



Keeyask Generation Project Environmental Impact Statement

Supporting Volume Aquatic Environment



June 2012

APPENDIX 2I

SUPPLEMENTARY SEDIMENT QUALITY TABLES



2I.1 REFERENCES

2I.1.1 LITERATURE CITED

- Bodaly, R.A., Strange, N.E., Hecky, R.E., Fudge, R.J.P., and Anema, C. 1987. Mercury content of soil, lake sediment, net plankton, vegetation, and forage fish in the area of the Churchill River Diversion, Manitoba, 1981-1982. Canadian Data Report of Fisheries and Aquatic Sciences 610: 30 pp.
- MWS. 2011. Manitoba Water Quality Standards, Objectives, and Guidelines. Water Science and Management Branch, MWS. MWS Report 2011-01, November 28, 2011. 67 pp.
- Persaud, D., Jaagumagi, R., and Hayton, A. 1993. Guidelines for the protection and management of aquatic sediment quality in Ontario. ISBN 0-7729-9248-7. Ontario Ministry of the Environment, Water Resources Branch, Toronto, ON. 27 pp.
- Williamson, D.A. 1980. Heavy metal concentrations in northern Manitoba lake and river sediments, August 1979. Department of Consumer & Corporate Affairs & Environment, Environmental Management Division, Environmental Control Branch, Water Pollution Control, Winnipeg, MB.
- Williamson, D.A. 1986. Mercury in water and sediments in the Churchill and Nelson rivers, Manitoba, Canada. Water Standards and Studies Report 86-3. Manitoba Environment and Workplace Safety and Health, Winnipeg, MB.

Table 2I-1: Heavy metal concentrations in northern Manitoba lake and river sediments, August 1979 (Williamson 1980)

