2015 Status of
SURFACE WATER QUALITY

Lower Athabasca Region, Alberta for January 2015–December 2015

Reporting on the
Surface Water Quality Management Framework
Lower Athabasca Regional Plan

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About EMSD

The Environmental Monitoring and Science Division (EMSD) is responsible for monitoring, evaluating and reporting on key air, water, land and biodiversity indicators. The division's mandate is to provide open and transparent access to scientific data and information on the condition of Alberta's environment, including specific indicators as well as cumulative effects, both provincially and in specific locations.

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Executive Summary

BACKGROUND

Prepared by Alberta Environment and Parks (AEP) – Environmental Monitoring and Science Division, this report presents monthly water quality results from the Old Fort monitoring station, Athabasca River, Alberta for 2015. These data are provided to fulfill reporting requirements mandated by the Surface Water Quality Management Framework, which supports the Lower Athabasca Regional Plan (LARP).

Reporting requirements for the LARP are determined by the Government of Alberta. The Environmental Monitoring and Science Division of AEP is responsible for monitoring, evaluation and reporting under the Environmental Management Frameworks, including the Surface Water Quality Management Framework.

Information provided in this report is compared to triggers and limits established in the Surface Water Quality Management Framework. Analysis and reporting methods are provided in this management framework.

2015 RESULTS SUMMARY

For 2015, a total of 38 water quality indicators were measured monthly at the Old Fort water quality monitoring station. The results were then compared to triggers and limits set within the Surface Water Quality Management Framework.

- No limits were exceeded.
- Level 2 annual mean triggers were exceeded for sulphate, dissolved uranium and dissolved strontium.
- A level 2 annual peak trigger was exceeded for dissolved uranium.

Lower Athabasca Regional Plan (LARP)

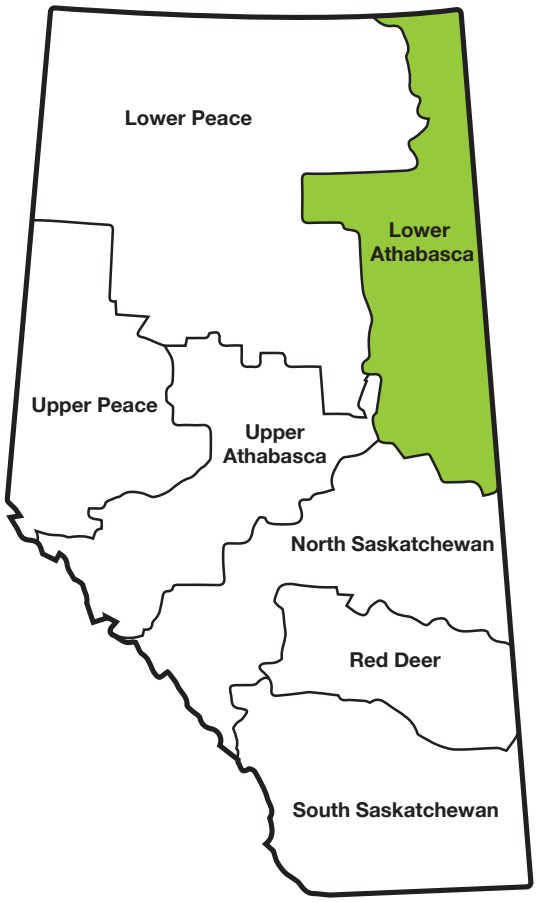
The Lower Athabasca Regional Plan is a management plan developed by the Government of Alberta under the Land Use Framework. The plan sets outcomes that describe what the Government of Alberta wants to accomplish at a regional level, and is given legislative authority under the Alberta Land Stewardship 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 Environmental Monitoring and Science Division of Alberta Environment and Parks is responsible for the monitoring, assessing and reporting on the condition of the environment in the Lower Athabasca Region, while other sections of the Government of Alberta are responsible for management of activities and resources in response to environmental conditions.

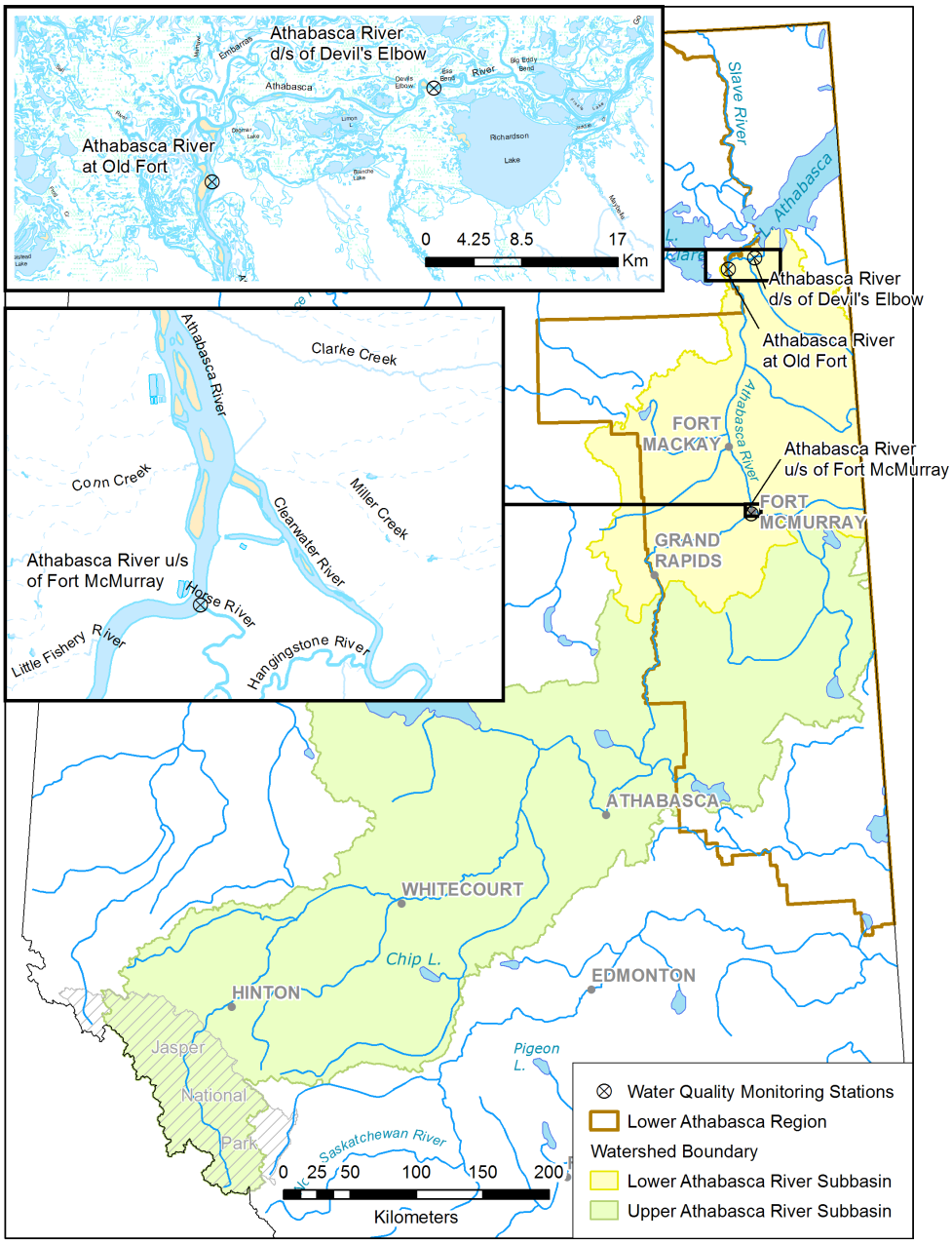
Figure 1: *Land Use Framework Regions of Alberta*



MONITORING STATIONS

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 Management Framework, Alberta Environment and Parks set ambient surface water quality 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 the entry of the Athabasca River into the Peace Athabasca Delta.

