Sulphur Dioxide Environmental Effects Monitoring for the Kitimat Modernization Project

Volume 2: 2019 Comprehensive Review Report Technical Appendices, V.3 Final

[Appendices 4, 5, and 6: Human Health, Vegetation, and Terrestrial Ecosystems (Soils)]

October 15, 2020

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Version Tracking Table

No.	Date	Summary of content /changes
V.1	October 31, 2019	Draft appendix for review by the B.C. Ministry of Environment and Climate Change Strategy
V.2	June 30, 2020	Draft appendix for KPAC review
V.3	October 15, 2020	Final appendix

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Volume 2: Technical Appendices of the 2019 Comprehensive Review of Sulphur Dioxide Environmental Effects Monitoring for the Kitimat Modernization Project, V.3 Final, is packaged in four parts: Appendix 1; Appendix 3; Appendices 4, 5 and 6; and Appendix 7. Each Technical Appendix is numbered according to the chapter in the Comprehensive Review Report (Volume 1) that it supports. There is no Appendix 2 as there is no appendix material for Section 2 in the Comprehensive Review Report.

Please cite this report as follows:

ESSA Technologies, J. Laurence, Risk Sciences International, Trent University, and Trinity Consultants. 2020. 2019 Comprehensive Review of Sulphur Dioxide Environmental Effects Monitoring for the Kitimat Modernization Project – Volume 2: Technical Appendices (Appendices 4, 5 and 6), V.3 Final. Prepared for Rio Tinto, B.C. Works, Kitimat, British Columbia.

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4 Appendix to Section 4 of the Comprehensive Review Report: Human Health

4.1 Histograms of Hourly SO_2 Concentrations for 2016 and 2017

The main body of the report contains histograms of hourly SO_2 concentrations for the year 2018 for each of the three residential monitoring stations.

This appendix contains the same type of histograms, but for the years 2016 and 2017.

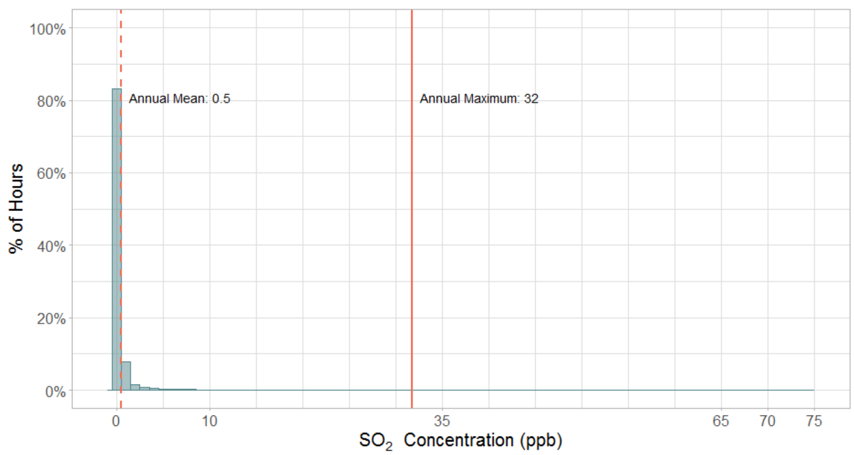

Figure 4.1: Histogram of Hourly Averaged SO_2 Concentrations (Riverlodge, 2016).

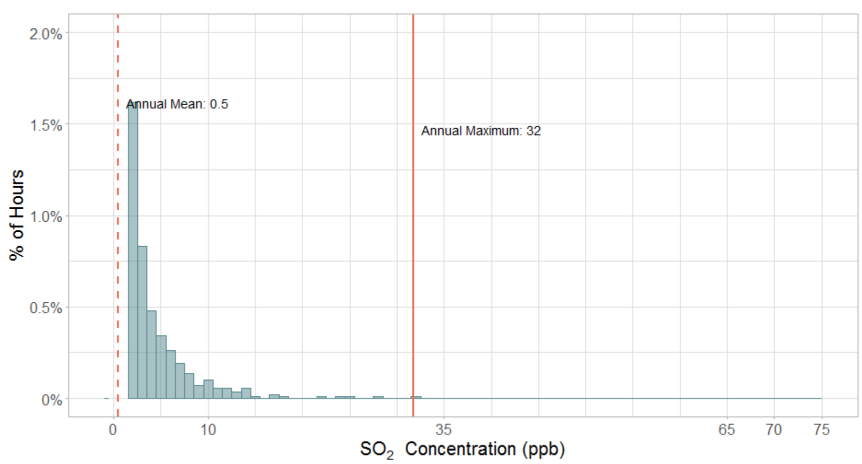

Figure 4.2: Histogram of Hourly SO_2 concentrations with y-axis cut off at 2% (Riverlodge, 2016). Note: The first two histogram bars are not shown because they exceed the limit of the y-axis.

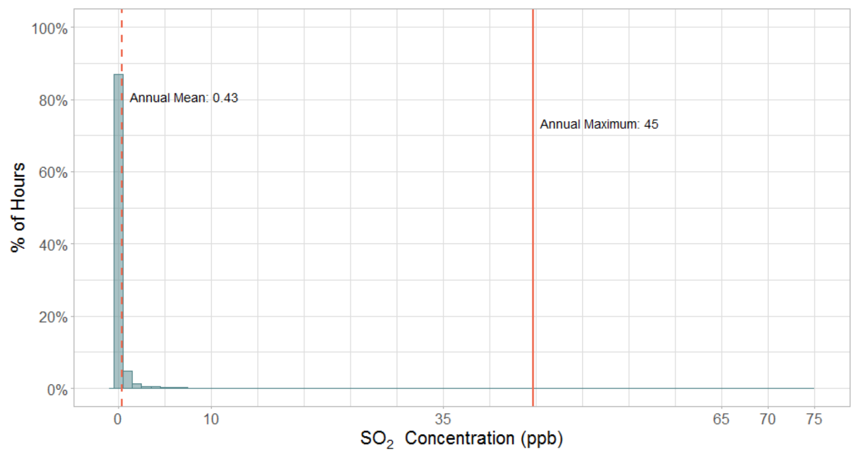

Figure 4.3: Histogram of Hourly Averaged SO_2 Concentrations (Riverlodge, 2017).