Site ID	Location	Latitude (deg min)	Longitude (deg min)	Depth of Sediment (cm)	Copper (µg/g d.w.)		Zinc (µg/g d.w.)		Cadmium (ug/g d.w.)		Nickel (µg/g d.w.)		Lead (µg/g d.w.)		Mercury ¹ (µg/g w.w.)		Mercury ² (µg/g d.w.)	
					Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
WQ050	Footprint Lake at Nelson House	55 46	98 54	1-3	34.0	0.0	123.0	4.6	3.0	0.0	70.0	0.0	32.0	0.0	0.04	0.006	0.08	0.0
WQ385	Churchill River at Granville Lake	56 08	100 30	1-3	5.0	0.0	28.0	0.0	1.0	0.0	10.0	0.0	5.3	0.0	0.02	0.005	0.02	0.0
WQ419	Snake Lake near outlet	56 36	101 36	1-3	92.6	58.5	200.0	89.3	4.0	0.0	19.3	1.15	35.0	8.18	0.03	0.01	0.29	0.07
WQ095	Coheram Lake near center of lake	56 50	101 53	1-3	426.7	55.0	121.3	5.9	2.0	0.0	616.7	104.1	21.0	0.0	0.02	0.005	0.08	0.03
WQ389	Barrington River upstream of Opachuanau Lake	56 45	99 58	1-3	33.3	1.5	136.0	3.0	2.0	0.0	68.0	0.0	32.0	0.0	0.03	0.0	0.07	0.005
WQ098	Rusty Lake near outlet	56 35	99 38	1-3	37.3	0.58	130.0	1.7	2.8	0.3	65.0	5.0	26.0	0.0	0.02	0.0	0.07	0.01
WQ418	Rusty Lake near Vermillion River inlet	56 34	99 35	1-3	27.0	1.7	108.3	9.2	2.0	0.0	45.0	0.0	21.0	0.0	0.02	0.005	0.07	0.00
WQ051	Southern Indian Lake at settlement	56 46	98 57	1-3	34.0	1.0	108.3	4.6	2.0	0.0	61.7	2.9	26.0	0.0	0.02	0.0	0.05	0.005
WQ047	Split Lake near community	56 14	96 05	1-3	22.0	2.0	67.3	5.7	2.0	0.0	55.3	4.6	31.7	11.5	0.02	0.0	0.04	0.005
WQ422	Apussigamasi Lake near inlet	54 49	97 42	1-3	25.3	1.2	80.0	1.7	2.0	0.0	83.0	0.0	20.0	0.0	0.02	0.005	0.04	0.00
WQ093	Burntwood River at Thompson (Float plane base)	55 45	97 50	1-3	10.0	-	33.0	-	1.0	-	36.0	-	10.0	-	0.02	-	0.02	-
WQ087	Schist Lake - south end	54 38	101 17	1-3	2833.3	305.5	60333.3	11547.0	252.0	72.0	69.3	4.6	216.7	5.8	0.06	0.02	0.24	0.06
WQ088	Athapuskow Lake at Bakers Narrows	54 40	101 40	1-3	125.3	25.4	1053.3	151.8	5.8	0.7	33.0	0.0	69.0	12.8	0.05	0.005	0.15	0.35
WQ421	Reed Lake - northeast area	54 40	100 17	1-3	36.7	1.5	126.0	11.5	1.2	0.0	50.0	0.0	20.7	1.2	0.02	0.005	0.09	0.02
WQ381	Wekusko Lake at Grass River Falls	54 48	99 57	1-3	4.3	0.6	21.0	1.7	1.0	0.0	11.0	0.0	5.0	0.0	0.01	0.0	-	-
WQ382	Wekusko Lake at Anderson Bay	54 49	99 57	1-3	25.0	10.6	84.0	30.3	1.2	0.0	39.7	18.9	17.3	6.4	0.03	0.005	0.07	0.017
WQ420	Wekusko Lake at Herb Bay	54 52	99 51	1-3	43.3	2.1	211.3	25.0	2.0	0.0	61.7	2.1	37.7	2.5	0.03	0.005	0.10	0.01
WQ413	Herblet Lake in West Bay	54 55	100 00	1-3	51.7	6.5	157.7	18.5	1.0	0.0	50.0	0.0	20.0	0.0	0.01	0.0	-	-
WQ362	Upper Ospwagan Lake - centre	55 32	98 05	1-3	34.7	3.5	283.3	50.3	2.0	0.0	69.3	5.1	38.3	4.7	0.02	0.005	0.04	0.01
WQ442	Cross Lake at settlement	54 37	97 47	1-3	24.0	1.0	174.3	43.7	2.0	0.0	48.7	1.15	40.0	5.0	0.02	0.0	0.04	0.0
WQ049	Nelson River at Norway House	53 59	97 50	1-3	17.7	1.5	230.0	22.9	1.0	0.0	35.3	2.5	26.0	1.7	0.02	0.0	0.03	0.005
WQ161	Cedar Lake at Oleson Point	53 20	100 12	1-3	28.0	1.7	167.0	13.1	1.7	0.3	47.0	1.7	37.7	2.5	0.03	0.0	0.07	0.005
WQ160	Moose Lake at settlement	53 43	100 17	1-3	18.0	-	103.0	-	1.5	-	35.0	-	28.0	-	0.03	-	0.05	-
WQ384	Saskatchewan River at The Pas	53 51	101 10	1-3	4.0	0.0	140.0	12.6	1.0	0.0	13.0	0.0	12.3	2.5	0.01	0.005	-	-
Manitoba Sediment Quality Guidelines (MWS 2011)	SQG PEL				35.7 197		123 315		0.6 3.5				35.0 91.3				0.17 0.486	
Ontario SQG (Persaud <i>et al.</i> 1993)	LEL SEL										16 75							

1. Wet weight.
2. Dry weight.

Table 2I-2: Mercury in sediments in northern Manitoba, Canada (Williamson 1986)

