2014 Status of
WATER QUALITY
Athabasca River, Alberta at the Old Fort Monitoring Station

Water Quality Management Framework
Lower Athabasca Regional Plan

Alberta Environmental Monitoring
Evaluation and Reporting Agency

aemera.org

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About AEMERA

Established on April 28, 2014 with the proclamation of the *Protecting Alberta's Environment Act*, the Alberta Environmental Monitoring, Evaluation and Reporting Agency (AEMERA) is the provincial monitoring agency responsible for measuring, assessing and informing the public on the condition of Alberta's environment.

Operating at arm's length from government to separate the monitoring, evaluation and reporting of environmental data and information from policy development and decision-making, effective 2014, AEMERA took over the management of all ambient monitoring activities, previously conducted by the Government with Alberta.

As part of its mandate, AEMERA is a working partner – along with Alberta Environment and Sustainable Resource Development (ESRD), the Alberta Energy Regulator (AER), Alberta Energy and Alberta Aboriginal Affairs – in managing and ensuring a coordinated and effective Integrated Resource Management System (IRMS) on behalf of all Albertans.

AEMERA's role within IRMS is to provide proactive, objective reporting of scientific data and information on the condition of Alberta's environment, including baseline environmental monitoring; cumulative effects monitoring; data evaluation and management; state of the environment reporting in all regions of Alberta; and credible data, evaluation, knowledge and reporting to inform policy and regulatory decision-making.

VISION

To be globally recognized as the comprehensive and trusted source of environmental data and information that results in better understanding of Alberta's environment and informs decision-making.

MISSION

To measure, assess and inform on the conditions of Alberta's environment.

Executive Summary

Background

Prepared by the Alberta Environmental Monitoring, Evaluation and Reporting Agency (AEMERA), this report presents the monthly water quality results for the Old Fort monitoring station, Athabasca River, Alberta for 2014. These data are provided to fulfill reporting requirements mandated by the Surface Water Quality Management Framework, which supports the Lower Athabasca Regional Plan (LARP).

The 2014 report is the first report produced by AEMERA for the Lower Athabasca Region. Alberta Environment and Sustainable Resource Development (now Alberta Environment and Parks) produced previous reports.

Reporting requirements for the Lower Athabasca Regional Plan are determined by the Government of Alberta. AEMERA has a responsibility for monitoring, evaluation and reporting under the Environmental Management Frameworks, including the Surface Water Quality Framework.

The information provided in this report is compared to triggers and limits established by Alberta Environment and Parks.

2014 results summary

In 2014, 38 water quality chemical parameters were measured monthly at the Old Fort water quality monitoring station. The results were then compared to targets and limits as defined by Alberta Environment and Parks in the Surface Water Quality Management Framework.

- No limits were exceeded for water quality parameters;
- Level 2 annual mean triggers were exceeded for sulphate and potassium; and
- Level 2 peak triggers were exceeded for dissolved cobalt and dissolved uranium.

Lower Athabasca Regional Plan

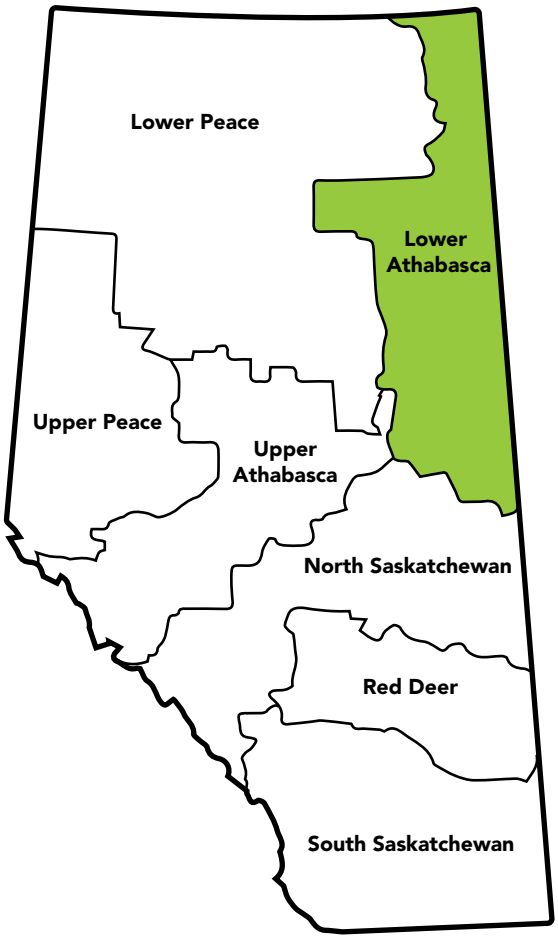
The Lower Athabasca Regional Plan is a management plan developed by the Government of Alberta under the Land Use Framework. The plan sets outcomes that describe what the Government of Alberta wants to accomplish at a regional level, and is given legislative authority under the *Alberta Land Stewardship Act*.

The Lower Athabasca Regional Plan applies to the Lower Athabasca Region, an area approximately 93,212 square kilometres in size located in the northeast corner of Alberta (Figure 1).

For more information on the Lower Athabasca Region, see the **Lower Athabasca Regional Plan.**

The Alberta Environmental Monitoring Evaluation and Reporting Agency (AEMERA) is responsible for monitoring, assessing and reporting on the condition of the environment in the Lower Athabasca Region, while the Government of Alberta is responsible for management of activities and resources in response to environmental conditions.

Figure 1: *Land Use Framework Regions of Alberta*

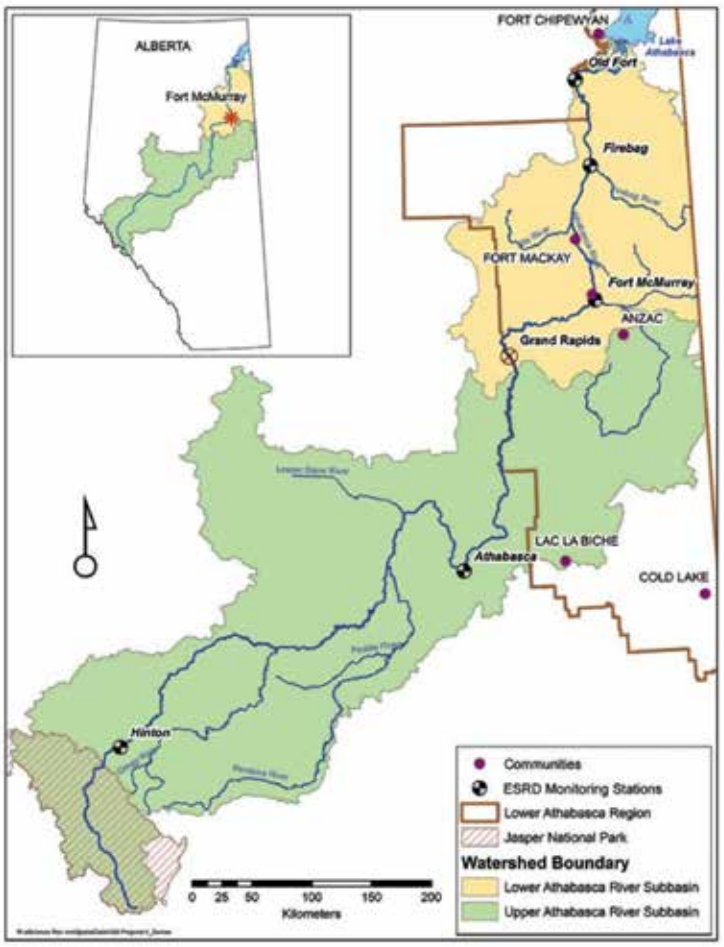


Monitoring Stations

Ambient surface water quality is measured monthly at the Old Fort monitoring station on the lower Athabasca River. The Old Fort monitoring station is located approximately 200 kilometres downstream of Fort McMurray (Figure 2).