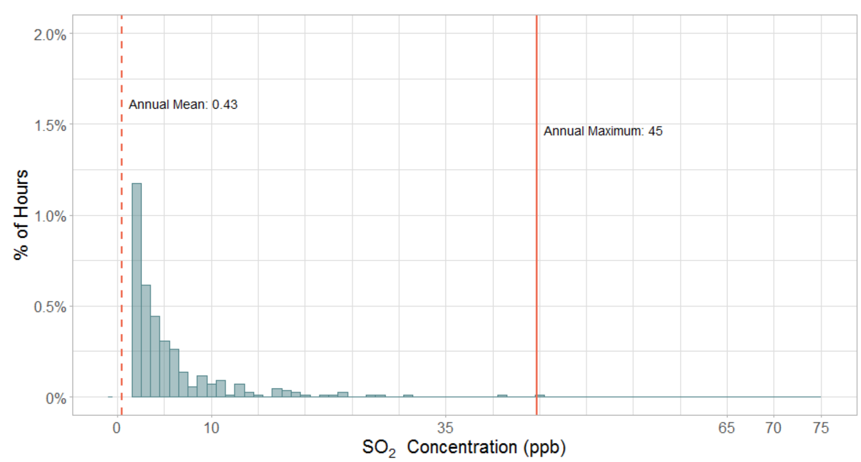

Figure 4.4: Histogram of Hourly SO_2 concentrations with y-axis cut off at 2% (Riverlodge, 2017). Note: The first two histogram bars are not shown because they exceed the limit of the y-axis.

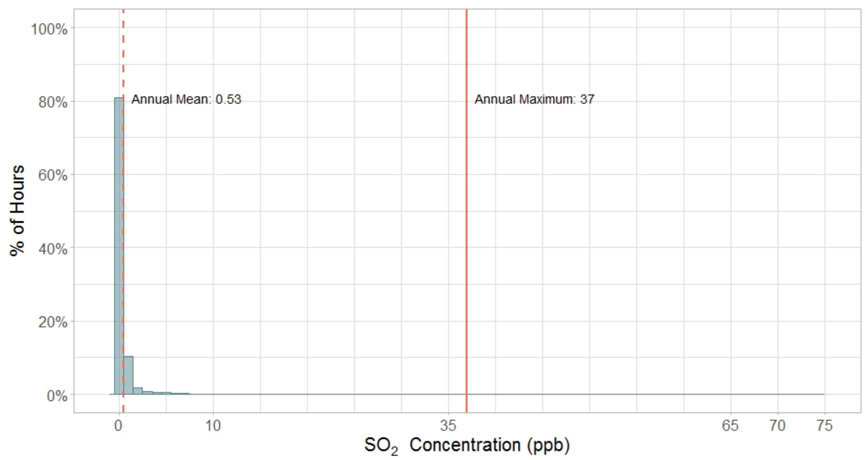

Figure 4.5: Histogram of Hourly Averaged SO_2 Concentrations (Whitesail, 2016).

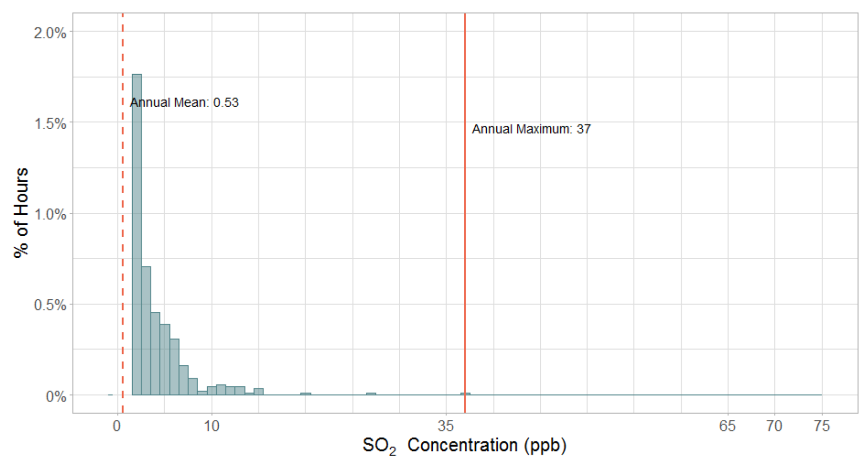

Figure 4.6: Histogram of Hourly SO_2 concentrations with y-axis cut off at 2% (Whitesail, 2016). Note: The first two histogram bars are not shown because they exceed the limit of the y-axis.

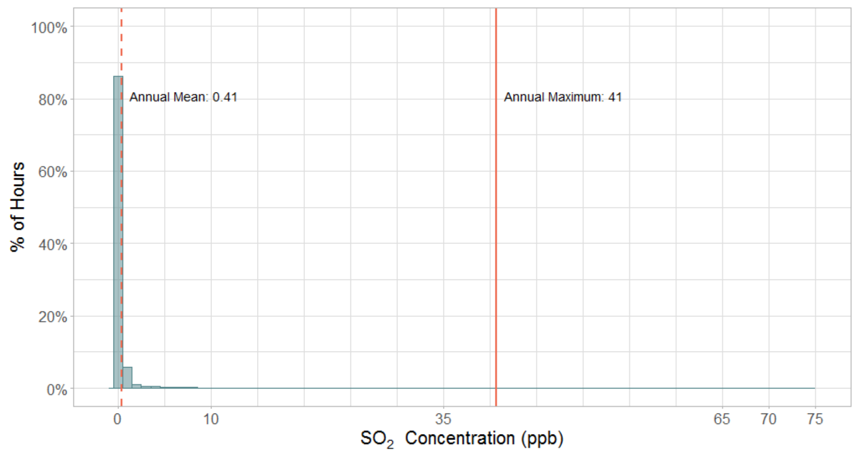

Figure 4.7: Histogram of Hourly Averaged SO_2 Concentrations (Whitesail, 2017).