Figure 2: *Location of AEP Long-term River Network (LTRN) Water Quality Stations on the Athabasca River*



Alberta Environment and Parks

Surface Water Quality Indicators, Triggers and Limits

The Surface Water Quality Management Framework identifies 38 surface water quality indicators 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 Management 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 Management 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) of historical data. Surface water quality limits are derived from provincial water quality guidelines. Surface water triggers and limits 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 2015. Sample collection and analysis followed standards and protocols established by Alberta Environment and Parks. The calculation of summary statistics and the statistical analysis employed are prescribed by Alberta Environment and Parks within Appendix B of the Surface Water Quality Management Framework.

Summary statistics for the general and metal water quality indicators are presented in Appendix B of this report (Table B1 and Table B2). The 2015 data are also presented graphically in relation to historical data in Figures B1 and B2.

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

ANNUAL MEANS COMPARED TO MEAN TRIGGERS

In 2015, a total of 12 of the 38 surface water quality indicators had annual mean values higher than the mean triggers established in the Surface Water Quality Management Framework. These 12 indicators were then subject to further statistical evaluation. The determination of whether observed changes deviated significantly from mean triggers was evaluated using parametric Welch's two-sample t-tests. In addition to the use of parametric t-tests, the Surface Water Quality Management Framework mandates the use of an additional, more conservative non-parametric comparison (the Wilcoxon-Mann-Whitney test). Of the 12 water quality indicators that had annual mean values higher than the mean triggers, eight met the assumptions of using parametric statistical methods while the remaining four did not meet the assumptions of parametric testing.

The difference in means was statistically significant ($p<0.05$) in two of the water quality indicators (dissolved uranium and dissolved strontium) that met the required assumptions for parametric statistics (Table 2). In addition, a statistically significant difference between the mean trigger and the 2015 mean value (tested for using the non-parametric Wilcoxon-Mann-Whitney test) was found for sulphate (Table 2).

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 at statistically significant levels (Tables 3 and 4; Table A2). In 2015, 10 water quality indicators had one or more observations in excess of the peak triggers established in the Surface Water Quality Management Framework. However, only dissolved uranium had a statistically significant number of samples with measured concentrations in excess of the peak triggers. Dissolved uranium exceeded the peak trigger on three different occasions (Table 4).

AMBIENT SURFACE WATER QUALITY LIMITS

None of the limits established in the Surface Water Quality Management Framework were exceeded in 2015 (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 Management Framework.*

GENERAL INDICATORS	UNITS	MEAN TRIGGER	2015 MEAN
Calcium (Ca^{2+})	mg/L	34.7	35.9
Chloride (Cl^{-})	mg/L	20.2	21.2
Magnesium (Mg^{+})	mg/L	9.5	10.5
Nitrate (NO_3-N)	mg/L	0.092	0.084
Potassium (K^{+})	mg/L	1.4	1.4
Sodium (Na^{+})	mg/L	21.5	22.9
Sulphate (SO_4^{-})	mg/L	26.7	33.4
Total Ammonia (NH_{3+4}-N)	mg/L	0.05	0.04
Total Dissolved Phosphorus (TDP)	mg/L	0.016	0.010
Total Nitrogen (TN)	mg/L	0.597	0.499
Total Phosphorus (TP)	mg/L	0.074	0.046

		Dissolved		Total	
METAL INDICATORS	UNITS	MEAN TRIGGER	2015 MEAN	MEAN TRIGGER	2015 MEAN
Aluminum	µg/L	16	8	1533	1480
Antimony	µg/L	0.107	0.065	0.148	0.068
Arsenic	µg/L	0.5	0.4	1.1	0.8
Barium	µg/L	52.6	49.8	79.3	66.5
Beryllium	µg/L	---	---	0.077	0.044
Bismuth	µg/L	---	---	0.0172	0.0063
Boron	µg/L	26	27	48	29
Cadmium	µg/L	0.0997	0.0105	0.3	0.0
Chromium	µg/L	0.41	0.18	3	1
Cobalt	µg/L	0.07	0.07	0.8	0.4
Copper	µg/L	1.6	0.9	3.1	1.6
Iron	µg/L	185	129	1899	1824
Lead	µg/L	0.56	0.04	3.3	0.6
Lithium	µg/L	6	7	9	1
Manganese	µg/L	12	12	65	47
Mercury	µg/L	---	---	0.0051	0.0023
Molybdenum	µg/L	0.7	0.6	0.9	0.7
Nickel	µg/L	1.6	0.6	3.4	1.3
Selenium	µg/L	0.229	0.130	0.333	0.173
Silver	µg/L	---	---	0.0243	0.0079
Strontium	µg/L	215	240	225	246
Thallium	µg/L	0.0238	0.0066	0.0546	0.0257

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

		Dissolved		Total	
METAL INDICATORS	**UNITS**	**MEAN TRIGGER**	**2015 MEAN**	**MEAN TRIGGER**	**2015 MEAN**
Thorium	µg/L	0.0284	0.0190	0.35	0.15
Titanium	µg/L	2	1	30	13
Uranium	µg/L	0.313	0.369	0.4	0.4
Vanadium	µg/L	0.45	0.22	4.4	3.0
Zinc	µg/L	4.5	4.5	12.3	8.5

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 2015**
Calcium (Ca^{2+})	mg/L	48.9	43.0	0
Chloride (Cl^{-})	mg/L	45	51	1
Magnesium (Mg^{+})	mg/L	13.7	12.0	0
Nitrate (NO_3-N)	mg/L	0.264	0.250	0
Potassium (K^{+})	mg/L	2.1	2.5	1
Sodium (Na^{+})	mg/L	43.7	43.0	0
Sulphate (SO_4^{-})	mg/L	41.4	41.0	0
Total Ammonia (NH_{3+4}-N)	mg/L	0.12	0.08	0
Total Dissolved Phosphorus (TDP)	mg/L	0.032	0.020	0
Total Nitrogen (TN)	mg/L	1.041	0.910	0
Total Phosphorus (TP)	mg/L	0.261	0.150	0