As described in the Surface Water Quality Framework, Alberta Environment and Sustainable Resource Development (now Alberta Environment and Parks) set ambient surface water triggers and limits for the lower Athabasca River. These triggers and limits were based upon long-term monitoring data for the Old Fort monitoring station, which is located upstream of where the Athabasca River enters the Peace Athabasca Delta.

Figure 2: *Location of AEMERA Water Quality Stations in the Upper and Lower Athabasca Regions of Alberta*



Alberta Environment and Parks

Surface Water Quality Indicators, Triggers and Limits

The Surface Water Quality Framework identifies 61 surface water quality parameters that include major ions, nutrients, and dissolved and total metals. Each of these water quality parameters, which are often referred to as water quality indicators within the Surface Water Quality Framework, has mean and peak triggers assigned. Mean and peak triggers were calculated form historic monitoring data for the Old Fort monitoring station. Additional details about the calculation of mean and peak triggers are provided in the Surface Water Quality Framework. Mean triggers are intended to identify shifts in average values and changes in the frequency of observed extreme values (peak triggers as defined by the 95th percentile) in relation to historical data. Surface water quality limits are derived from provincial water quality guidelines. Surface water triggers (WQTs) and limits (WQLs) can be found in Tables 2 and 3 of the Surface Water Quality Management Framework.

Data Verification and Metric Calculation

The data used in this report result from monthly water quality monitoring at the Old Fort monitoring station in 2014. Sample collection and analyses followed standards and protocols established by Alberta Environment and Parks. The calculation of summary statistics and the statistical analyses employed are prescribed by Alberta Environment and Parks within Appendix B of the Surface Water Quality Framework.

Summary statistics for the general and metal water quality parameters are presented in Appendix B of this report (Table B1 and Table B2). The 2014 data are also presented graphically in relation to historical data in Figures B1 and B2. The water quality data for 2014 and the historical data for the Athabasca River at Old Fort monitoring station is available through the Alberta Environmental Monitoring Evaluation and Reporting Information Service (AEMERIS) at: **http://aemeris.aemera.org**

Appendix A of this report provides additional information on the assessment of each surface water quality parameter in comparison to the mean and peak triggers and presents the detailed results of the statistical analyses. A summary is provided below.

ANNUAL MEANS COMPARED TO MEAN TRIGGERS

In 2014, a total of 13 of the 38 surface water quality parameters had annual mean values higher than the mean trigger established in the Surface Water Quality Framework. These 11 indicators were subsequently subject to further statistical evaluation. The determination of whether observed changes deviated significantly from mean triggers was evaluated by using parametric Welch's two-sample t-tests. In addition to the use of parametric t-tests, the Surface Water Quality Framework mandates the use of an additional, more conservative nonparametric comparison (the Wilcoxon-Mann-Whitney test).

For 11 water quality parameters that met the assumptions of using parametric statistical methods, the difference between the 2014 annual mean and the mean trigger was not statistically significant (t-test results; $p>0.05$). In contrast, for two water quality parameters that did not meet the assumptions of parametric testing, (potassium and sulphate), they were found to have statistically significant differences between the 2014 annual means and the mean triggers using the nonparametric Wilcoxon-Mann-Whitney test (see Table 3).

ANNUAL DATA COMPARED TO PEAK TRIGGERS

For a peak trigger to be exceeded, the number of samples higher than the peak trigger must be greater than would be expected by chance, and this difference must be statistically significant (Tables 3 and 4; Table A2). In 2014, five water quality parameters had one or more observations higher than the peak triggers established in the Surface Water Quality Framework; however, only two of these five parameters had a statistically significant number of sampling occasions where the measured concentrations were higher. These were dissolved cobalt (three occasions) and dissolve uranium (four occasions) (see Table 4).

AMBIENT SURFACE WATER QUALITY LIMITS

None of the limits established in the Surface Water Quality Framework were exceeded in 2014 (Tables A3 and A4).

Table 2: *Comparison of the Ambient Means Against the Mean Triggers at the Old Fort Water Quality Monitoring Station*

Note: Only the indicators with concentrations that were statistically significant (shaded in blue) exceeded the mean trigger. Annual mean values were calculated from n=12 monthly observations. In the case of Ca, a statistically significant decrease is tested for as per the Surface Water Quality Framework.

GENERAL INDICATORS	UNITS	MEAN TRIGGER	2014 MEAN
Calcium (Ca^{2+})[1]	mg/L	34.7	35.3
Chloride (Cl^-)	mg/L	20.2	18.3
Magnesium (Mg^+)	mg/L	9.5	9.9
Nitrate (NO_3-N)	mg/L	0.0092	0.0860
Potassium (K^+)	mg/L	1.4	1.6
Sodium (Na^+)	mg/L	21.5	20.8
Sulphate (SO_4^-)	mg/L	26.7	31.3
Total Ammonia (NH_{3+4}-N)	mg/L	0.05	0.04
Total Dissolved Phosphorus (TDP)	mg/L	0.016	0.014
Total Phosphorus (TP)	mg/L	0.074	0.063
Total Nitrogen (TN)	mg/L	0.597	0.556

		Dissolved Metals		Total Metals	
METAL INDICATORS	UNITS	MEAN TRIGGER	2014 MEAN	MEAN TRIGGER	2014 MEAN
Aluminum	µg/L	16	13	1533	2026
Antimony	µg/L	0.107	0.069	0.148	0.072
Arsenic	µg/L	0.5	0.5	1.1	0.9
Barium	µg/L	52.6	48.7	79.3	72.4
Beryllium	µg/L	---	---	0.077	0.050
Bismuth	µg/L	---	---	0.0172	0.0074
Boron	µg/L	26	27	48	30
Cadmium	µg/L	0.0997	0.0126	0.3	0.0
Chromium	µg/L	0.41	0.22	3	2
Cobalt	µg/L	0.07	0.08	0.8	0.6
Copper	µg/L	1.6	1.2	3.1	2.0
Iron	µg/L	185	153	1899	1591
Lead	µg/L	0.56	0.07	3.3	0.8
Lithium	µg/L	6	6	9	7
Manganese	µg/L	12	10	65	59
Mercury	µg/L	---		0.0051	0.0037
Molybdenum	µg/L	0.7	0.6	0.9	0.6
Nickel	µg/L	1.6	0.8	3.4	2.0

		Dissolved Metals		Total Metals	
METAL INDICATORS	**UNITS**	**MEAN TRIGGER**	**2014 MEAN**	**MEAN TRIGGER**	**2014 MEAN**
Selenium	µg/L	0.229	0.192	0.333	0.297
Silver	µg/L	---		0.0243	0.0101
Strontium	µg/L	215	219	225	229
Thallium	µg/L	0.0238	0.0047	0.0546	0.0269
Thorium	µg/L	0.0284	0.0284	0.35	0.30
Titanium	µg/L	2	2	30	30
Uranium	µg/L	0.313	0.338	0.4	0.4
Vanadium	µg/L	0.45	0.25	4.4	3.7
Zinc	µg/L	4.5	1.0	12.3	5.2

Table 3: *Comparison of Peak Values Against Maximum Values and Peak Triggers at Old Fort Surface Water Quality Monitoring Station (General Indicators)*