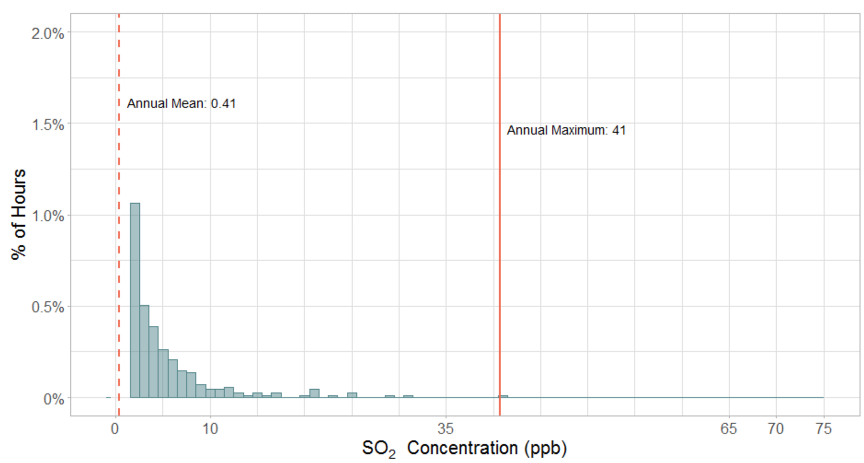

Figure 4.8: Histogram of Hourly SO_2 concentrations with y-axis cut off at 2% (Whitesail, 2017). Note: The first two histogram bars are not shown because they exceed the limit of the y-axis.

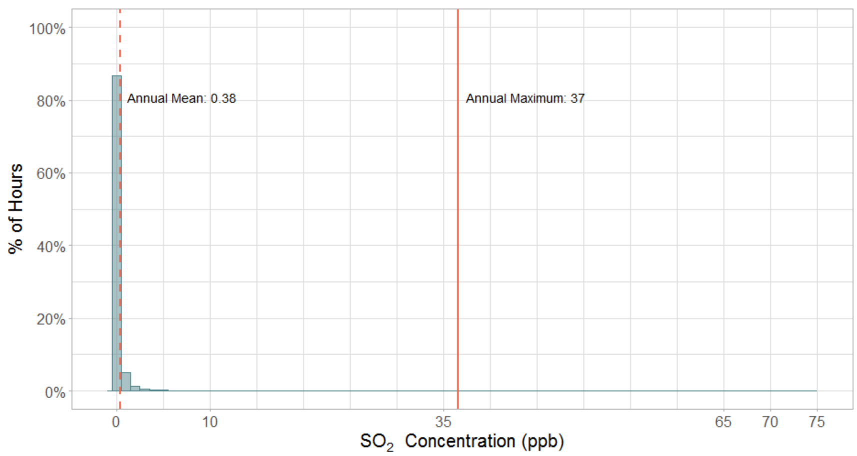

Figure 4.9: Histogram of Hourly Averaged SO_2 Concentrations (Kitamaat Village, 2016).

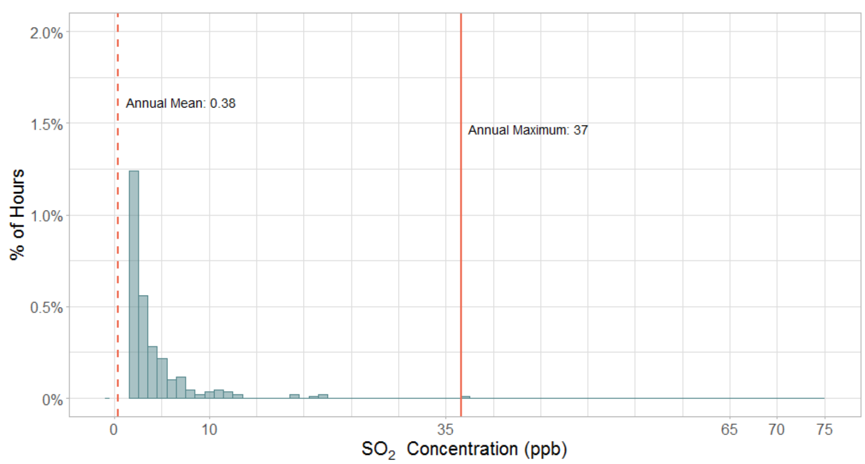

Figure 4.10: Histogram of Hourly SO_2 concentrations with y-axis cut off at 2% (Kitamaat Village, 2016). Note: The first two histogram bars are not shown because they exceed the limit of the y-axis..

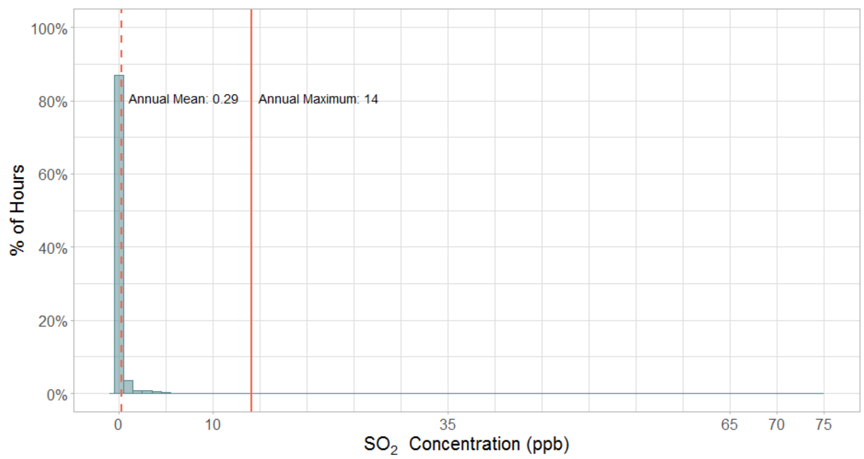

Figure 4.11: Histogram of Hourly Averaged SO_2 Concentrations (Kitamaat Village, 2017).

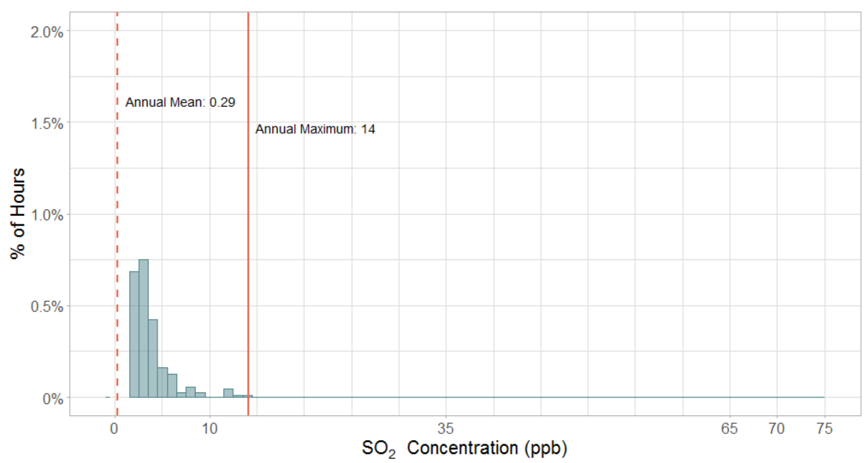

Figure 4.12: Histogram of Hourly SO_2 concentrations with y-axis cut off at 2% (Kitamaat Village, 2017). Note: The first two histogram bars are not shown because they exceed the limit of the y-axis.