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

		Dissolved			Total		
METAL INDICATOR	**UNITS**	**PEAK TRIGGER**	**2015 MAXIMUM VALUE**	**NUMBER OF OCCURRENCES HIGHER THAN TRIGGER IN 2015**	**PEAK TRIGGER**	**2015 MAXIMUM VALUE**	**NUMBER OF OCCURRENCES HIGHER THAN TRIGGER IN 2015**
Aluminum	µg/L	49	21	0	6454	5690	0
Antimony	µg/L	0.202	0.118	0	0.388	0.125	0
Arsenic	µg/L	0.7	0.5	0	2.5	1.7	0
Barium	µg/L	73.7	61.1	0	147.6	107.0	0
Beryllium	µg/L	---	0.016	0	0.269	0.168	0
Bismuth	µg/L	---	0.009	0	0.0564	0.0270	0
Boron	µg/L	40	38	0	69	42	0
Cadmium	µg/L	0.515	0.018	0	1.2	0.1	0
Chromium	µg/L	0.65	0.30	0	8	5	0
Cobalt	µg/L	0.11	0.13	1	2.2	1.5	0
Copper	µg/L	3.6	1.9	0	7.2	4.2	0
Iron	µg/L	372	245	0	5821	7250	1
Lead	µg/L	0.56	0.12	0	7	3	0
Lithium	µg/L	9	9	2	12	10	0
Manganese	µg/L	36	45	1	141	91	0
Mercury	µg/L	---	---	0	0.0159	0.0065	0
Molybdenum	µg/L	1.2	0.8	0	1.6	0.8	0
Nickel	µg/L	4.7	1.1	0	8.2	4.4	0
Selenium	µg/L	0.409	0.240	0	0.581	0.280	0
Silver	µg/L	---	0.004	0	0.0677	0.0200	0
Strontium	µg/L	361	340	0	361	340	0
Thallium	µg/L	0.1137	0.015	0	0.1751	0.0915	0
Thorium	µg/L	0.0942	0.0575	0	1.44	0.62	0
Tin	µg/L	---	0.097	0	---	0.098	0
Titanium	µg/L	7	3	0	104	33	0
Uranium	µg/L	0.381	0.492	3	0.7	0.7	1
Vanadium	µg/L	0.698	0.480	0	16	12	0
Zinc	µg/L	12.4	27.1	2	25.6	33.9	1

Appendix A

STATISTICAL METHODS USED TO ASSESS MEAN AND PEAK TRIGGERS

The Surface Water Quality Management Framework includes 38 indicators with 61 mean trigger values and 61 peak trigger values. 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 general indicators were analysed by Maxxam Analytics and the metal indicators by Alberta Innovates Technology Futures.

The 2015 data 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 water quality triggers from 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 2015 water quality indicator means are not different from the historical means (i.e., mean triggers). These tests were only conducted when the 2015 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), 12 annual means were higher than the historical mean triggers. All 12 means were consequently examined statistically. Parametric and non-parametric test results were consistent for all the indicators tested (Table A1), with the exception of dissolved strontium which was statistically significant using a t-test, but not using the Wilcoxon rank sum test. Only indicators with 2015 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 2015 Data Against the Ambient Mean Surface Water Quality Triggers*

			Welch's two sample t-test			Wilcoxon rank sum test	
INDICATOR	**MEAN TRIGGER**	**2015 MEAN**	**T-STATISTIC**	**DF**	**P-VALUE**	**W-STATISTIC**	**P-VALUE**
General Indicators							
Calcium (Ca^{+})	34.7	35.9	0.798	14.03	0.438	1592.5	0.455
Chloride (Cl^{-})*	20.2	21.2	0.816	12.86	0.215	1549	0.285
Magnesium (Mg^{+})	9.5	10.5	2.098	13.77	0.0549	1839.5	0.075
Potassium (K^{+})	1.4	2.5	0.206	12.86	0.42	1490.5	0.371
Sodium (Na^{+})*	21.5	43	0.969	12.9	0.175	0.371	0.24
Sulphate (SO_4^{-})	26.7	41	3.56	13.89	0.0016	2037	0.00412
Metal Indicators							
Boron D	26	27.71	0.768	24.11	0.225	344	0.186
Lithium D	6	6.9	1.28	18.6	0.108	364	0.104
Strontium D*	215	240.8	1.88	26.68	0.0359	381.5	0.0571
Strontium T	225	245.5	1.09	26.47	0.142	386.5	0.0810
Uranium D	0.313	0.37	3.34	23.87	0.00136	316.5	0.00198
Uranium T	0.4	0.42	0.0551	23.42	0.478	308.5	0.525

Note: p-value=level of significance, D=dissolved, T=total.

Blue highlighted values indicate statistical significance.

**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 2015 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 (Table 3 and A2).

Table A2: *Results of the Statistical Assessment of the 2015 Data Against the Ambient Peak Surface Water Quality Triggers*

INDICATOR	**PEAK TRIGGER**	**NUMBER OF OCCURRENCES HIGHER THAN TRIGGER**	**BINOMIAL TEST VALUE**
General Indicators			
Chloride (Cl^{-})	45	1	0.460
Potassium (K^{+})	2.1	1	0.460
Metal Indicators			
Cobalt D	0.11	1	0.460
Iron T	5821	1	0.460
Lithium D	9	2	0.118
Manganese D	36	1	0.460
Uranium D	0.381	3	0.0196
Uranium T	0.7	1	0.460
Zinc D	12.4	2	0.118
Zinc T	25.6	1	0.460

Note: Blue highlighted 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 2015 Data Against Surface Water Quality Limits*

INDICATOR	UNIT	SURFACE WATER QUALITY LIMIT	SAMPLE SIZE	PERCENT OF 2015 SAMPLES HIGHER THAN A LIMIT	2015 MEAN
General Indicators					
Calcium (Ca^{2+})	mg/L	1000	12	None	35.9
Chloride (Cl^{-})	mg/L	100	12	None	21.2
Sodium (Na^{+})	mg/L	200	12	None	22.9
Sulphate (SO_4^{-})	mg/L	500	12	None	33.4
Total Ammonia (NH_{3+4}-N)	mg/L	Varies with pH and temperature*	12	None	0.042
Nitrate (NO_3-N)	mg/L	2.9	12	None	0.08
Metal Indicators					
Antimony T	µg/L	6	12	None	0.068
Arsenic T	µg/L	5	12	None	0.8
Barium T	µg/L	1000	12	None	66.5
Beryllium T	µg/L	100	12	None	0.044
Boron T	µg/L	500	12	None	29.6
Chromium T	µg/L	50	12	None	1.4
Cobalt T	µg/L	50	12	None	0.42
Lithium T	µg/L	2500	12	None	7.7
Molybdenum T	µg/L	10	12	None	0.65
Nickel T	µg/L	Varies with hardness*	12	None	1.3
Selenium T	µg/L	1	12	None	0.17
Silver T	µg/L	0.1	12	None	0.0079
Thallium T	µg/L	0.8	12	None	0.026
Uranium T	µg/L	10	12	None	0.42
Vanadium T	µg/L	100	12	None	3