Site ID	Location	Latitude (deg min)	Longitude (deg min)		Total Mercury (ug/g d.w.)				
					1979	1980	1981	1982	1983
WQ385	Churchill River at Granville Lake	56 08	100 30	Replicate 1	<0.02	0.02	<0.04	<0.03	<0.03
				Replicate 2	0.02	0.03	0.03	-	<0.04
				Replicate 3	0.02	0.03	<0.04	-	<0.04
				Mean	0.02	0.03		-	<0.04
WQ389	Barrington River upstream of Opachuanau Lake	56 45	99 58	Replicate 1	0.07	0.06	0.07	<0.05	<0.06
				Replicate 2	0.06	0.07	0.07	-	<0.05
				Replicate 3	0.07	0.09	<0.04	-	0.05
				Mean	0.07	0.07		-	
WQ051	Southern Indian Lake at settlement	56 46	98 57	Replicate 1	0.05	0.04	<0.03	<0.04	<0.04
				Replicate 2	0.05	0.05	<0.04	-	<0.04
				Replicate 3	0.04	0.06	<0.04	-	<0.04
				Mean	0.05	0.05		-	<0.04
WQ050	Footprint Lake at Nelson House	55 46	98 54	Replicate 1	0.08	0.07	0.06	<0.03	<0.04
				Replicate 2	0.08	0.09	0.06	-	<0.04
				Replicate 3	0.08	0.07	<0.04	-	<0.03
				Mean	0.08	0.08		-	<0.04
WQ093	Burntwood River at Thompson (Float plane base)	55 45	97 50	Replicate 1	0.02	-	<0.03	<0.03	<0.03
				Replicate 2	-	-	<0.03	-	<0.03
				Replicate 3	-	-	<0.03	-	<0.03
				Mean	-	-		-	<0.03
WQ422	Apussigamasi Lake near inlet	54 49	97 42	Replicate 1	0.04	0.04	<0.03	<0.04	<0.03
				Replicate 2	0.04	0.03	<0.03	-	<0.03
				Replicate 3	0.04	0.04	<0.03	-	<0.03
				Mean	0.04	0.04		-	<0.03
WQ047	Split Lake near community	56 14	96 05	Replicate 1	0.03	0.04	<0.03	<0.04	<0.04
				Replicate 2	0.04	0.04	<0.03	-	<0.04
				Replicate 3	0.04	0.05	<0.03	-	<0.04
				Mean	0.04	0.04		-	<0.04
WQ049	Nelson River at Norway House	53 59	97 50	Replicate 1	0.03	0.03	0.03	0.06	<0.06
				Replicate 2	0.04	0.04	0.05	-	<0.07
				Replicate 3	0.03	0.04	0.05	-	<0.05
				Mean	0.03	0.04		-	<0.07
WQ442	Cross Lake at settlement	54 37	97 47	Replicate 1	0.04	0.05	<0.03	0.06	<0.09
				Replicate 2	0.04	0.04	0.06	-	<0.04
				Replicate 3	0.04	0.04	0.03	-	<0.04
				Mean	0.04	0.04		-	<0.09
WQ048	Sipiwesk Lake near outlet	55 13	97 20	Replicate 1	-	0.02	<0.03	<0.03	<0.04
				Replicate 2	-	0.03	<0.03	-	<0.04
				Replicate 3	-	0.03	<0.03	-	<0.04
				Mean	-	0.03	<0.03	-	<0.04
Manitoba Sediment Quality Guidelines SQG								0.17	
(MWS 2011) PEL								0.486	

Table 2I-3: Mean and standard error (SE) of metals from triplicate surficial sediment quality samples (upper 5 cm) collected at selected sites along the Burntwood River system in 2001 and 2002 and comparisons to sediment quality guidelines. Means indicated in blue and red exceed Manitoba sediment quality guidelines (SQGs) and probable effect levels (PELs) for sediments, respectively (MWS 2011). Means indicated in blue and red italics exceed the Ontario lowest effect level (LEL) and the severe effect level (SEL) for sediments, respectively (Persaud *et al.* 1993)