4.2 Histograms of Daily 1-Hour Maximum SO_2 Concentrations for 2016 and 2017

The main body of the report contains histograms of the daily 1-hour maximum (D1HM) SO_2 concentrations for the year 2018 for each of the three residential monitoring stations. Note that the 97.5th percentile is shown on each graph, as this is the value that is used in the most recent KPI calculation based on the three-year average of the 97.5th percentile D1HM values over the years 2016-2018. The 97th percentile in each case is slightly lower, and can be found in the main report in Table 4-5 of the main report.

This appendix contains the same type of histograms, but for the years 2016 and 2017. Each histogram is shown twice. The first time the y-axis is shown at full scale (0-100%), while in the second instance, the y-axis is “zoomed in” to the range of 0-2%, in order to show the low frequency occurrences that are not easily discerned on the full scale. For the zoomed-in view, histogram bars that exceed 2% are removed.

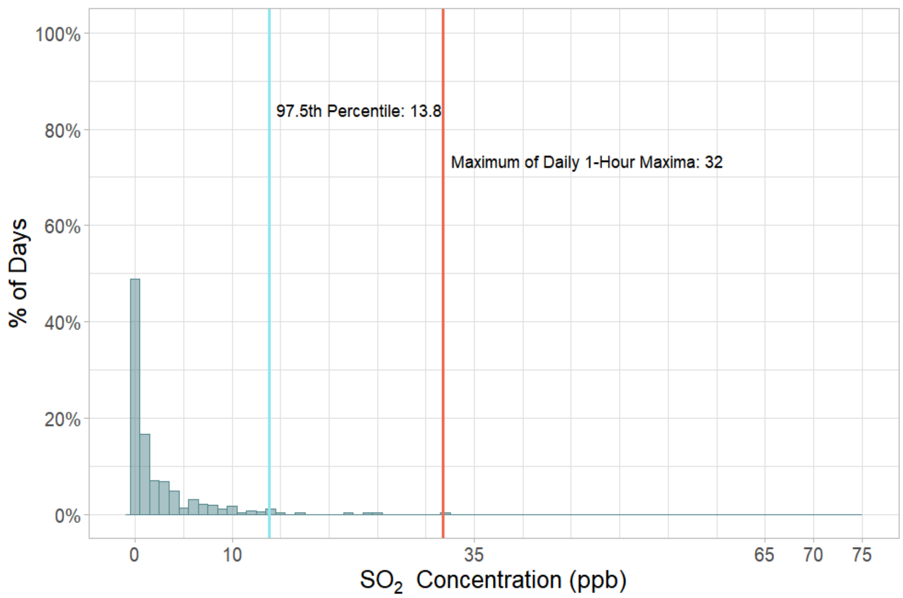

Figure 4.13: Histogram of D1HM SO_2 Concentrations (Riverlodge, 2016).

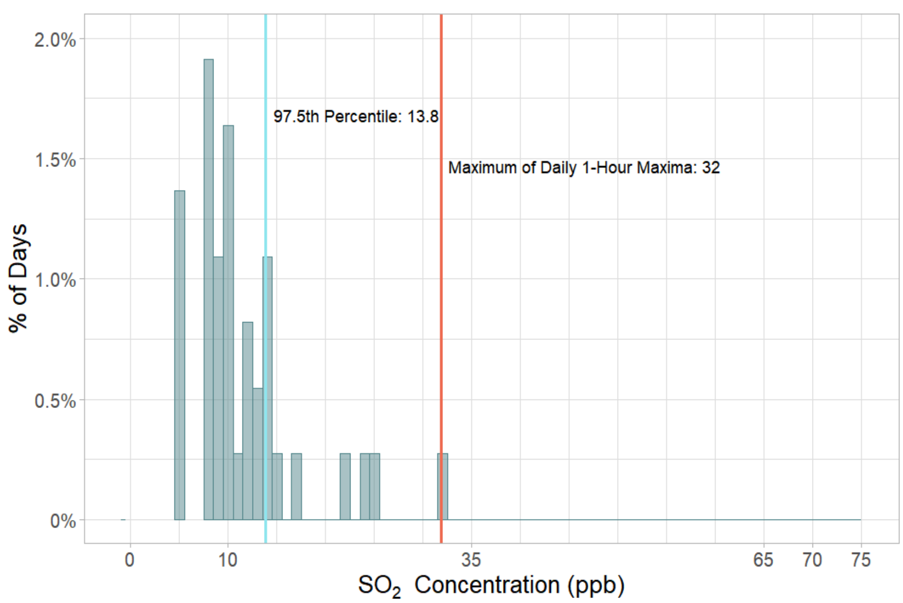

Figure 4.14: Histogram of D1HM SO_2 Concentrations with y-axis cut off at 2% (Riverlodge, 2016). Note: Several of the first histogram bars (0-4 ppb and 6-7ppb) are not shown because they exceed the limit of the y-axis.