Note: T=total

Table A4: *Calculated Total Ammonia and Total Nickel Limits for 2015 Samples*

SAMPLE DATE	WATER TEMPERATURE (ºC)	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)
14/01/2015*	0.2	6.82	0.077	6.26	150	0.828	74
13/02/2015*	-0.21	7.46	0.083	4.51	160	0.633	78
10/03/2015*	-0.1	6.75	0.05	6.37	140	0.691	69
15/04/2015*	0.1	7.61	0.077	3.94	120	4.36	61
13/05/2015	12.96	8.16	0.05	1.91	100	1.86	52
17/06/2015	16.72	8.2	0.05	1.56	120	2.25	61
21/07/2015	20.23	7.99	0.05	1.71	110	1.42	57
11/08/2015	21.93	8.04	0.05	1.42	120	2.07	61
22/09/2015	9.36	7.95	0.05	2.61	130	0.769	65
20/10/2015	6.66	8.05	0.05	2.26	140	0.559	69
17/11/2015	-0.04	7.48	0.05	4.44	150	0.366	74
08/12/2015*	-0.11	6.77	0.067	6.34	150	0.098	74

**These samples taken downstream of Devil's Elbow, as opposed to at Old Fort, due to accessibility limitations*

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Appendix B

Summary Statistics for the 2015 Data from the Athabasca River at Old Fort Monitoring Station

Table B1: *Summary Statistics for the 2015 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 (Ca^{2+})	12	43	27	36	35.92	42.98	42.78	41.9	24.81	4.98
Chloride (Cl^{-})	12	51	6.7	19.5	21.19	50.76	48.58	38.9	154.91	12.45
Magnesium (Mg^{+})	12	12	8.6	11	10.49	12	12	12	2.44	1.56
Nitrate (NO_3-N)	12	0.25	0.0015	0.0425	0.084	0.25	0.25	0.23	0.0093	0.097
Nitrite (NO_2-N)	12	0.0032	0.0015	0.0015	0.0016	0.0032	0.0030	0.0023	2.41E-07	0.00049
Nitrogen NO_3+NO_2	12	0.25	0.0015	0.0425	0.085	0.25	0.25	0.23	0.0095	0.10
Nitrogen Total Kjeldahl (TKN)	12	0.72	0.2	0.385	0.42	0.72	0.71	0.66	0.024	0.15
pH	12	8.2	6.75	7.78	7.61	8.20	8.20	8.18	0.31	0.56
Potassium (K^{+})	12	2.5	0.7	1.25	1.40	2.49	2.42	2.12	0.25	0.50
Sodium (Na^{+})	12	43	8.6	20.5	22.88	42.87	41.68	36.4	95.29	9.76
Strontium D	12	340	163	245.5	240.83	339.52	335.16	315.8	2701.79	51.98
Strontium T	12	340	165	249.5	245.5	339.53	335.27	316.35	2657	51.55
Sulphate (SO_4-)	12	41	23	35.5	33.42	40.99	40.89	40.45	37.54	6.13
Temperature Water	12	21.93	-0.21	3.43	7.31	21.91	21.74	20.99	75.35	8.68
Total Ammonia (NH_{3+4}-N)	12	0.083	0.025	0.025	0.042	0.083	0.082	0.080	0.00064	0.0253
Total Dissolved Phosphorus (TDP)	12	0.02	0.0015	0.009	0.010	0.020	0.020	0.019	2.74E-05	0.0052
Total Phosphorus (TP)	12	0.15	0.007	0.031	0.046	0.15	0.14	0.11	0.0015	0.039

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

Table B2: *Summary Statistics for the 2015 Data from the Athabasca River at Old Fort Monitoring Station – Metal Indicators*

