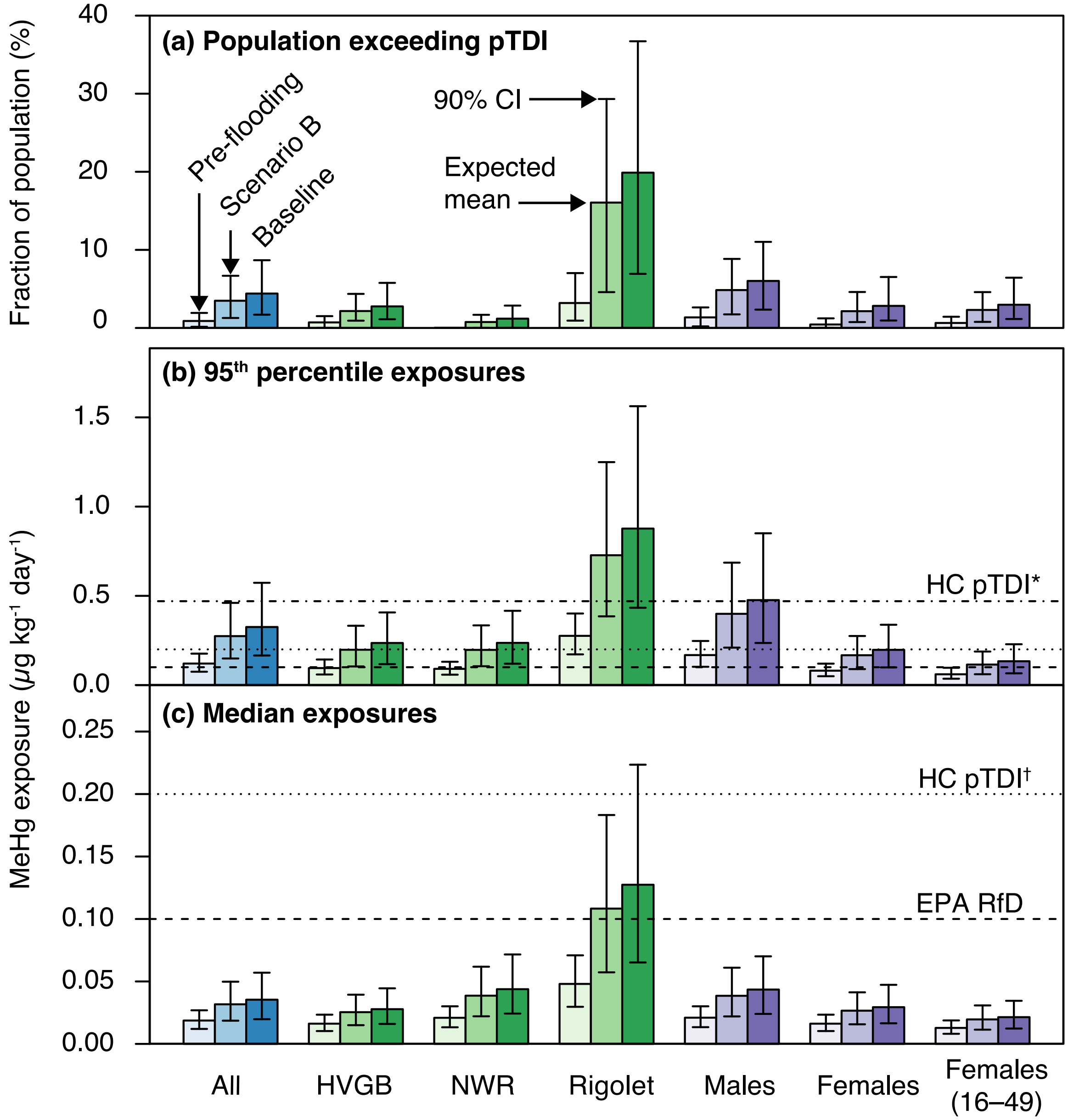

Figure 3.2: Impact of creation of Muskrat Falls reservoir under baseline parameters and under Scenario B, as compared to measured pre-flooding conditions, on the proportion of the population exceeding Health Canada's pTDI levels (a), on the 95th percentile MeHg exposures (b) and on median exposures (c) for various demographics. 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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