Sample Location		Year	Trace Metal Concentration (µg/g d.w.)															
			Aluminum	Arsenic	Barium	Beryllium	Boron	Bismuth	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury
Notigi Control Structure	Mean	2001	22,900	3.24	169	1.16	5.5	0.36	0.23	9,187	52.0	18.3	30.7	33,200	16.2	11,367	869	0.03
	SE		416	0.32	2	0.03	0.6	0.02	0.05	727	0.3	0.5	1.1	1,060	0.5	384	67	0.01
Wapisu Lake	Mean	2001	22,667	3.92	183	1.08	5.5	0.35	0.20	6,487	52.9	16.5	27.0	37,533	14.3	11,333	2,093	0.04
	SE		433	0.10	1	0.03	0.2	0.01	0.01	260	0.8	0.3	0.5	751	0.4	120	70	0.00
Wuskwatim Lake	Mean	2001	16,033	2.57	143	0.73	7.3	0.26	0.18	28,067	50.5	13.8	26.1	28,967	11.5	21,400	1,353	0.03
	SE		384	0.04	2	0.00	0.3	0.01	0.00	1,822	1.1	0.1	1.8	285	0.1	58	43	0.00
	Mean	2002	19,667	3.78	187	0.88	0.3	6.40	0.22	16,533	59.0	16.5	26.2	32,400	14.4	19,000	1,287	0.04
	SE		633	0.74	19	0.02	0.0	0.26	0.02	1,568	2.1	0.6	0.6	751	0.3	702	197	0.00
Burntwood River (Taskinigup Falls)	Mean	2002	16,967	12.79	116	0.71	5.2	0.22	0.17	11,667	42.7	11.7	26.7	25,367	12.3	12,033	389	0.03
	SE		219	8.25	1	0.00	0.6	0.00	0.01	426	0.4	0.0	1.0	219	1.2	145	7	0.01
Opegano Lake	Mean	2001	14,767	3.02	116	0.72	8.4	0.21	0.16	40,167	44.1	12.7	31.1	26,333	10.7	14,367	664	< 0.02
	SE		2,436	0.54	14	0.12	0.8	0.02	0.04	18,143	6.8	1.5	5.7	5,556	1.1	1,962	100	-
	Mean	2002	16,800	7.07	729	0.72	5.5	0.23	0.24	36,867	41.6	18.9	28.0	33,000	10.9	19,300	7,909	< 0.02
	SE		987	1.73	511	0.04	0.5	0.02	0.09	3,212	2.4	4.4	0.9	2,982	0.3	1,069	5,546	-
Birch Tree Lake	Mean	2002	11,800	2.80	91	0.51	0.1	5.00	0.10	18,400	38.2	11.0	19.9	19,000	7.9	15,067	610	< 0.02
	SE		1,026	0.06	8	0.04	0.0	0.32	0.01	907	2.2	0.8	1.9	1,735	0.6	376	55	-
Manitoba Sediment Quality Guidelines	SQG			5.9							37.3			35.7				0.17
	PEL			17							90			197		91.3		0.486
Ontario Sediment Quality Guidelines	LEL													20,000			460	
	SEL													40,000			1,100	

Table 2I-3: Mean and standard error (SE) of metals from triplicate surficial sediment quality samples (upper 5 cm) collected at selected sites along the Burntwood River system in 2001 and 2002 and comparisons to sediment quality guidelines. Means indicated in blue and red exceed Manitoba sediment quality guidelines (SQGs) and probable effect levels (PELs) for sediments, respectively (MWS 2011). Means indicated in blue and red italics exceed the Ontario lowest effect level (LEL) and the severe effect level (SEL) for sediments, respectively (Persaud *et al.* 1993)

Sample Location	Year	Trace Metal Concentration (µg/g d.w.)													
		Molybdenum	Nickel	Potassium	Selenium	Silver	Sodium	Strontium	Thallium	Tin	Titanium	Uranium	Vanadium	Zinc	
Notigi Control Structure	Mean	2001	0.31	<i>38.4</i>	4,833	0.2	< 1	207	30.0	0.4	< 4	1,477	1.58	48.7	88
	SE		0.01	0.8	37	0.1	-	12	2.3	0.0	-	60	0.04	1.3	4
Wapisu Lake	Mean	2001	0.30	<i>39.6</i>	5,027	0.1	< 1	217	27.6	0.4	< 4	1,490	1.87	46.9	85
	SE		0.01	0.5	84	0.0	-	5	0.6	0.0	-	15	0.06	0.8	3
Wuskwatim Lake	Mean	2001	0.46	<i>40.1</i>	3,863	< 0.1	< 1	207	29.8	0.3	< 4	1,357	1.06	42.6	69
	SE		0.18	1.3	35	-	-	2	0.8	0.0	-	26	0.01	0.6	1
	Mean	2002	0.28	<i>44.2</i>	4,780	< 0.1	< 1	231	29.0	0.4	< 4	1,473	1.44	49.9	83
	SE		0.00	1.3	150	-	-	7	0.7	0.0	-	29	0.07	1.7	2
Burntwood River (Taskinigup Falls)	Mean	2002	0.30	<i>35.1</i>	3,457	< 0.1	< 1	211	24.3	0.3	< 4	1,153	1.63	33.9	64
	SE		0.01	0.3	47	-	-	12	0.9	0.0	-	9	0.03	0.4	0
Opegano Lake	Mean	2001	0.76	<i>37.6</i>	3,300	0.2	< 1	205	39.1	0.2	< 4	987	1.20	35.9	67
	SE		0.22	6.0	555	0.1	-	30	9.7	0.0	-	108	0.12	3.9	9
	Mean	2002	0.52	<i>38.6</i>	3,877	< 0.1	< 1	237	48.5	0.4	< 4	1,071	1.49	37.7	62
	SE		0.14	1.6	254	-	-	15	7.5	0.1	-	45	0.05	1.0	3
Birch Tree Lake	Mean	2002	0.24	<i>39.6</i>	2,650	< 0.1	< 1	173	22.4	< 0.2	< 4	822	0.85	28.4	43
	SE		0.05	1.2	227	-	-	11	1.5	-	-	63	0.04	1.8	4
Manitoba Sediment Quality Guidelines	SQG														123
	PEL														315
Ontario Sediment Quality Guidelines	LEL			<i>16</i>											
	SEL			<i>75</i>											