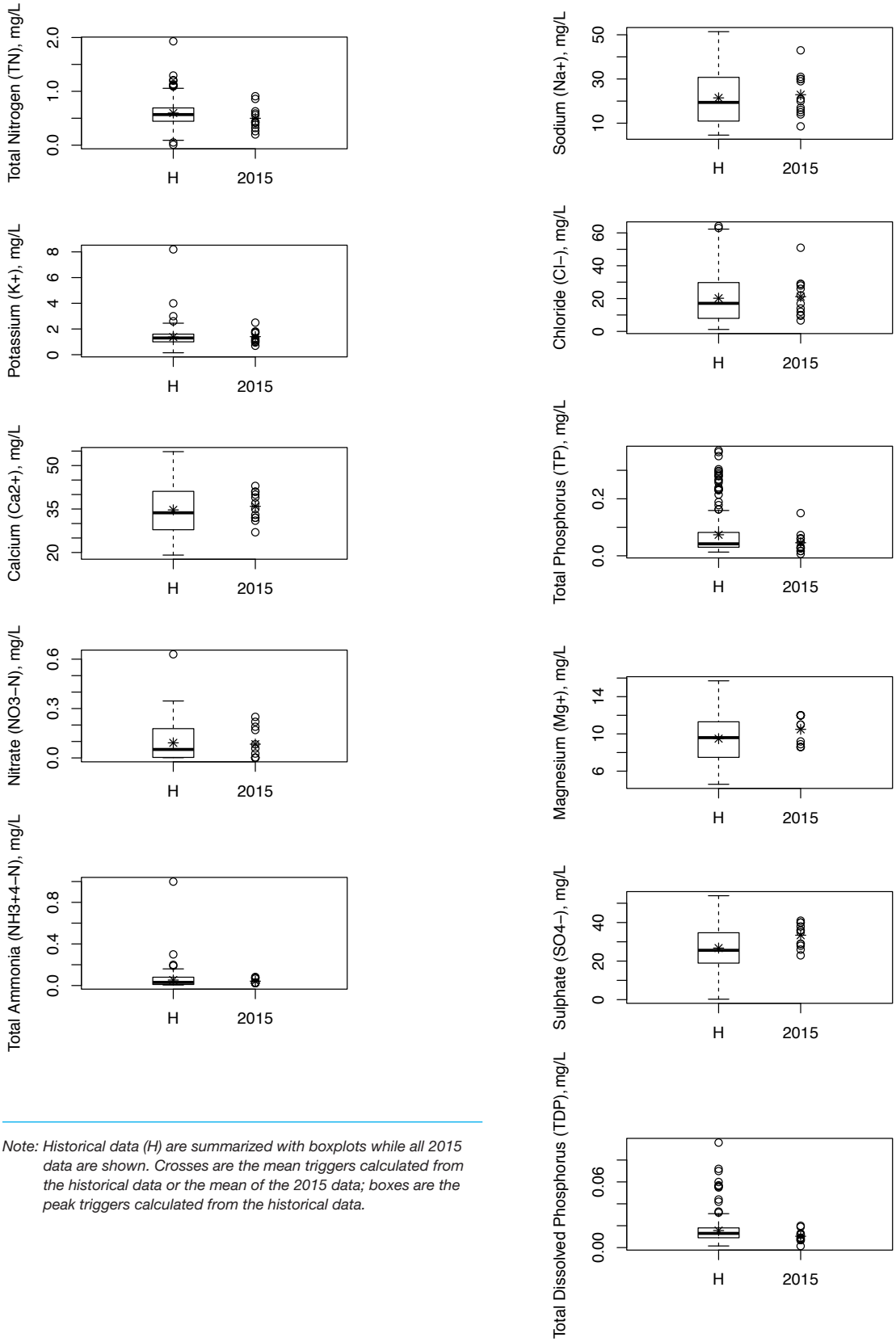
METAL INDICATOR	N	MAX	MIN	MEDIAN	MEAN	P99.9	P99	P95	VARIANCE	SD
Aluminum D	12	20.8	2.33	4.785	8.17	20.74	20.22	17.89	34.89	5.91
Aluminum T	12	5690	96	479	1480.5	5677.57	5565.7	5068.5	3512542.46	1874.18
Antimony D	12	0.118	0.034	0.054	0.065	0.12	0.12	0.11	0.00076	0.028
Antimony T	12	0.125	0.034	0.0605	0.068	0.12	0.12	0.12	0.00083	0.029
Arsenic D	12	0.515	0.337	0.4135	0.42	0.51	0.51	0.51	0.0035	0.059
Arsenic T	12	1.74	0.418	0.6085	0.8	1.73	1.68	1.44	0.15	0.39
Barium D	12	61.1	41.9	48.4	49.89	61.08	60.87	59.95	40.96	6.40
Barium T	12	107	51.2	61.95	66.51	106.75	104.47	94.35	237.19	15.40
Beryllium D	12	0.016	0.0045	0.0045	0.0065	0.016	0.015	0.013	1.52E-05	0.0039
Beryllium T	12	0.168	0.004	0.016	0.044	0.17	0.16	0.14	0.0026	0.051
Bismuth D	12	0.009	0.0015	0.0015	0.0032	0.0090	0.0088	0.0079	7.79E-06	0.0028
Bismuth T	12	0.027	5.00E-04	0.0035	0.0063	0.027	0.026	0.020	6.36E-05	0.0080
Boron D	12	37.6	15.4	28.15	27.71	37.57	37.27	35.95	43.40	6.59
Boron T	12	41.5	16.5	29.65	29.61	41.43	40.79	37.93	41.31	6.43
Cadmium D	12	0.018	0.004	0.01	0.011	0.018	0.018	0.017	1.61E-05	0.0040
Cadmium T	12	0.062	0.006	0.0245	0.025	0.062	0.060	0.050	0.00024	0.015
Chromium D	12	0.3	0.05	0.2	0.18	0.3	0.3	0.3	0.010	0.10
Chromium Hex	4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0	0
Chromium T	12	5.36	0.05	0.595	1.38	5.34	5.13	4.19	2.65	1.63
Cobalt D	12	0.129	0.001	0.0645	0.067	0.13	0.13	0.12	0.0011	0.034
Cobalt T	12	1.47	0.037	0.23	0.42	1.46	1.41	1.15	0.18	0.42
Copper D	12	1.87	0.54	0.805	0.93	1.86	1.81	1.59	0.15	0.39
Copper T	12	4.2	0.69	0.975	1.59	4.18	4.03	3.36	1.15	1.07
Iron D	12	245	29.4	160.5	129.73	244.56	240.6	223	5796.97	76.14
Iron T	12	7250	457	795.5	1824.08	7218.1	6931	5655	4147189.54	2036.46
Lead D	12	0.119	0.012	0.0285	0.044	0.12	0.12	0.10	0.0011	0.034
Lead T	12	2.6	0.076	0.2125	0.60	2.59	2.47	1.94	0.57	0.75

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	P99.9	P99	P95	VARIANCE	SD
Lithium D	12	9.49	4.3	6.65	6.9	9.49	9.46	9.35	2.93	1.71
Lithium T	12	9.6	5.65	7.685	7.69	9.60	9.57	9.46	1.85	1.36
Manganese D	12	45.3	0.56	6.965	12.18	45.07	42.99	33.75	188.16	13.72
Manganese T	12	90.7	26.6	37.75	46.74	90.45	88.16	77.99	404.14	20.10
Mercury T	12	0.00652	0.00062	0.00123	0.0023	0.0065	0.0063	0.0054	3.83E-06	0.0020
Molybdenum D	12	0.75	0.548	0.6125	0.64	0.75	0.75	0.75	0.0048	0.069
Molybdenum T	12	0.76	0.557	0.6205	0.65	0.76	0.76	0.76	0.0047	0.068
Nickel D	12	1.14	0.003	0.442	0.55	1.14	1.12	1.05	0.11	0.33
Nickel T	12	4.36	0.098	0.7985	1.33	4.34	4.13	3.20	1.40	1.18
Selenium D	12	0.24	0.02	0.135	0.13	0.24	0.236	0.22	0.0034	0.058
Selenium T	12	0.28	0.03	0.18	0.17	0.28	0.27	0.25	0.0040	0.064
Silver D	12	0.004	5.00E-04	0.001	0.0016	0.004	0.004	0.004	1.87E-06	0.0014
Silver T	12	0.02	0.001	0.0075	0.0079	0.020	0.020	0.018	3.77E-05	0.0061
Thallium D	12	0.015	2.00E-04	0.00595	0.0066	0.015	0.015	0.013	1.71E-05	0.0041
Thallium T	12	0.0915	0.00045	0.01325	0.026	0.091	0.087	0.070	0.00072	0.027
Thorium D	12	0.0575	4.00E-04	0.01225	0.019	0.057	0.056	0.049	0.00034	0.018
Thorium T	12	0.623	0.0131	0.06705	0.15	0.62	0.59	0.46	0.035	0.19
Tin D	12	0.097	0.0015	0.0195	0.026	0.096	0.091	0.068	0.00062	0.025
Tin T	12	0.098	0.0015	0.041	0.042	0.098	0.094	0.077	0.00056	0.024
Titanium D	12	3.45	0.52	1.19	1.43	3.44	3.39	3.13	0.78	0.88
Titanium T	12	33.1	2.46	8.36	13.43	33.07	32.81	31.67	136.06	11.66
Uranium D	12	0.492	0.308	0.361	0.37	0.49	0.48	0.44	0.0022	0.047
Uranium T	12	0.732	0.349	0.3895	0.42	0.73	0.70	0.59	0.010	0.10
Vanadium D	12	0.38	0.1	0.205	0.22	0.38	0.37	0.35	0.0090	0.095
Vanadium T	12	11.9	0.39	1.325	3.04	11.85	11.35	9.17	12.59	3.55
Zinc D	12	27.1	0.045	0.775	4.50	27.01	26.21	22.65	78.34	8.85
Zinc T	12	33.9	1.2	4.5	8.5	33.78	32.71	27.96	103.76	10.19