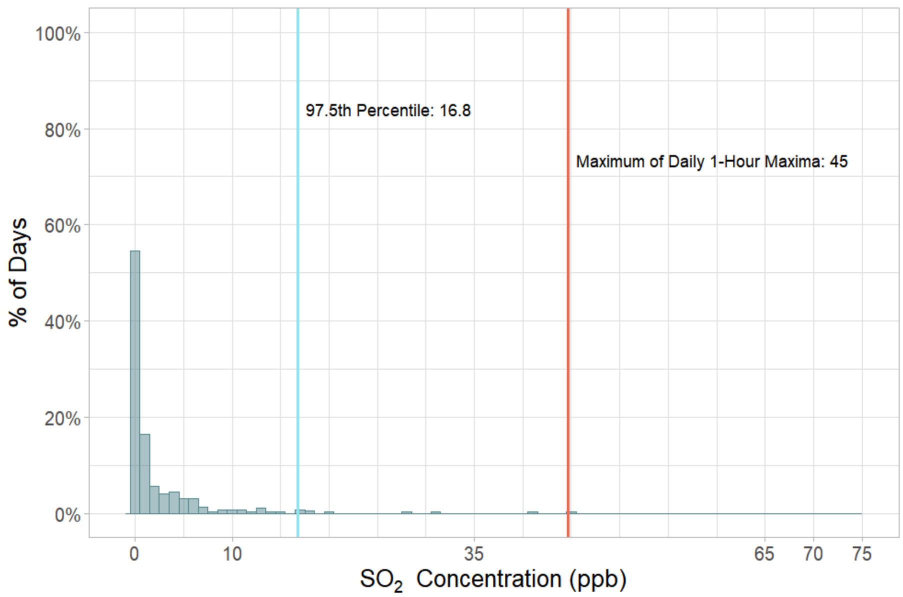

Figure 4.15: Histogram of D1HM SO_2 Concentrations (Riverlodge, 2017).

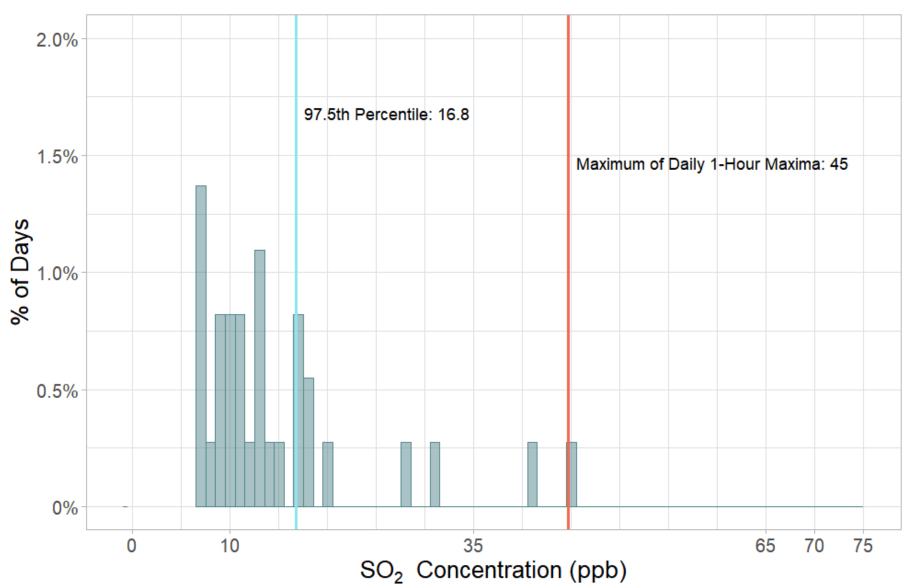

Figure 4.16: Histogram of D1HM SO_2 Concentrations with y-axis cut off at 2% (Riverlodge, 2017). Note: The first seven histogram bars are not shown because they exceed the limit of the y-axis.

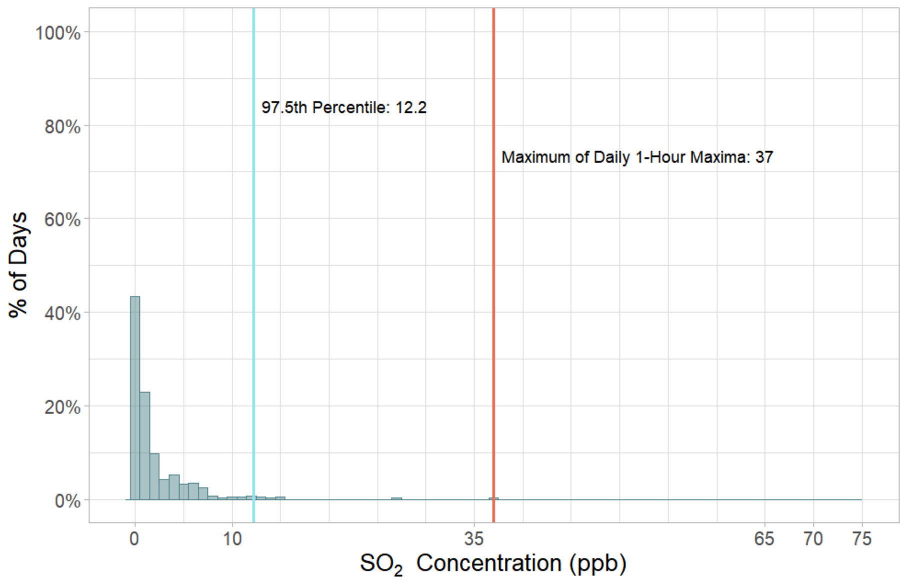

Figure 4.17: Histogram of D1HM SO_2 Concentrations (Whitesail, 2016).

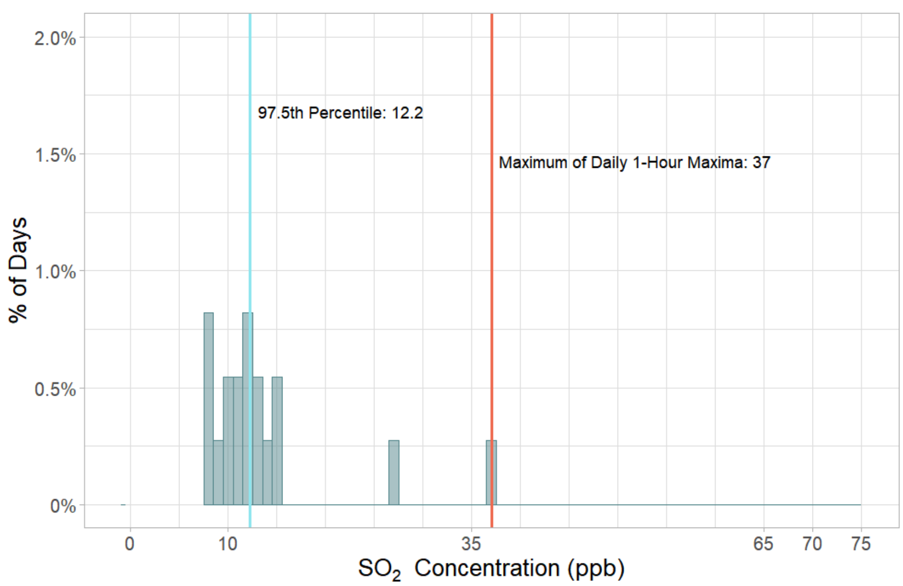

Figure 4.18: Histogram of D1HM SO_2 Concentrations with y-axis cut off at 2% (Whitesail, 2016). Note: The first eight histogram bars are not shown because they exceed the limit of the y-axis.