Table 2I-4: Mercury content of sediment in northern Manitoba lakes Manitoba, 1981 (Bodaly *et al.* 1987)

Site ID	Location/Area	Depth of Sediment (cm)	Method of collection	Total Mercury ($\mu\text{g/g d.w.}$)		
				Mean	n	SD
5	Southern Indian Lake Area (SIL) 5	approx. 4.7 cm	Ekman Dredge, six replicates	0.017	6	0.004
4	SIL Area 4	approx. 4.7 cm	Ekman Dredge, six replicates	0.009	6	0.002
SA	SIL Sandhill Bay	approx. 4.7 cm	Ekman Dredge, six replicates	0.014	6	0.002
WB	SIL Wapuw Bay	approx. 4.7 cm	Ekman Dredge, six replicates	0.053	6	0.006
6	SIL Area 6	approx. 4.7 cm	Ekman Dredge, six replicates	0.045	6	0.004
I	Issett Lake	approx. 4.7 cm	Ekman Dredge, six replicates	0.050	6	0.010
G	Granville Lake	approx. 4.7 cm	Ekman Dredge, six replicates	0.024	6	0.017
WM	West Mynarski Lake	approx. 4.7 cm	Ekman Dredge, six replicates	0.058	6	0.013
CM	Central Mynarski Lake	approx. 4.7 cm	Ekman Dredge, six replicates	0.015	6	0.010
EM	East Mynarski Lake	approx. 4.7 cm	Ekman Dredge, six replicates	0.020	6	0.003
NW	Notigi Lake, west basin	approx. 4.7 cm	Ekman Dredge, six replicates	0.028	6	0.019
NE	Notigi Lake, east basin	approx. 4.7 cm	Ekman Dredge, six replicates	0.014	6	0.003
F	Footprint Lake	approx. 4.7 cm	Ekman Dredge, six replicates	0.060	6	0.004
Manitoba Sediment Quality Guidelines (MWS 2011)	SQG PEL			0.17 0.486		

APPENDIX 2J

ADDITIONAL MERCURY

MEASUREMENTS: 2011



AQUATIC ENVIRONMENT
SECTION 2: WATER AND SEDIMENT QUALITY

2J.1 INTRODUCTION

Keeyask water quality studies conducted up to 2011 applied an analytical detection limit sufficiently low to facilitate comparisons to the MWQSOGs for mercury for PAL issued in 2002 (Williamson 2002). The 2002 PAL guideline for mercury (0.0001 mg/L) is notably higher than the revised guideline issued in 2011 (0.000026 mg/L; MWS 2011). To provide baseline data for the study area that can be compared to the current PAL guideline, a sampling program was undertaken in fall 2011. The following provides a brief description of the methods and results of this study.

2J.2 METHODS

Water samples were collected from six sites as illustrated in Map 2J-1 on 12 and 13 October 2011 for analysis of total mercury, dissolved mercury, and total methylmercury. Samples were also collected for analysis of dissolved methylmercury but were preserved incorrectly at the analytical laboratory and had to be discarded. Samples were collected as surface grabs (approximately 30 cm below the water surface) at each of the sites by directly filling the sample bottles provided by the analytical laboratory.

