

# Geological controls concerning mercury accumulations in stream and lake sediments across Canada



Natural Resources Canada / Ressources naturelles Canada

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**Abstract.** This poster displays the open-file data of the Geological Survey of Canada (GSC) for the total mercury (THg) concentrations in stream and lake sediments ( $n = 142,000$ ) across Canada. These concentrations vary widely from 5 to 10,000 ppb, with regional averages varying from 29 (central Nunavut) to 165 ppb (Vancouver Island, BC). These variations are due to:

- geogenic Hg sources that are further enhanced in areas subject to past and current mining activities, especially in the Selwyn Basin (Yukon), Central Quebec, and southwestern Nova Scotia; elsewhere, geogenic sources are more scattered; at and near mining activities, THg concentrations tend to vary from 1,000 to 10,000 ppb;
- THg in sediments correlates well with other base metals such as Cu, Ag, and Zn, but correlates more strongly with LOI owing to the strong affinity between organic matter and Hg;
- as a result, biological sequestration of atmospheric Hg increases with increased presence of vegetation as it ranges from none on ice fields to low on barren rocks, intermediate on grass and lichens covered fields, to high in forested areas; hence, atmospheric Hg sequestration is prominent along the southern regions of Canada, with the alpine icefields in British Columbia being the main exception;
- mineral and organically bound Hg is partially released from sediments while in transit from uplands to lowlands and subject to sunlight exposure;
- wetlands in upland areas retain sediment-bound Hg.

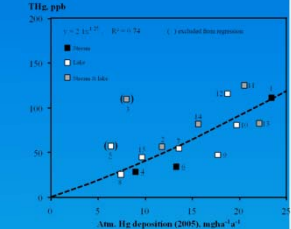
## Methodology

Lake sediments were retrieved via helicopter at or near lake centers, coring the top 30 cm and discarding the top 10 cm portion. Stream sediments were retrieved via helicopter or road access, using the available sediment from a particular location within the water-filled channel. Stream and lake morphological parameters were ascertained numerically (depth, channel width) and categorically (stream order, channel network morphology). Sediment attributes referring to colour and texture were also noted. Sediments were examined for (i) most metals using atomic absorption and/or inductively coupled plasma spectrophotometry, (ii) THg was determined using cold-vapor atomic fluorescence spectrometry, (iii) sample were also analyzed for pH and LOI (loss on ignition). Sampling locations were recorded. The resulting THg values were mapped by survey area, and were overlaid on the national digital elevation model (DEM, 300 m resolution) and water atlas. Both data layers were used for the upland/lowland delineation, with the latter set to be <4m in elevation away from the nearest open water sources.