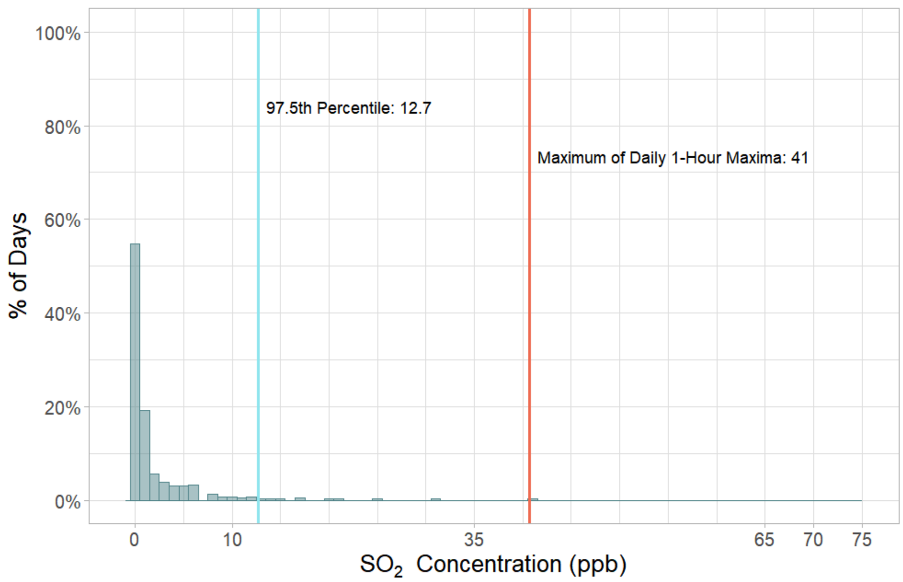

Figure 4.19: Histogram of D1HM SO_2 Concentrations (Whitesail, 2017).

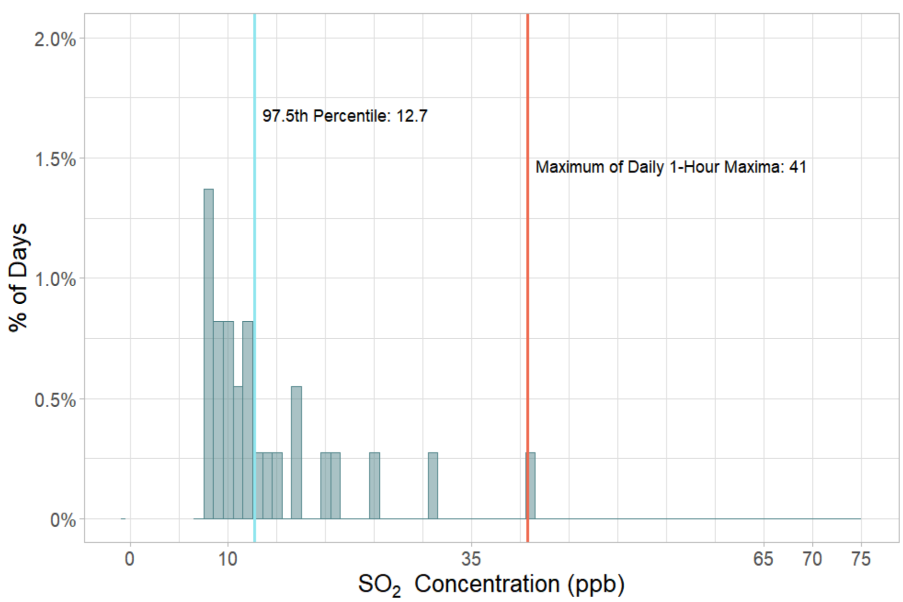

Figure 4.20: Histogram of D1HM SO_2 Concentrations with y-axis cut off at 2% (Whitesail, 2017). Note: The first eight histogram bars are not shown because they exceed the limit of the y-axis.

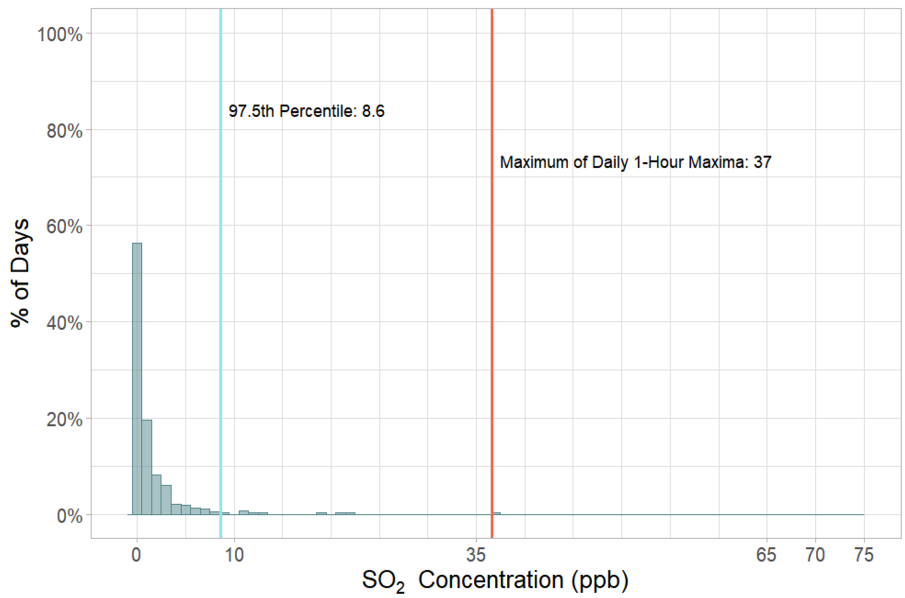

Figure 4.21: Histogram of D1HM SO_2 Concentrations (Kitamaat Village, 2016).