GENERAL INDICATOR	UNITS	PEAK TRIGGER	MAXIMUM VALUE	NUMBER OF OCCURRENCES HIGHER THAN TRIGGER IN 2014
Calcium (Ca2+)	mg/L	48.9	47.0	0
Chloride (Cl-)	mg/L	45	31	0
Magnesium (Mg+)	mg/L	13.7	14.0	1
Nitrate (NO3-N)	mg/L	0.264	0.260	0
Potassium (K+)	mg/L	2.1	2.4	1
Sodium (Na+)	mg/L	43.7	33.0	0
Sulphate (SO4-)	mg/L	41.4	42.0	1
Total Ammonia (NH3+4-N)	mg/L	0.12	0.09	0
Total Dissolved Phosphorus (TDP)	mg/L	0.032	0.023	0
Total Nitrogen (TN)	mg/L	1.041	1.000	0
Total Phosphorus (TP)	mg/L	0.261	0.160	0

Table 4: *Comparison of Peak Values Against Maximum Values and Peak Triggers at Old Fort Surface Water Quality Monitoring Station*

		Dissolved Metals			Total Metals		
METAL INDICATOR	**UNITS**	**PEAK TRIGGER**	**MAXIMUM VALUE**	**NUMBER OF OCCURRENCES HIGHER THAN TRIGGER IN 2014**	**PEAK TRIGGER**	**MAXIMUM VALUE**	**NUMBER OF OCCURRENCES HIGHER THAN TRIGGER IN 2014**
Aluminum	µg/L	49	46	0	6454	8160	2
Antimony	µg/L	0.202	0.130	0	0.388	0.131	0
Arsenic	µg/L	0.7	0.5	0	2.5	1.9	0
Barium	µg/L	73.7	64.8	0	147.6	114.0	0
Beryllium	µg/L	---	---	---	0.269	0.173	0
Bismuth	µg/L	---	---	---	0.0564	0.0400	0
Boron	µg/L	40	33	0	69	36	0
Cadmium	µg/L	0.515	0.021	0	1.2	0.1	0
Chromium	µg/L	0.65	0.50	0	8	6	0
Cobalt	µg/L	0.11	0.18	3	2.2	1.6	0
Copper	µg/L	3.6	2.4	0	7.2	4.9	0
Iron	µg/L	372	283	0	5821	4300	0
Lead	µg/L	0.56	0.20	0	7	3	0
Lithium	µg/L	9	8	0	12	9	0
Manganese	µg/L	36	31	0	141	101	0
Mercury	µg/L	---	---	---	0.0159	0.0130	0
Molybdenum	µg/L	1.2	0.7	0	1.6	0.8	0
Nickel	µg/L	4.7	1.5	0	8.2	4.9	0
Selenium	µg/L	0.409	0.380	0	0.581	0.440	0
Silver	µg/L	---	---	---	0.0677	0.0430	0
Strontium	µg/L	361	336	0	361	344	0
Thallium	µg/L	0.1137	0.0070	0	0.1751	0.0877	0
Thorium	µg/L	0.0942	0.0789	0	1.44	1.11	0
Titanium	µg/L	7	6	0	104	109	1
Uranium	µg/L	0.381	0.397	4	0.7	0.5	0
Vanadium	µg/L	0.698	0.440	0	16	13	0
Zinc	µg/L	12.4	2.0	0	25.6	14.9	0

Appendix A

STATISTICAL METHODOLOGY USED TO ASSESS MEAN AND PEAK TRIGGERS

The Surface Water Quality Framework includes 38 indicators with 61 mean trigger values and 61 peak trigger values, as many of the metal indicators include triggers for both total and dissolved metals (i.e., 27 total metals, 23 dissolved metals and 11 general). Water samples for the general indicators were analysed by Maxxam Analytics and the metal indicators by Alberta Innovates Technology Futures.

The 2014 data set was prepared similarly to the historical data set. Observations below the method detection limit were replaced with half the detection limit to be consistent with the development of the water quality triggers from the historical data. With the exception of nitrate and total ammonia, all indicators had 30% or fewer of the 2014 observations below detection, as was the case with the historical data.

MEAN TRIGGERS

Welch's two sample t-tests and Wilcoxon-Mann-Whitney tests were conducted to test the null hypothesis that the 2014 water quality indicator means are not different from the historical means (i.e., mean triggers). These tests were only conducted when the 2014 indicator mean was higher than the mean trigger (or in the case of calcium and magnesium, higher or lower). The "exact rank tests" package in R was used to compute the Wilcoxon-Mann-Whitney tests (Hothorn and Hormik, 2012). Quantile-quantile (Q-Q) plots and the Shapiro-Wilk test were used to assess the normality of the historical data, as annual samples sizes are too small to provide distributional information. If the water quality indicator was non-normal prior to transformation, but was not significantly non-normal after log transformation, the Welch's test was run on the log-transformed data. Because much of the historical data are not normally distributed, and given that water quality data often have outliers that can affect the outcome of parametric comparisons, both parametric (Welch's two sample t-tests) and non-parametric comparisons (Wilcoxon-Mann-Whitney tests) were conducted to enhance the robustness of the conclusions.

Of the 61 mean triggers examined (11 general, 27 total metal, 23 dissolved metal), 27 annual means were higher than the historical mean triggers, while calcium was lower. Consequently, 28 indicators were examined statistically (i.e., the 27 that were higher plus calcium, which was lower). Parametric and non-parametric test results were consistent for all the indicators tested (Table A1). Only indicators with 2014 means higher than historical mean triggers were statistically evaluated. Two-sided tests were conducted for both calcium and magnesium and one-sided tests for the remaining indicators.

Table A1: *Results of the Statistical Assessment of the 2014 Data Against the Ambient Mean Surface Water Quality Triggers*

Statistical analyses were only run if the 2014 mean value was higher (or lower in the case of Ca2+) than the mean trigger.

			Welch's two sample t-test			Wilcoxon rank sum test	
INDICATOR	**MEAN TRIGGER**	**2014 MEAN**	**T-STATISTIC**	**DF**	**P-VALUE**	**W-STATISTIC**	**P-VALUE**
General Indicators							
Potassium (K+)	1.4	1.6	1.402	13.27	0.092	1823.0	0.044
Sulphate (SO4-)	26.7	31.3	1.767	12.44	0.051	1811.5	0.048
Metal Indicators							
Aluminum T*	1533	2026	1.61	21.983	0.061	398	0.112
Arsenic D	0.5	0.5	-0.76	48.83	0.449	256	0.498
Boron D	26	27	0.50	37.87	0.312	333	0.243
Lithium D	6	6	0.55	20.64	0.293	324.5	0.294
Thorium D	0.0284	0.0284	-0.01	21.72	0.994	153.5	0.172
Titanium D*	2	2	-0.13	19.167	0.899	299	0.932
Uranium D	0.313	0.338	1.34	20.76	0.098	264.5	0.067
Uranium T	0.4	0.4	0.36	51.03	0.362	367.5	0.173

Note: p-value=level of significance, D=dissolved, T=total.
Bolded and underlined values are statistically different.
**The data for these indicators were log-normally distributed, so the t-tests were performed on the log-transformed data.*

PEAK TRIGGERS

Binomial tests were conducted to test the null hypothesis that in 2014 the historical 95th percentile (i.e., peak trigger) for a given indicator was not exceeded more than 5 per cent of the time (the expected frequency given no change). Binomial tests were only run for a water quality indicator when one or more of the annual samples were higher than a peak trigger (Tables 3 and Table A2).

Table A2: *Results of the Statistical Assessment of the 2014 Data Against the Ambient Peak Surface Water Quality Triggers*

INDICATOR	**PEAK TRIGGER**	**NUMBER OF OCCURRENCES HIGHER THAN TRIGGER**	**BINOMIAL TEST P-VALUE***
General Indicators			
Magnesium (Mg+)	13.7	1	0.460
Potassium (K+)	2.1	1	0.460
Sulphate (SO4-)	41.4	1	0.460
Metal Indicators			
Cobalt	0.11	3	0.020
Uranium	0.381	4	0.002

Note: Bolded and underlined values are statistically significant.
p-value=level of significance, D=dissolved, T=total

LIMITS

A limit will have been exceeded if the annual mean for a given water quality indicator exceeds the surface water quality limit for that indicator (Table A3). For water quality indicators where the limit is calculated using toxicity modifying factors (i.e., total ammonia and total nickel), a limit exceedance will have occurred when more than 50 per cent of the monthly samples exceed the limit in a given year (Table A4). See Table A4 for computed limits for water quality indicators with toxicity modifying factors.