Quality assurance/quality control procedures included the use of the clean-hands-dirty-hands procedure for ultra-trace mercury and standard measures to prevent sample contamination. Samples were kept cool (approximately 4°C) and in the dark until submission to a Canadian Association for Laboratory Accreditations, Inc. accredited analytical laboratory (ALS Laboratories, Winnipeg, MB) within 48 hours of collection. In addition, one field blank and one trip blank were submitted with the environmental samples and a duplicate sample was collected from a random site.

2J.3 RESULTS

Total mercury, dissolved mercury, and total methylmercury were not detected in any samples collected upstream and downstream of the Kelsey GS, Gull Rapids, or the Limestone GS or from the field and trip blanks (Table 2J-1).

2J.4 REFERENCES

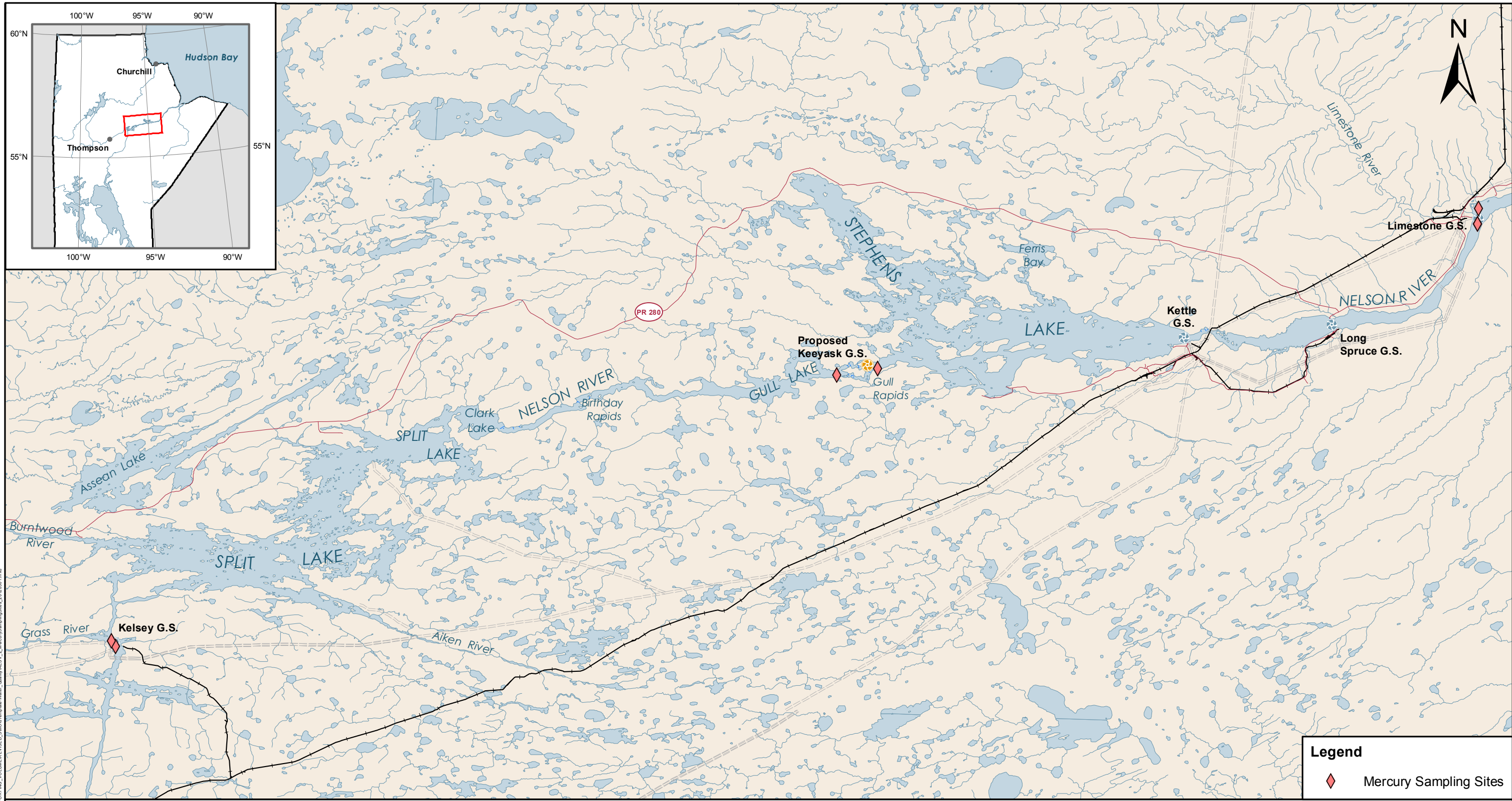
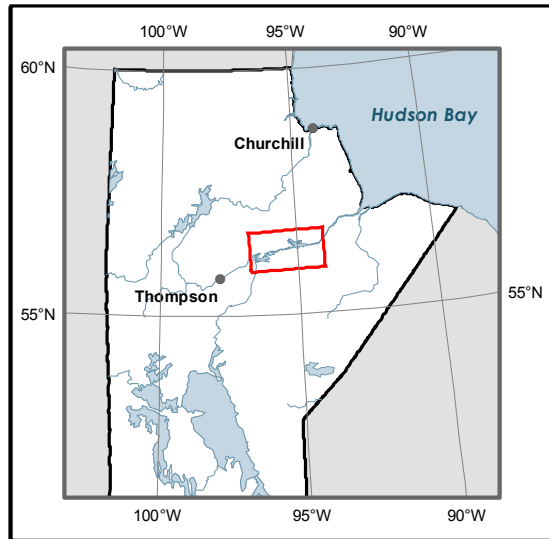
2J.4.1 LITERATURE CITED