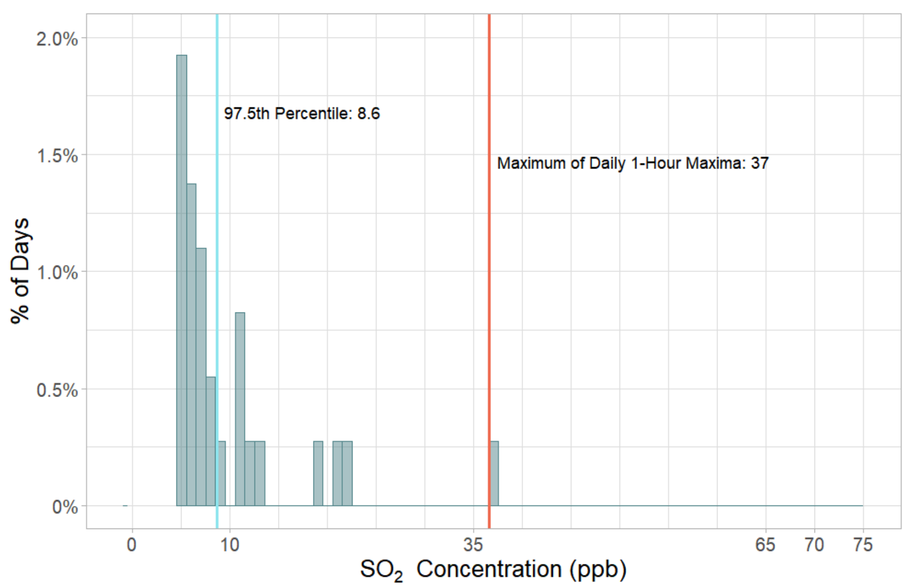

Figure 4.22: Histogram of D1HM SO_2 Concentrations with y-axis cut off at 2% (Kitamaat Village, 2016). Note: The first two histogram bars are not shown because they exceed the limit of the y-axis.

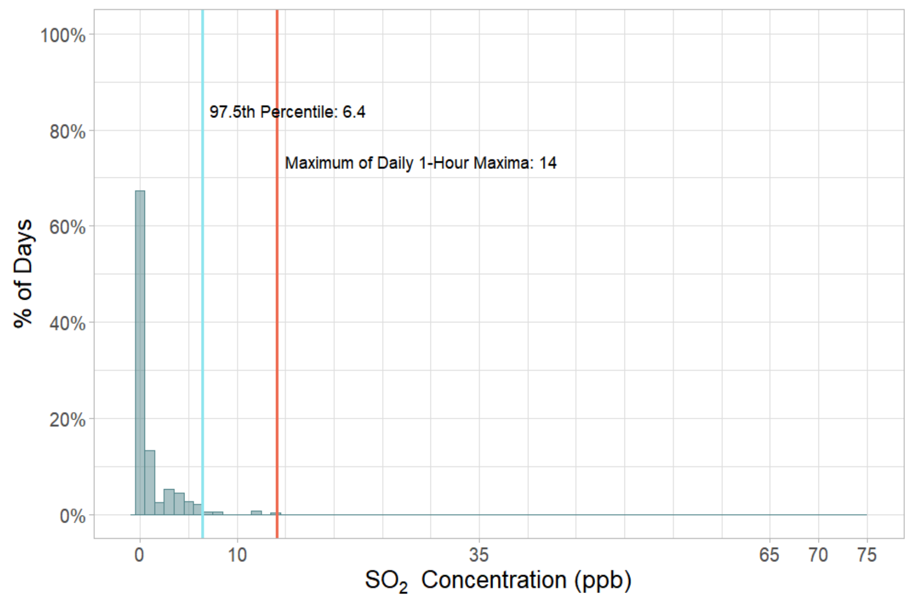

Figure 4.23: Histogram of D1HM SO_2 Concentrations (Kitamaat Village, 2017).

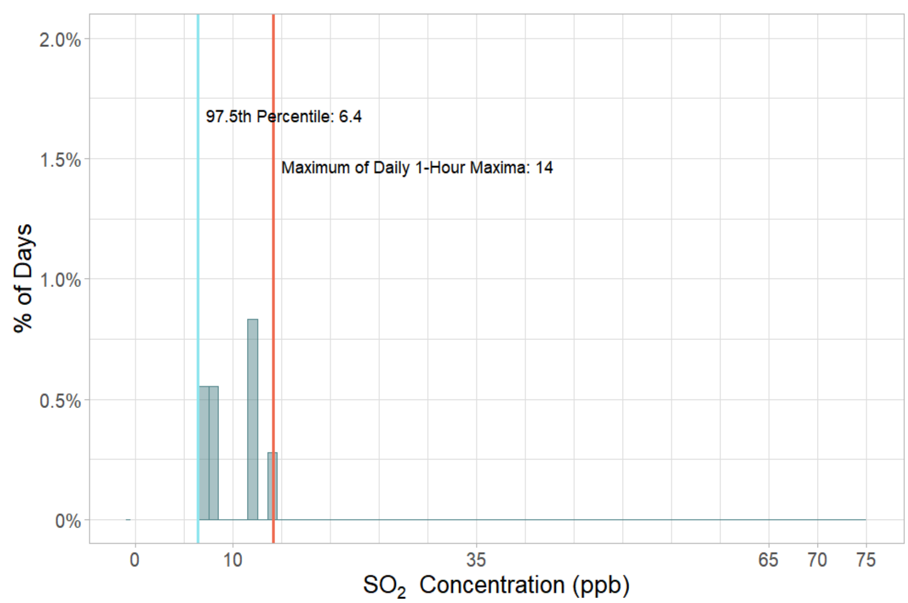

Figure 4.24: Histogram of D1HM SO_2 Concentrations with y-axis cut off at 2% (Kitamaat Village, 2017). Note: The first seven histogram bars are not shown because they exceed the limit of the y-axis.

5 Appendix to Section 5 of the Comprehensive Review Report: Vegetation

5.1 CALPUFF modeled SO_2 concentrations by emissions scenario and by year at vegetation sampling locations

The following pages contain three tables for each of the three years in each of the three scenarios

- Actual emissions, 2016
- Actual emissions, 2017
- Actual emissions, 2018

- 35 tpd scenario, 2016
- 35 tpd scenario, 2017
- 35 tpd scenario, 2018

- 42 tpd scenario, 2016
- 42 tpd scenario, 2017
- 42 tpd scenario, 2018

All concentrations are in ppb.