Table A3: *Assessment of the 2014 Data Against Surface Water Quality Limits*

INDICATOR	UNIT	SURFACE WATER QUALITY LIMIT	SAMPLE SIZE	PERCENT OF 2014 SAMPLES HIGHER THAN A LIMIT	2014 MEAN
General Indicators					
Calcium (Ca2+)	mg/L	1000	12	None	35
Chloride (Cl-)	mg/L	100	12	None	18
Sodium (Na+)	mg/L	200	12	None	21
Sulphate (SO4-)	mg/L	500	12	None	31
Total Ammonia (NH3+4-N)	mg/L	Varies with pH and temperature*	12	None	0.04
Nitrate (NO3-N)	mg/L	2.9	12	None	0.6
Metal Indicators					
Antimony T	µg/L	6	12	None	0.1
Arsenic T	µg/L	5	12	None	0.9
Barium T	µg/L	1000	12	None	72
Beryllium T	µg/L	100	12	None	0.1
Boron T	µg/L	500	12	None	30
Chromium T	µg/L	50	12	None	2
Cobalt T	µg/L	50	12	None	0.6
Lithium T	µg/L	2500	12	None	7
Molybdenum T	µg/L	10	12	None	0.6
Nickel T	µg/L	Varies with hardness*	12	None	2.0
Selenium T	µg/L	1	12	None	0.3
Silver T	µg/L	0.1	12	None	0.01
Thallium T	µg/L	0.8	12	None	0.03
Uranium T	µg/L	10	12	None	0.4
Vanadium T	µg/L	100	12	None	4

Note: T=total

Table A4: *Calculated Total Ammonia and Total Nickel Limits for 2014 Samples*

SAMPLE DATE	WATER TEMPERATURE (°C)	PH (PH UNITS)	TOTAL AMMONIA (mg/L)	CALCULATED TOTAL AMMONIA LIMIT (mg/L)	HARDNESS (mg/L)	TOTAL NICKEL (µg/L)	CALCULATED TOTAL NICKEL LIMIT (µg/L)
1/21/2014	0.06	7.06	0.085	5.77	140	0.561	69
2/11/2014	0.07	5.97	0.06	6.96	140	0.567	69
3/18/2014	0.05	6.88	<0.05	6.16	150	0.648	74
4/16/2014	0.07	7.71	<0.05	3.54	130	1.2	65
5/13/2014	6.95	7.81	<0.05	3.14	72	4.84	40
6/10/2014	13.7	7.68	<0.05	3.66	77	4.85	42
7/16/2014	22.03	7.78	<0.05	2.01	91	1.76	48
8/13/2014	21.61	7.74	<0.05	2.16	99	1.55	52
9/17/2014	10.5	8.2	<0.05	1.79	110	2.77	57
10/22/2014	5.72	7.67	0.053	3.70	110	2.12	57
11/19/2014	-0.08	6.99	0.07	5.93	150	1.35	74
12/10/2014	0.02	7.51	0.083	4.33	140	1.36	69

Note: It is necessary to calculate sample-specific limits for total ammonia and total nickel as these water quality indicators have toxicity modifying factors that vary across samples.

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R Development Core Team. 2012. R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL: http://www.r-project.org/.

Appendix B

Summary Statistics for the 2014 Data from the Athabasca River at Old Fort Monitoring Station

Table B1: *Summary Statistics for the 2014 Data from the Athabasca River at Old Fort Monitoring Station – General Indicators*

INDICATOR	N	MAX	MIN	MEDIAN	MEAN	P99.9	P99	P95	VARIANCE	SD
Calcium (Ca2+)	12	47	22	35.5	35.25	46.967	46.67	45.35	64.932	8.0580282
Chloride (Cl-)	12	31	5.5	20.5	18.341667	31	31	31	91.230	9.5514357
Magnesium (Mg+)	12	14	5.4	10.5	9.925	13.978	13.78	12.9	6.704	2.589182
Nitrate (NO3-N)	12	0.26	0.0015	0.0655	0.086	0.25945	0.2545	0.2325	0.008	0.0892163
Potassium (K+)	12	2.4	0.91	1.55	1.5675	2.3956	2.356	2.18	0.210	0.4585972
Sodium (Na+)	12	33	8.7	23	20.841667	32.978	32.78	31.9	83.968	9.1634113
Sulphate (SO4-)	12	42	15	33.5	31.25	41.967	41.67	40.35	73.295	8.561
Total Ammonia (NH3+4-N)	12	0.085	0.025	0.025	0.0438333	0.084978	0.08478	0.0839	0.001	0.0247564
Total Dissolved Phosphorus (TDP)	12	0.023	0.008	0.0135	0.0135833	0.022923	0.02223	0.01915	0.000	0.004295
Total Nitrogen (TN)	12	1	0.18	0.545	0.5558333	0.99813	0.9813	0.9065	0.051	0.22581
Total Phosphorus (TP)	12	0.16	0.02	0.036	0.0626667	0.15989	0.1589	0.1545	0.003	0.0556374

Note: All values are in mg/L; n= sample size, P= percentile, SD= standard deviation

Table B2: *Summary Statistics for the 2014 Data from the Athabasca River at Old Fort Monitoring Station – Metal Indicators*

METAL INDICATOR	N	MAX	MIN	MEDIAN	MEAN	99.9TH P	99TH P	95TH P	VARIANCE	SD
Aluminum D	12	45.9	3.7	6.1	13.1	45.9	45.8	45.6	242.6	15.6
Aluminum T	12	8160	240	830	2026	8148	8038	7550	7384462	2717
Antimony D	12	0.130	0.042	0.057	0.069	0.130	0.126	0.111	0.001	0.025
Antimony T	12	0.131	0.043	0.058	0.072	0.131	0.129	0.122	0.001	0.028
Arsenic D	12	0.541	0.367	0.431	0.457	0.541	0.540	0.537	0.004	0.061
Arsenic T	12	1.9	0.6	0.7	0.9	1.8	1.8	1.8	0.2	0.5
Barium D	12	65	35	48	49	65	64	62	102	10
Barium T	12	114	57	66	72	114	113	110	336	18
Beryllium T	12	0.173	0.002	0.030	0.050	0.173	0.170	0.159	0.003	0.055
Bismuth T	12	0.04	5.00E-04	0.00425	0.0073767	0.039714	0.03714	0.0257	0.0001208	0.01099286
Boron D	12	32.5	17.7	28.2	26.85	32.489	32.39	31.95	20.891818	4.57075685
Boron T	12	36.3	21.7	29.65	29.708333	36.2956	36.256	36.08	23.149924	4.81143682
Cadmium D	12	0.021	0.0079	0.0118	0.01255	0.020956	0.02056	0.0188	1.61E-05	0.00401441
Cadmium T	12	0.079	0.014	0.022	0.0302917	0.078747	0.07647	0.06635	0.0003963	0.01990676
Chromium D	12	0.5	0.05	0.2	0.2217833	0.5	0.5	0.5	0.0294566	0.17162925
Chromium T	12	6.33	0.13	0.922	1.7511667	6.32186	6.2486	5.923	4.2974374	2.07302615
Cobalt D	12	0.179	0.034	0.07365	0.08305	0.17834	0.1724	0.146	0.0016088	0.04011025
Cobalt T	12	1.57	0.132	0.3865	0.60275	1.56945	1.5645	1.5425	0.285278	0.53411424
Copper D	12	2.37	0.72	0.9505	1.2091667	2.36879	2.3579	2.3095	0.3429649	0.58563203
Copper T	12	4.93	0.86	1.335	2.0366667	4.92802	4.9102	4.831	2.3181899	1.5225603
Iron D	12	283	22.9	160.5	153.10833	282.527	278.27	259.35	5842.6754	76.4373952
Iron T	12	4300	588	1136	1591	4298.68	4286.8	4234	1724656	1313.26159
Lead D	12	0.196	0.016	0.04035	0.067325	0.195956	0.19556	0.1938	0.0040889	0.06394474
Lead T	12	2.84	0.0619	0.431	0.822075	2.83857	2.8257	2.7685	0.9093446	0.95359563
Lithium D	12	8.49	4.03	6.985	6.4616667	8.48571	8.4471	8.2755	2.342997	1.53068513
Lithium T	12	8.92	5.15	7.45	7.2283333	8.91472	8.8672	8.656	1.228597	1.10842094
Manganese D	12	30.5	0.6	5.07	9.5108333	30.4043	29.543	25.715	104.52397	10.2236966