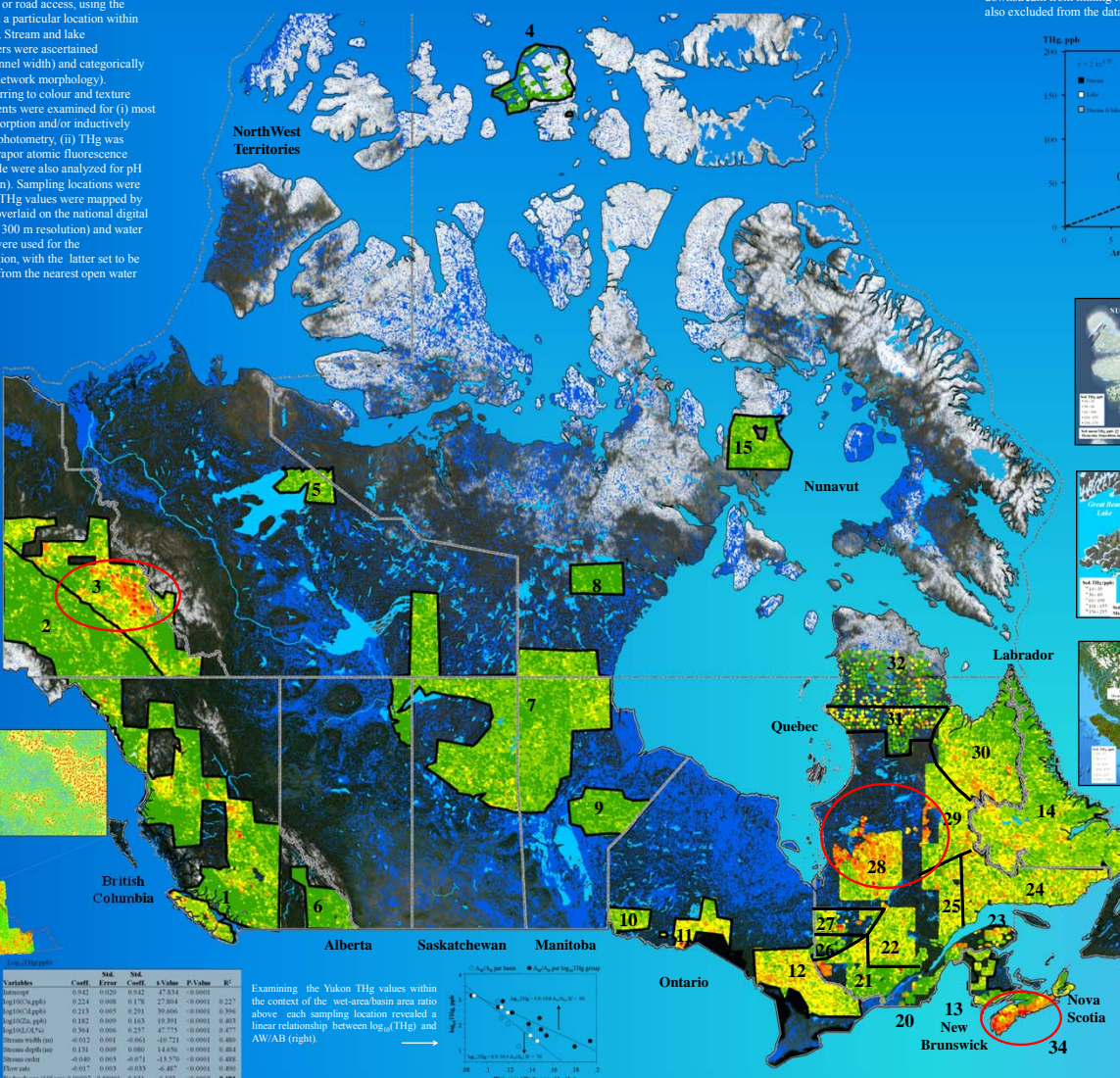
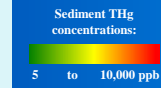
## Map of Canada, showing overlays of:

- the Hg concentration data compiled within the open file system of the Geological Survey of Canada, by survey region (numbered); top layer;
- lowlands < 4m from shorelines (ocean, lakes, river, major streams), in blue; intermediate layer;
- extent of vegetation cover from none (white) to barren and grasslands (light to dark brown) to forests (dark); lowest layer.

**Plotting mean THg by GSC survey zone versus the 2005 GRAHM-projections for wet and dry atmospheric Hg deposition (c/o D. Ashford, Env. Canada).** Zones with major trace element occurrences (3, 5) and locations downstream from mining locations with THg > 1500 ppb are also excluded from the data.

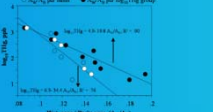


The above satellite images for GSC survey zones 1, 4, 5, and 6 show (i) how THg in lake and/or stream sediments drop on land covered by barrens and permanent to seasonal ice, and (ii) the extent of geogenic 'salt & pepper' control on THg in the metal-rich region north-east of Great Bear Lake.



**Yukon:** examining the stream sediments within the Selwyn Basin revealed strong correlations between  $\log_{10}(\text{THg})$  and other metals as well as LOI, and stream morphology and bedrock type to a lesser extent (right).

**Examining the Yukon THg values within the context of the wet-area/basin area ratio above each sampling location revealed a linear relationship between  $\log_{10}(\text{THg})$  and AW/AB (right).**