- MWS. 2011. Manitoba Water Quality Standards, Objectives, and Guidelines. Water Science and Management Branch, MWS. MWS Report 2011-01, November 28, 2011. 67 pp.
- Williamson, D.A. 2002. Manitoba Water Quality Standards, Objectives, and Guidelines. Manitoba Conservation Report 2002-11. Final Draft: November 22, 2002. 76 p.

Table 2J-1: Total mercury, dissolved mercury, and total methylmercury in surface water samples collected in the study area, fall 2011

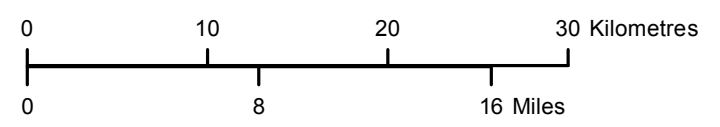
Location	UTMs			Total mercury (mg/L)	Dissolved mercury (mg/L)	Total methylmercury (mg/L)	
	Zone	Easting	Northing				
Analytical Detection Limit				0.000001	0.000001	0.00000005	
Upstream of Kelsey GS	15V	653737	6212821	<0.000001	<0.000001	<0.00000005	
Downstream of Kelsey GS	15V	653235	6213361	<0.000001	<0.000001	<0.00000005	
Gull Rapids	15V	360271	6245881	<0.000001	<0.000001	<0.00000005	
Downstream of Gull Rapids	15V	364824	6246606	<0.000001	<0.000001	<0.00000005	
Limestone GS Reservoir	15V	431634	6262701	Replicate 1	<0.000001	<0.000001	<0.00000005
	15V	431634	6262701	Replicate 2	<0.000001	<0.000001	<0.00000005
	15V	431634	6262701	Replicate 3	<0.000001	<0.000001	<0.00000005
Nelson River downstream of Limestone GS	15V	431787	6264417		<0.000001	<0.000001	<0.00000005
Field Blank				<0.000001	<0.000001	<0.00000005	
Trip Blank				<0.000001	<0.000001	<0.00000005	
MWQSOG ¹ /CCME ² Guideline				0.000026		0.000004	

1. MWQSOGs = Manitoba Water Quality Standards, Objectives and Guidelines.
2. CCME = Canadian Council of Ministers of the Environment.



Legend

◆ Mercury Sampling Sites



Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:250 000

Mercury in Water Sampling Sites 2011

File Location: G:\ES\Keeyask\Publin_MXDoc\SUPP\REPORTING_VOLUMEREVISED_SRD\Templates\Water_Quality\MESV_2_MercurySamplingSite_201020001.mxd