Table B2: *Summary Statistics for the 2014 Data from the Athabasca River at Old Fort Monitoring Station – Metal Indicators (continued)*

METAL INDICATOR	N	MAX	MIN	MEDIAN	MEAN	99.9TH P	99TH P	95TH P	VARIANCE	SD
Manganese T	12	101	29.6	48.25	58.616667	100.9461	100.461	98.305	708.70697	26.6215509
Mercury T	12	0.013	0.000682	0.001575	0.0037217	0.0129956	0.012956	0.01278	1.92E-05	0.00438566
Molybdenum D	12	0.721	0.359	0.6315	0.60875	0.720824	0.71924	0.7122	0.012688	0.11264112
Molybdenum T	12	0.765	0.363	0.6565	0.6388333	0.764659	0.76159	0.74795	0.0130691	0.11431999
Nickel D	12	1.46	0.312	0.63	0.75	1.45967	1.4567	1.4435	0.1641618	0.40516888
Nickel T	12	4.85	0.561	1.455	1.9646667	4.84989	4.8489	4.8445	2.2240666	1.49133048
Selenium D	12	0.38	0.11	0.175	0.192	0.378471	0.36471	0.30355	0.0054711	0.07396682
Selenium T	12	0.44	0.19	0.28	0.29725	0.439725	0.43725	0.42625	0.0086982	0.09326417
Silver T	12	0.043	9.00E-04	0.00485	0.0101417	0.042967	0.04267	0.04135	0.0002197	0.01482157
Strontium D	12	336	104	222.5	218.5	335.417	330.17	306.85	4814.2727	69.3849604
Strontium T	12	344	111	229	229.33333	343.538	339.38	320.9	5291.8788	72.7453008
Thallium D	12	0.007	0.0016	0.00445	0.004725	0.0069956	0.006956	0.00678	2.49E-06	0.0015766
Thallium T	12	0.0877	0.0068	0.01405	0.0268917	0.0876857	0.087557	0.086985	0.0008489	0.02913609
Thorium D	12	0.0789	0.0043	0.0209	0.0283583	0.0788835	0.078735	0.078075	0.0006506	0.02550688
Thorium T	12	1.11	0.0479	0.159	0.3008167	1.108185	1.09185	1.01925	0.1245092	0.35285859
Titanium D	12	5.66	0.5	1.62	2.0516667	5.65582	5.6182	5.451	2.8264515	1.68120538
Titanium T	12	109	3.96	14.735	29.72	108.879	107.79	102.95	1298.4151	36.0335273
Uranium D	12	0.397	0.249	0.342	0.3375833	0.396934	0.39634	0.3937	0.0028621	0.05349844
Uranium T	12	0.545	0.366	0.419	0.4308333	0.544637	0.54137	0.52685	0.0028143	0.05305029
Vanadium D	12	0.44	0.102	0.215	0.2509167	0.44	0.44	0.44	0.0141599	0.11899538
Vanadium T	12	12.5	0.646	1.905	3.65475	12.4846	12.346	11.73	16.471385	4.05849536
Zinc D	12	1.95	0.39	1.08	0.9908333	1.94351	1.8851	1.6255	0.2014265	0.44880565
Zinc T	12	14.9	1.31	3.53	5.21	14.8912	14.812	14.46	21.539291	4.64104416

Note: All values are in mg/L; n= sample size, P= percentile, SD= standard deviation

Figure B1: *Graphical Presentations of the Historical and 2014 Data for the Athabasca River at Old Fort Monitoring Station (General Indicators).*

Note: Historical data (H) are summarized with boxplots while all the 2014 data are shown. Crosses are the mean triggers ca lculated from t he historical data or the mean of the 2014 data; boxes are t he peak trigger calculated from the historical data.