## Summary table: THg concentrations in lakes and streams, uplands versus lowlands, by survey region

Survey zone	Terrain	THg in lake sediments, ppb				THg in stream sediments, ppb				Lakes versus streams					
		n	Mean	Std. dev.	Std. err. C.I. diff. P-value*	n	Mean	Std. dev.	Std. err. C.I. diff. P-value*	C.I. diff. P-value*					
Vancouver Island, British Columbia (1)	Upland	-	-	-	-	2,448	179.4	500.4	101	-	-				
Selwyn, Ontario (11)	Upland	5,735	132.8	100.8	1.3	4.3	<0.001	117	42.4	36.7	3.4	11.0	0.000	18,297	<0.001
New Brunswick (13)	Upland	299	128.9	41.9	2.4	-	-	-	-	-	-	-	-	-	-
Yukon, East (3)	Upland	72	123.2	111.3	15.1	47.8	<0.001	9,557	142.7	153.4	1.6	7.7	<0.001	35,501	0.56
Yukon, West (2)	Upland	24	105.8	66.7	13.6	-	-	-	-	-	-	-	-	-	-
Ontario, Central (12)	Upland	2,263	123.1	61.8	1.3	4.6	<0.001	-	-	-	-	-	-	-	-
British Columbia, West & North, Yukon, West (2)	Upland	542	103.5	75.1	3.1	12.3	0.0004	31,550	58.9	128.5	0.7	3.3	0.007	10,798	<0.001
Labrador (14)	Upland	5,506	80.0	52.1	0.7	1.8	<0.001	1,116	32.6	35.2	0.9	5.4	0.039	8,732	<0.001
Ontario, West (10)	Upland	966	59.7	36.7	1.2	4.2	<0.001	-	-	-	-	-	-	-	-
North-West Territories, Great Bear Lake, Northeast (5)	Upland	163,391	58.3	33.7	0.3	-	-	-	-	-	-	-	-	-	-
Boreal Plains (7)	Upland	15,193	58.5	32.4	0.3	0.7	<0.001	-	-	-	-	-	-	-	-
Oxford House, Manitoba (9)	Upland	48.9	29.6	0.8	1.3	<0.001	-	-	-	-	-	-	-	-	-
Repulse Bay Peninsula, Nunavut (5)	Upland	1,539	44.7	19.8	0.5	1.9	0.070	-	-	-	-	-	-	-	-
Baker Lake, Nunavut (8)	Upland	686	25.9	16.7	0.6	2.0	<0.001	-	-	-	-	-	-	-	-
British Columbia, East (6)	Upland	-	-	-	-	-	-	3,032	35.7	44.9	0.8	4.7	0.720	-	-
Bathurst Island, Nunavut (4)	Upland	-	-	-	-	-	-	311	25.7	16.4	0.9	-	-	-	-
Zones with lake & stream data	Upland	20,437	100.9	76.5	0.5	1.90	<0.001	48,367	71.7	131.7	0.6	2.7	<0.001	1.9	<0.001
All zones	Upland	31,701	63.7	45.1	0.7	-	-	12,311	64.5	126.1	2.6	-	-	2.1	<0.001
Total	Upland	75,479	73.7	47.7	0.7	-	-	66,158	72.3	137.5	1.6	-	-	2.9	<0.001

The tables on the left and right show details about THg in lake and streams by upland and lowland location across Canada, and in Quebec in particular. There are clear trends with

THg (lakes)  $\approx$  1.41 THg (streams),

THg (upland lakes)  $\approx$  1.27 THg (lowland lakes),

and

THg (upland streams)  $\approx$  1.15 THg (lowland streams).

These trends may be due to (i) differences between lake versus stream sediments sampling (recent stream sediments versus older lake sediments), (ii) more anoxic conditions and higher Hg-binding S contents in lake sediments, (iii) lake sediments would contain highly organic matter, with the humification process concentrating more and more Hg on less organic matter. Across Quebec, THg (upland streams)  $\approx$  1.08 THg (lowland streams) but this ratio varies by survey zone from 1.06 to 1.65. For Nova Scotia (details not shown), THg concentrations vary from 10 to 10,000 ppb, with the largest values at and near abandoned gold mines.

**Summary.** This poster and the article referred to below indicate that THg concentrations in lake and stream sediments vary widely across Canada,

**References**  
M. Nasr, J. Ogilvie, A. M. Castonguay, A. Rencz, P. A. Arp. 2011. Total Hg concentrations in stream and lake sediments: Discerning geospatial patterns and controls across Canada. Applied Geochemistry, in print.

## Quebec GSC THg survey data

Survey area	n	THg (ppb)	THg (ppb) ratio
Abitibi, Pontiac, A (26)	5,717	79	2,799
Abitibi, Pontiac, B (27)	173	102	110
Appalaches, A (20)	2,910	89	780
Appalaches, B (24)	7,229	149	727
Chaudière, A (30)	14,159	123	5,394
Genesville, A (21)	10,245	154	3,107
Genesville, B (22)	6,474	92	1,997
Genesville, C (25)	5,606	95	1,067
Genesville, D (24)	14,547	112	2,824
Minto, Bécancour, Ashmun, A (29)	4,530	112	2,611
Minto, Bécancour, Ashmun, B (31)	1,059	81	300
Optica, La Grande, Opéme, Nonville (25)	8,330	205	4,828
Plate-forme	30	16	27
Total	80,329	126	26,319