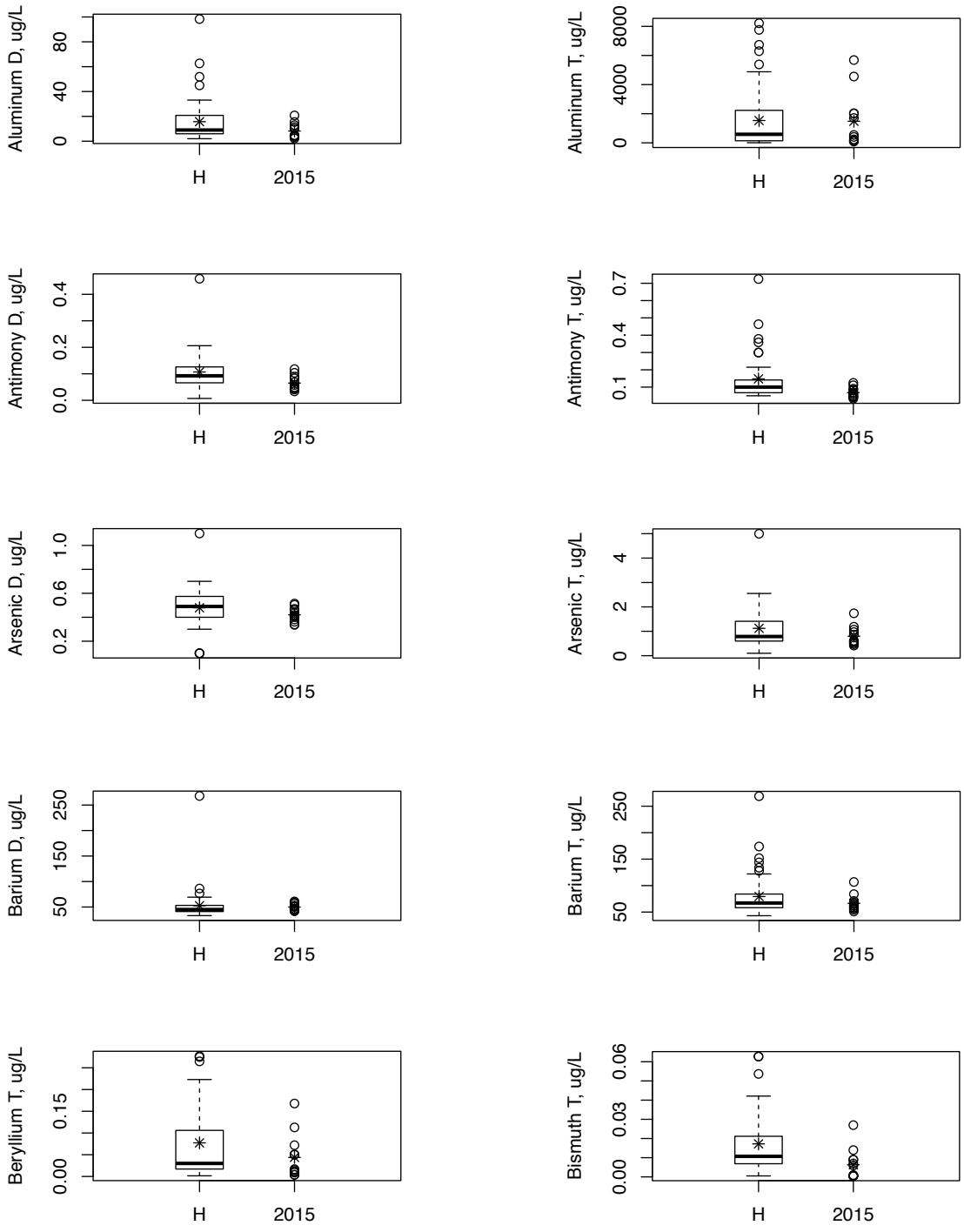
Note: All values are in mg/L; n= sample size, P= percentile, SD= standard deviation

Figure B1: *Graphical Presentations of the Historical and 2015 Data for the Athabasca River at Old Fort Monitoring Station (General Indicators)*

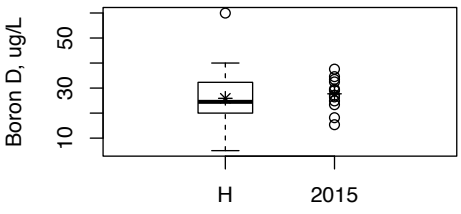


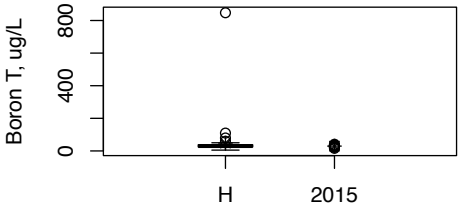
Note: Historical data (H) are summarized with boxplots while all 2015 data are shown. Crosses are the mean triggers calculated from the historical data or the mean of the 2015 data; boxes are the peak triggers calculated from the historical data.

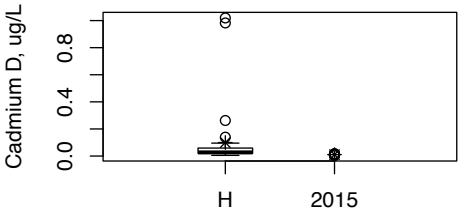
Figure B2: *Graphical Presentations of the Historical and 2015 Data for the Athabasca River at Old Fort Monitoring Station (Metal Indicators)*

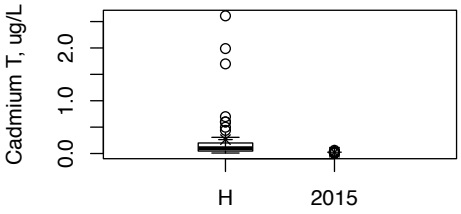


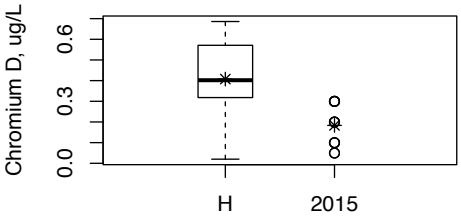
Note: Historical data (H) are summarized with boxplots while all 2015 data are shown. Crosses are the mean triggers calculated from the historical data or the mean of the 2015 data; boxes are the peak triggers calculated from the historical data.