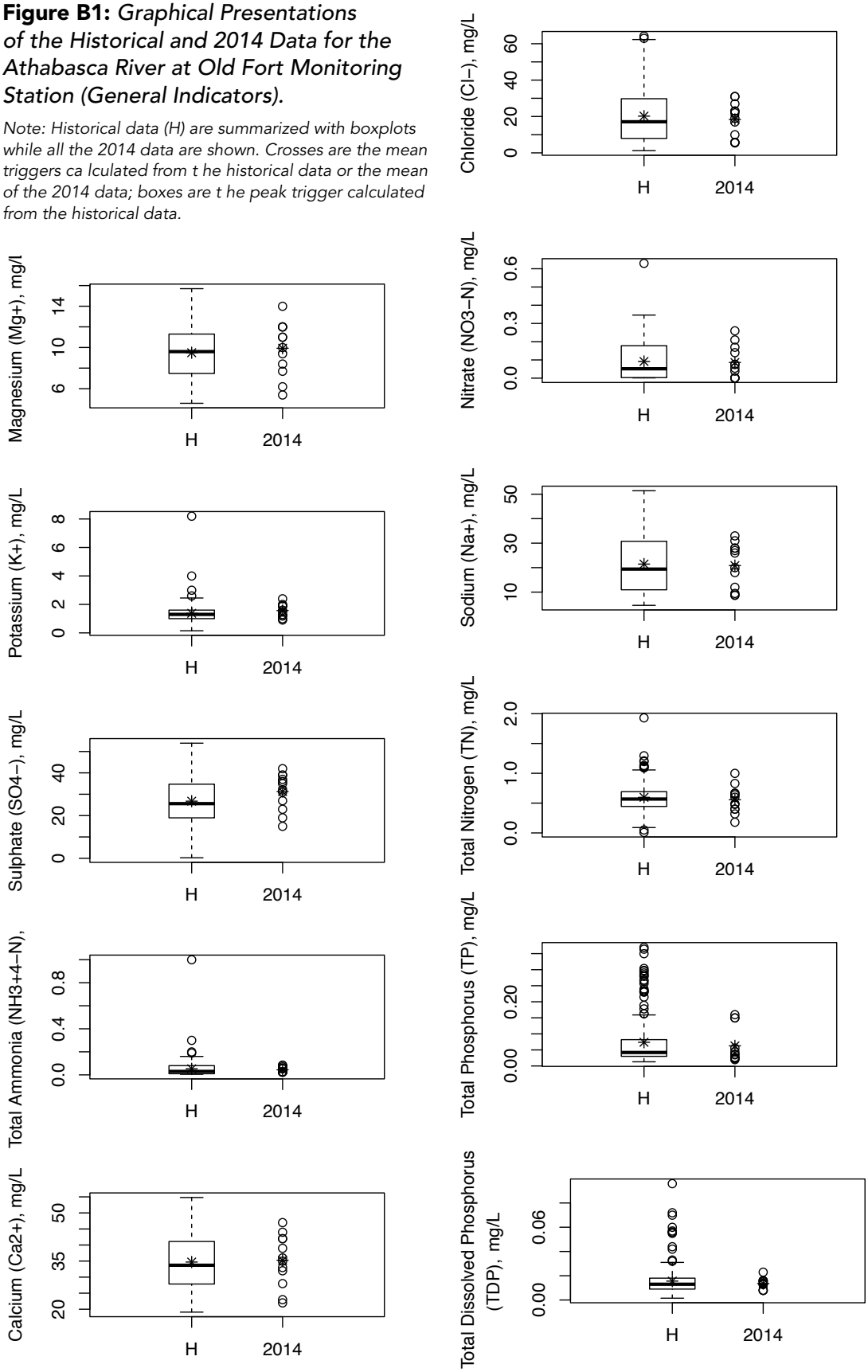
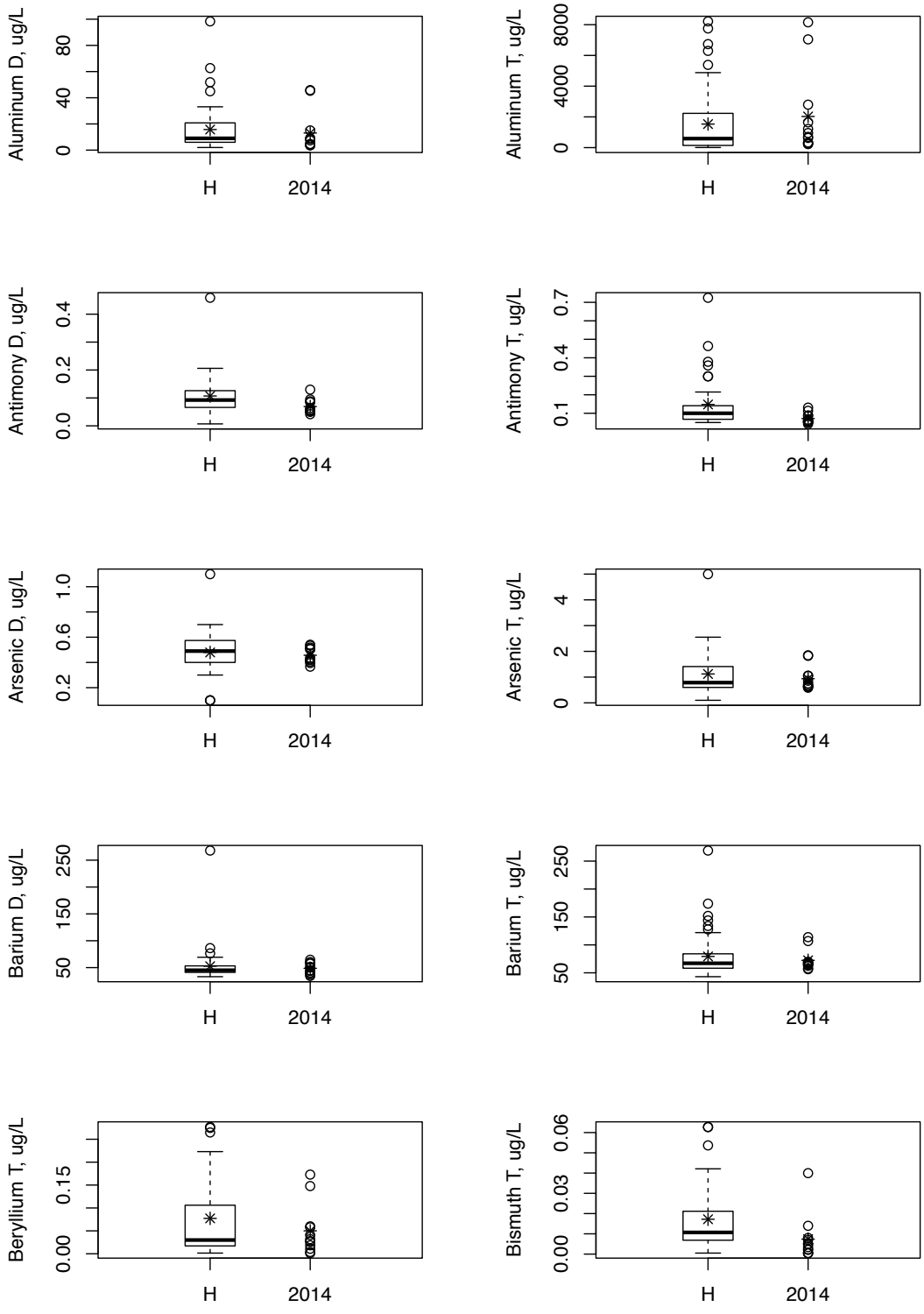
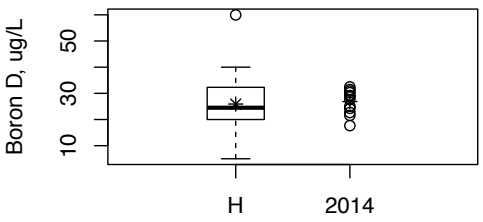
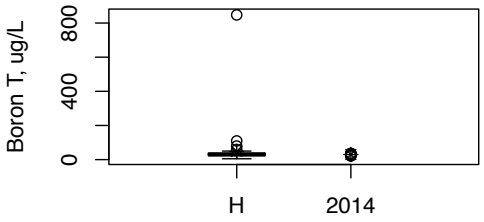


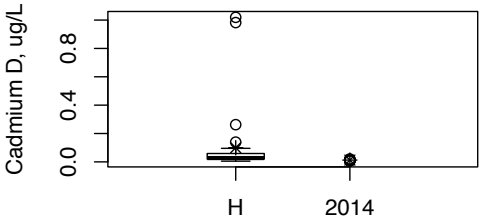
Figure B2: *Graphical Presentations of the Historical and 2014 Data for the Athabasca River at Old Fort Monitoring Station (Metal Indicators).*

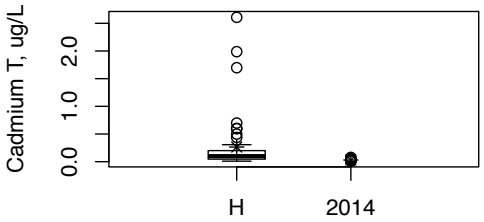
Note: Historical data (H) are summarized with boxplots while all the 2014 data are shown. Crosses are the mean triggers calculated from the historical data or the mean of the 2014 data; boxes are the peak trigger calculated from the historical data.