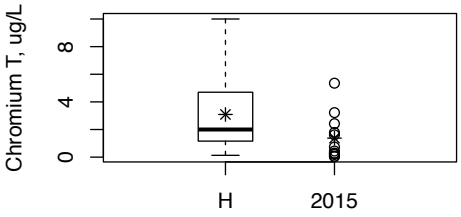

Boron D, ug/L
10
30
50
H
2015

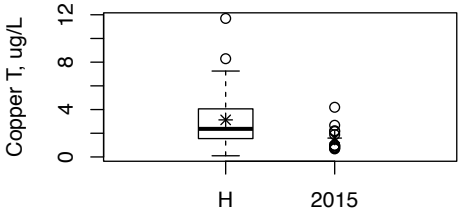

Boron T, ug/L
0
400
800
H
2015

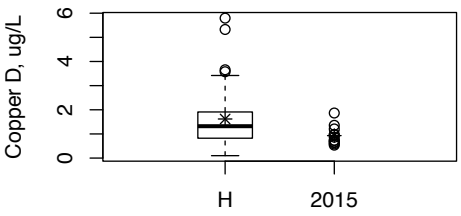

Cadmium D, ug/L
0.0
0.4
0.8
H
2015

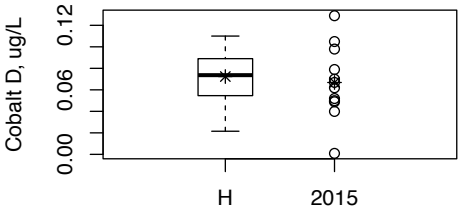

Cadmium T, ug/L
0.0
1.0
2.0
H
2015

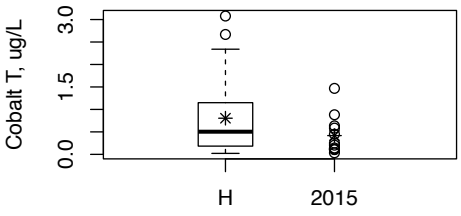

Chromium D, ug/L
0.0
0.3
0.6
H
2015

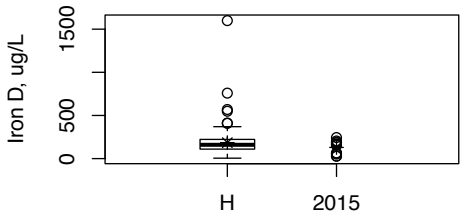

Chromium T, ug/L
0
4
8
H
2015

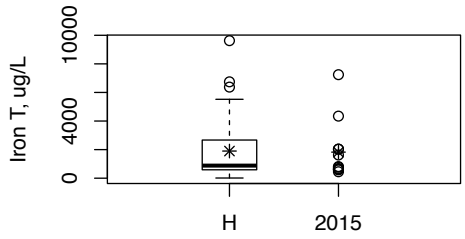

Copper T, ug/L
0
4
8
12
H
2015

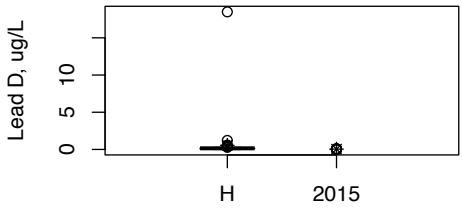

Copper D, ug/L
0
2
4
6
H
2015

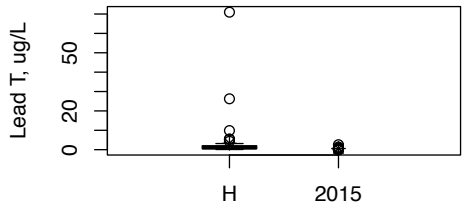

Cobalt D, ug/L
0.00
0.06
0.12
H
2015

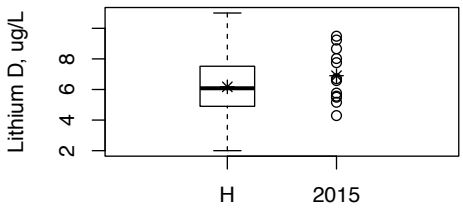

Cobalt T, ug/L
0.0
1.5
3.0
H
2015

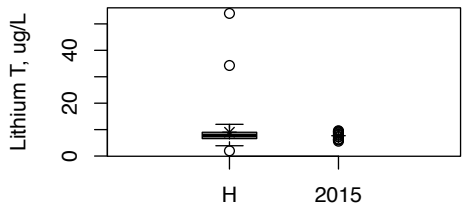

Iron D, ug/L
0
500
1500
H
2015

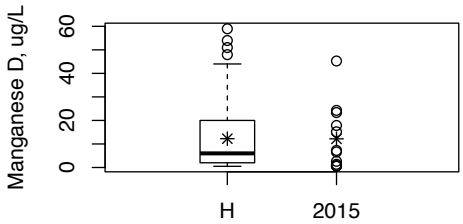

Iron T, ug/L
0
4000
10000
H
2015

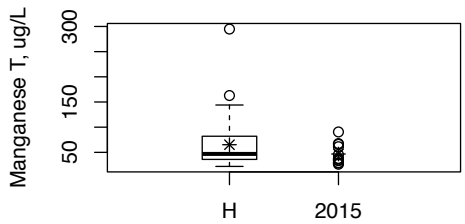

Lead D, ug/L
0
5
10
H
2015

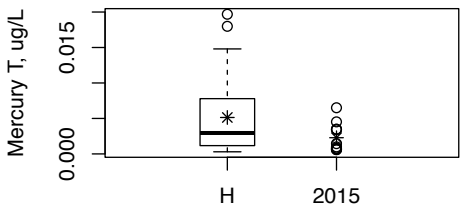

Lead T, ug/L
0
20
50
H
2015

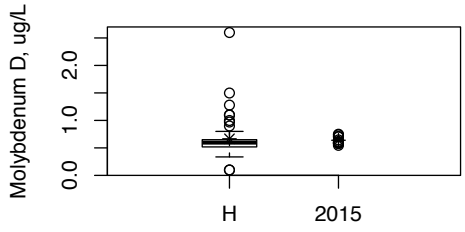

Lithium D, ug/L
2
4
6
8
H
2015

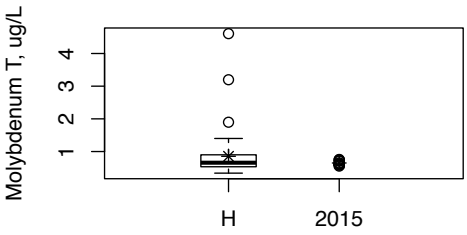

Lithium T, ug/L
0
20
40
H
2015

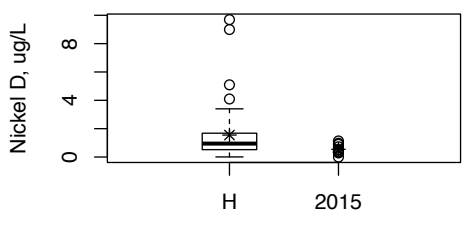

Manganese D, ug/L
0
20
40
60
H
2015

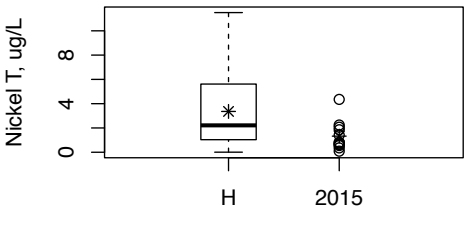

Manganese T, ug/L
50
150
300
H
2015

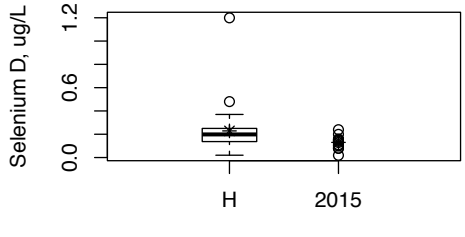

Mercury T, ug/L