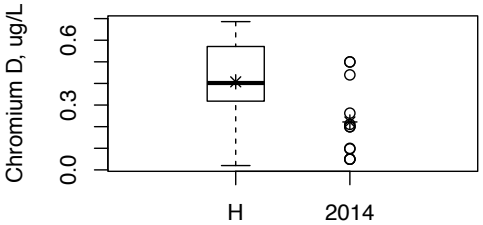


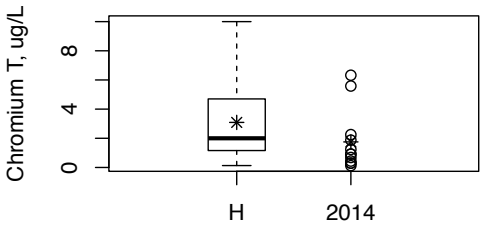

Boron D, ug/L
10
30
50
H
2014

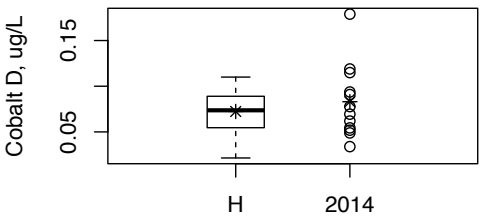

Boron T, ug/L
0
400
800
H
2014

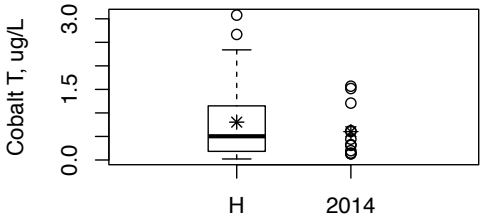

Cadmium D, ug/L
0.0
0.4
0.8
H
2014

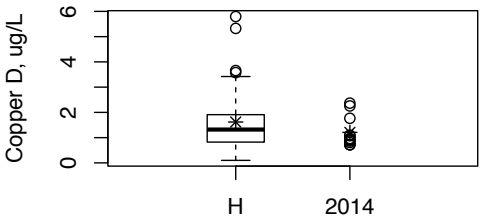

Cadmium T, ug/L
0.0
1.0
2.0
H
2014

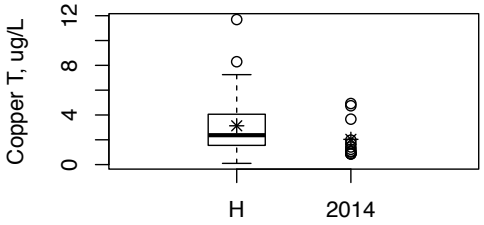

Chromium D, ug/L
0.0
0.3
0.6
H
2014

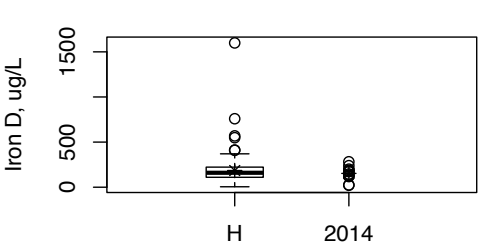

Chromium T, ug/L
0
4
8
H
2014

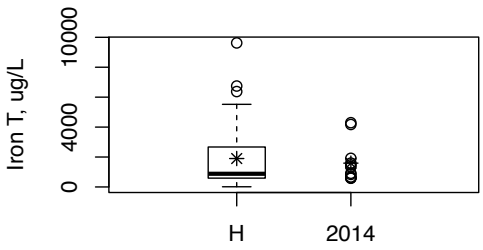

Cobalt D, ug/L
0.05
0.15
H
2014

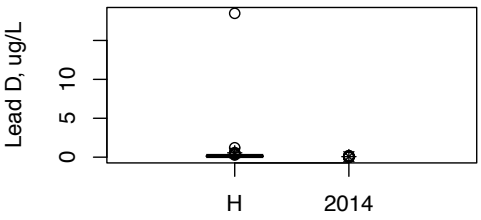

Cobalt T, ug/L
0.0
1.5
3.0
H
2014

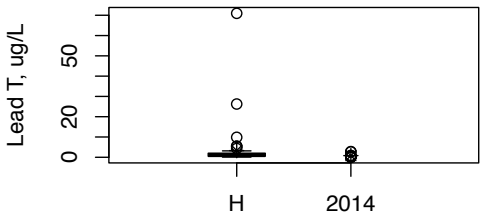

Copper D, ug/L
0
2
4
6
H
2014

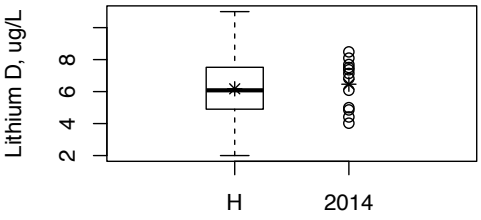

Copper T, ug/L
0
4
8
12
H
2014

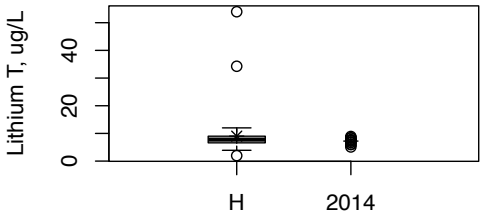

Iron D, ug/L
0
500
1500
H
2014

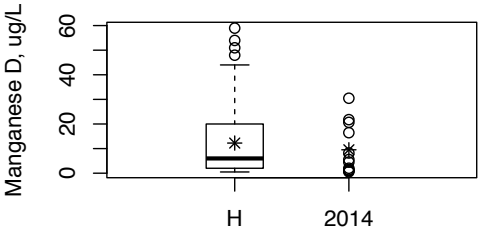

Iron T, ug/L
0
4000
10000
H
2014

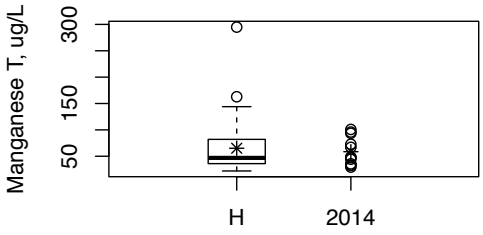

Lead D, ug/L
0
5
10
H
2014

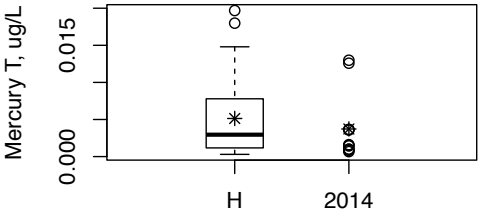

Lead T, ug/L
0
20
50
H
2014

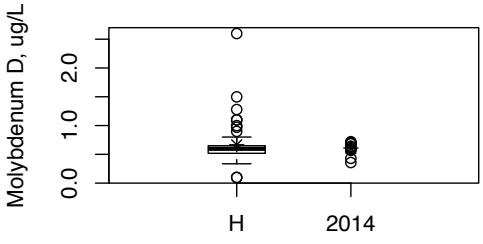

Lithium D, ug/L
2
4
6
8
H
2014

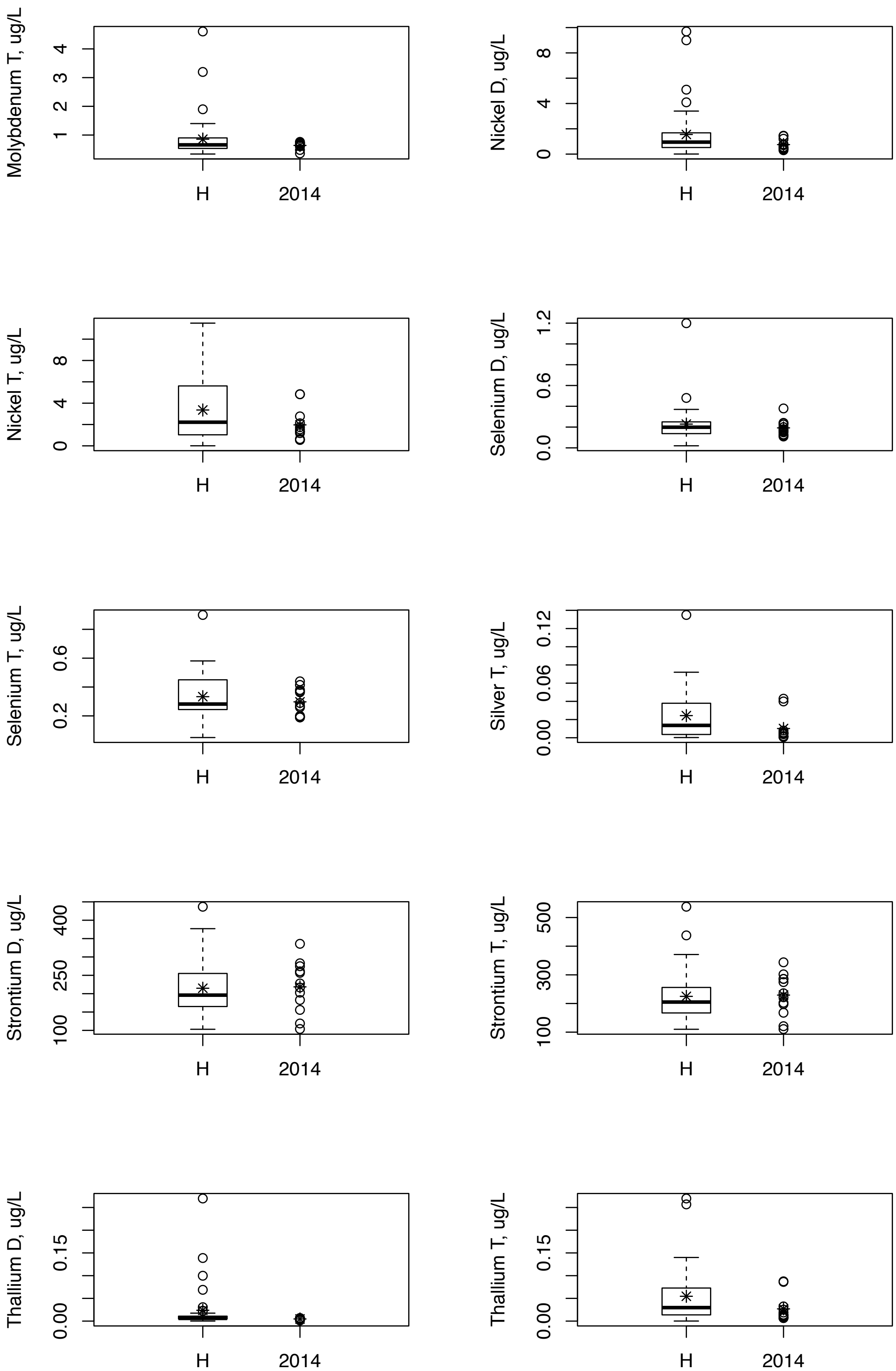

Lithium T, ug/L
0
20
40
H
2014