0.000
0.015
H
2015

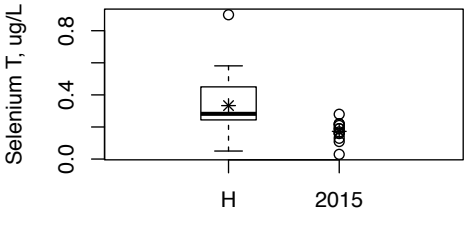

Molybdenum D, ug/L
0.0
1.0
2.0
H
2015

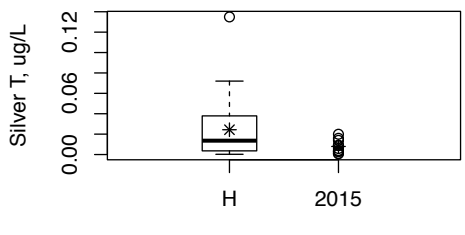

Molybdenum T, ug/L
1
2
3
4
H
2015

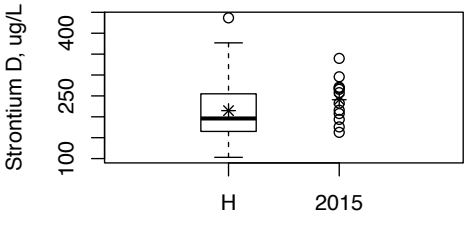

Nickel D, ug/L
0
4
8
H
2015

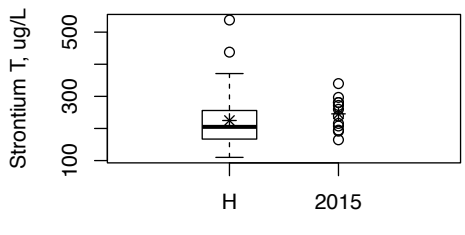

Nickel T, ug/L
0
4
8
H
2015

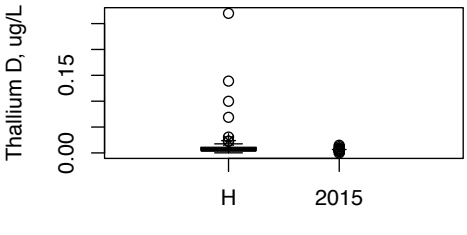

Selenium D, ug/L
0.0
0.6
1.2
H
2015

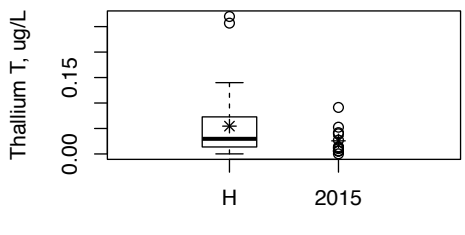

Selenium T, ug/L
0.0
0.4
0.8
H
2015

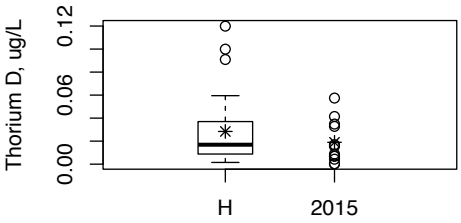

Silver T, ug/L
0.00
0.06
0.12
H
2015

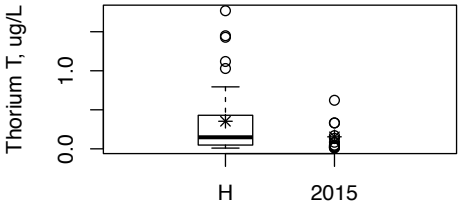

Strontium D, ug/L
100
250
400
H
2015

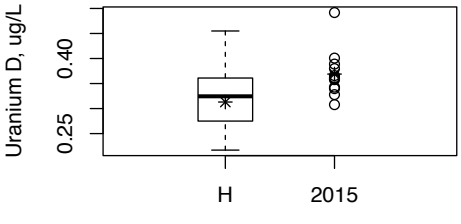

Strontium T, ug/L
100
300
500
H
2015

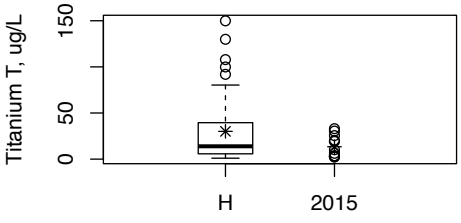

Thallium D, ug/L
0.00
0.15
H
2015

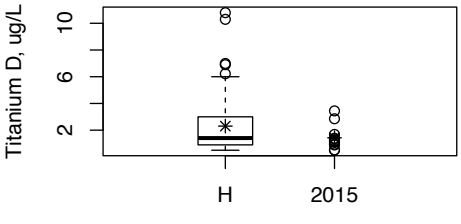

Thallium T, ug/L
0.00
0.15
H
2015

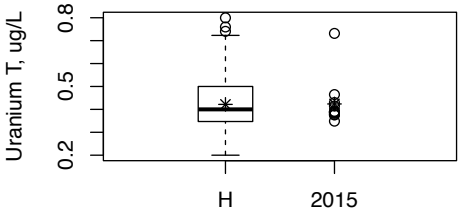

Thorium D, ug/L
0.00
0.06
0.12
H
2015

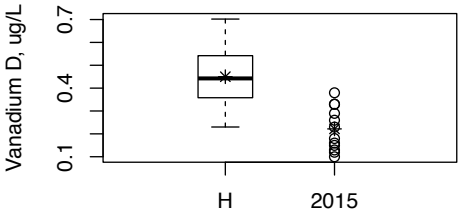

Thorium T, ug/L
0.0
1.0
H
2015

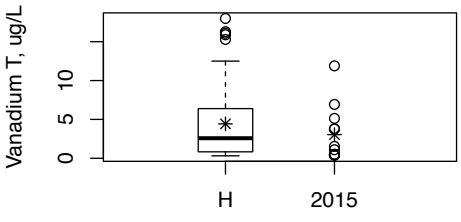

Uranium D, ug/L
0.25
0.40
H
2015

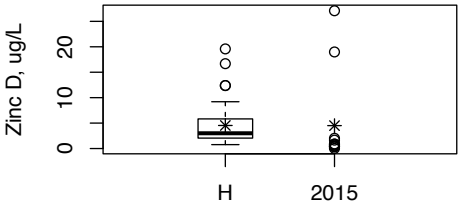

Titanium T, ug/L
0
50
150
H
2015

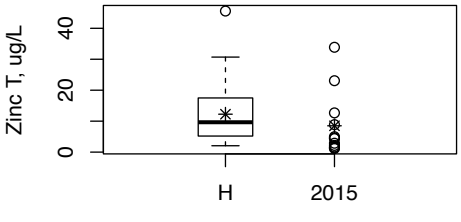

Titanium D, ug/L
2
6
10
H
2015


Uranium T, ug/L
0.2
0.5
0.8
H
2015


Vanadium D, ug/L
0.1
0.4
0.7
H
2015


Vanadium T, ug/L
0
5
10
H
2015


Zinc D, ug/L
0
10
20
H
2015


Zinc T, ug/L
0
20
40
H
2015