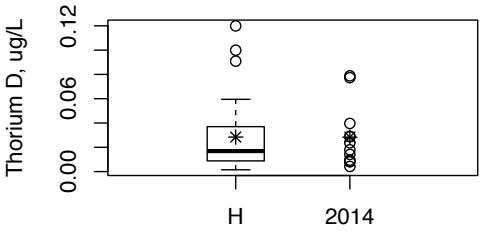

Manganese D, ug/L
0
20
40
60
H
2014

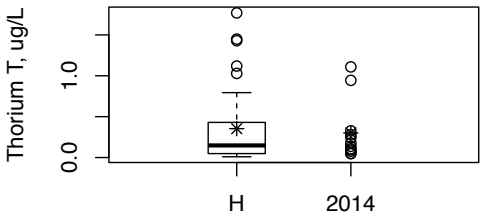

Manganese T, ug/L
50
150
300
H
2014

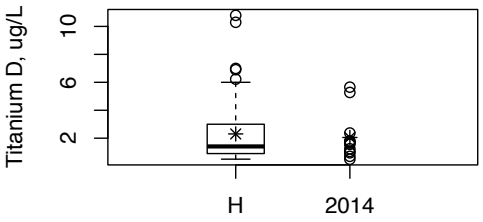

Mercury T, ug/L
0.000
0.015
H
2014

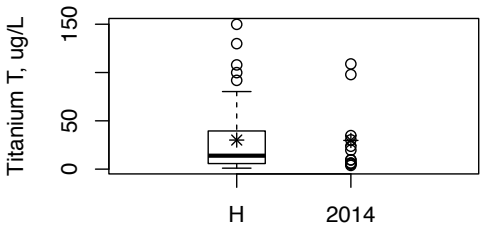

Molybdenum D, ug/L
0.0
1.0
2.0
H
2014

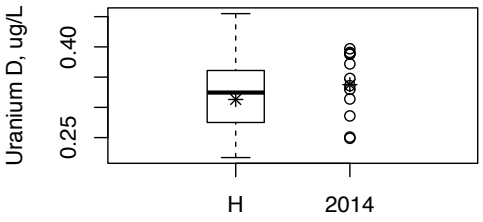

Molybdenum T, ug/L
1
2
3
4
H
2014
Nickel D, ug/L
0
4
8
H
2014
Nickel T, ug/L
0
4
8
H
2014
Selenium D, ug/L
0.0
0.6
1.2
H
2014
Selenium T, ug/L
0.2
0.6
H
2014
Silver T, ug/L
0.00
0.06
0.12
H
2014
Strontium D, ug/L
100
250
400
H
2014
Strontium T, ug/L
100
300
500
H
2014
Thallium D, ug/L
0.00
0.15
H
2014
Thallium T, ug/L
0.00
0.15
H
2014

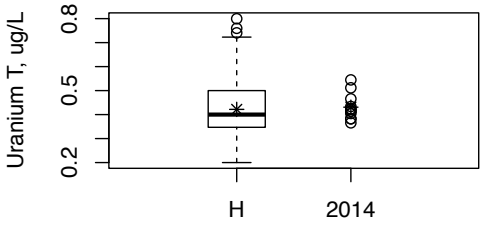

Thorium D, ug/L
0.00
0.06
0.12
H
2014

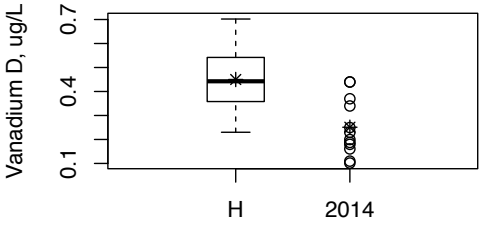

Thorium T, ug/L
0.0
1.0
H
2014

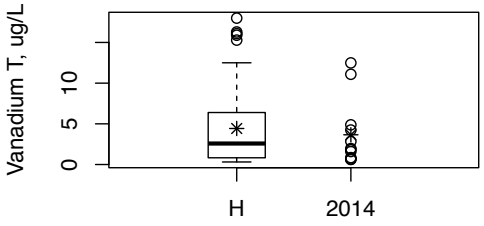

Titanium D, ug/L
2
6
10
H
2014

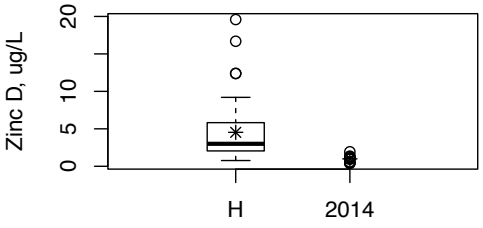

Titanium T, ug/L
0
50
150
H
2014

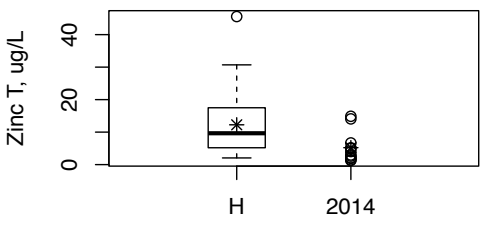

Uranium D, ug/L
0.25
0.40
H
2014


Uranium T, ug/L
0.2
0.5
0.8
H
2014


Vanadium D, ug/L
0.1
0.4
0.7
H
2014


Vanadium T, ug/L
0
5
10
H
2014


Zinc D, ug/L
0
5
10
20
H
2014


Zinc T, ug/L
0
20
40
H
2014