Table 5.1: Actual emissions, 2016. (All concentrations are in ppb.) Background SO_2 concentrations of 5.53, 2.80, 1.74, and 0.47 ppb for 1-hour, 3-hour, 24-hour, and annual (and growing season) average, respectively, are not included in the SO_2 concentrations listed in the table. However, these background values are considered when evaluating the risk of impacts to vegetation.

	2016															
	1-hour Max				3-hour Max				24-hour Max				Annual Average			
Plots/ year	All Hours	All Daylight	GS	GS Daylight	3-hour	All Daylight	GS	GS Daylight	24-hour	All Daylight	GS	GS Daylight	All Hours	All Daylight	GS	GS Daylight
1	168.0	168.0	168.0	168.0	95.1	71.0	52.0	44.6	38.1	43.3	20.2	15.1	7.1	6.5	2.9	2.1
20	151.8	148.3	148.3	148.3	134.4	112.4	103.1	103.1	59.3	78.4	36.1	55.4	8.6	10.9	5.5	7.8
37	298.9	298.9	298.9	298.9	104.3	101.6	104.3	104.3	20.8	35.2	20.8	35.2	2.1	3.0	2.7	4.0
39	115.1	115.1	115.1	115.1	68.0	71.2	68.0	92.2	19.1	29.7	19.1	29.7	4.4	5.9	7.1	9.8
42	216.1	216.1	141.9	141.9	85.3	95.2	76.4	114.2	25.7	31.4	25.7	31.4	5.4	6.8	4.2	6.0
43A	68.6	68.6	68.6	68.6	52.5	51.2	42.4	54.1	12.7	19.5	12.7	19.5	1.4	1.8	1.8	2.2
43B	111.6	111.6	105.1	72.5	85.9	61.7	85.9	52.8	18.6	22.5	18.6	22.5	1.7	2.1	2.1	2.6
44	178.9	150.5	150.4	137.5	158.6	86.6	88.5	102.8	26.4	42.7	24.9	42.7	3.4	5.0	3.9	6.1
44A	123.0	123.0	123.0	123.0	41.7	62.3	41.7	41.7	9.9	10.4	7.6	9.5	0.7	0.6	0.8	0.6
46	86.9	86.9	76.8	76.8	55.1	54.4	45.9	59.7	13.2	20.4	13.2	20.4	1.6	2.1	2.1	2.7
47B	49.8	49.8	49.8	49.8	34.2	33.9	31.3	44.1	15.0	19.0	15.0	18.6	2.8	3.5	4.3	5.3
52(A)	52.3	52.3	52.3	52.3	32.7	39.5	32.7	45.8	9.8	15.1	9.8	15.1	1.8	2.3	2.6	3.3
54	47.8	47.8	47.8	47.8	26.0	32.5	26.0	36.0	9.9	12.4	8.9	12.4	1.5	1.8	1.9	2.4
55	85.9	85.9	32.0	32.0	55.8	44.2	22.3	15.3	9.2	11.9	4.6	5.7	0.6	0.7	0.7	0.8
56(A)	70.1	33.6	24.3	24.3	40.6	26.0	15.4	13.7	10.7	9.7	3.6	5.5	0.5	0.5	0.5	0.5
57	90.5	90.5	20.2	20.2	70.8	86.8	13.4	13.4	15.0	17.3	3.2	4.9	0.5	0.5	0.4	0.4
68	33.3	32.4	16.1	14.5	18.6	16.5	7.8	9.7	3.6	5.7	1.4	2.2	0.3	0.3	0.3	0.3
69	78.3	65.9	29.8	22.4	45.4	25.6	12.0	12.0	13.4	9.2	1.9	2.7	0.4	0.4	0.3	0.3
70	21.5	14.1	13.6	13.6	14.5	10.2	7.8	7.8	4.2	3.9	1.8	2.7	0.2	0.3	0.2	0.3
78 (A)	39.4	35.2	39.4	29.2	28.1	24.4	28.1	22.3	11.8	16.0	11.8	9.7	2.3	2.5	3.2	3.5
79	72.9	72.9	72.9	72.9	39.6	43.4	39.6	33.7	12.7	14.0	12.7	14.0	3.0	3.4	4.7	5.3
80	50.1	46.5	48.6	46.5	38.5	36.7	38.5	28.5	11.5	12.4	11.5	10.4	2.5	2.7	3.8	3.9
81B	103.9	79.9	103.9	51.7	62.4	64.8	62.4	31.3	12.0	10.4	12.0	10.2	1.3	1.3	1.8	1.8
81C	40.9	40.9	35.6	30.1	31.0	28.9	21.1	26.4	6.4	10.6	6.4	10.6	1.0	1.0	1.3	1.4
82	65.9	34.4	65.9	31.3	50.6	23.1	50.6	21.7	14.2	10.8	14.2	8.7	2.3	2.0	3.7	3.0
84 (A) (B)	6.5	6.5	6.3	6.3	5.0	4.4	3.5	3.4	1.7	2.5	0.9	1.4	0.1	0.2	0.1	0.2
85	11.9	6.6	11.9	6.6	8.3	4.6	8.3	5.6	2.1	1.9	2.1	1.9	0.5	0.4	0.8	0.6
86	10.4	7.2	10.4	7.2	7.4	5.0	7.4	5.6	2.8	3.3	2.8	2.1	0.7	0.6	1.1	0.8
87	163.8	84.6	41.7	40.8	59.2	47.4	30.0	34.6	29.5	28.4	8.6	10.8	4.3	3.7	1.7	1.3
88	52.4	52.4	38.3	38.3	39.7	43.5	26.8	26.8	25.0	30.0	7.1	9.5	3.2	2.8	1.3	1.1
89	52.1	45.6	32.4	31.3	40.3	39.3	21.4	17.1	17.0	16.0	7.6	5.0	2.8	2.2	1.2	0.8
89A	52.5	45.7	33.3	31.5	40.6	39.7	21.5	17.2	17.0	16.1	7.7	5.1	2.9	2.3	1.2	0.8
90	56.4	22.4	56.4	22.4	43.0	18.7	43.0	13.1	9.5	6.0	9.5	6.0	1.2	0.9	2.0	1.4
91(A)	68.3	33.1	68.3	33.1	55.2	24.9	55.2	24.0	14.9	10.0	14.9	8.9	2.3	2.2	3.7	3.3
92	48.6	34.2	46.7	32.1	28.6	28.5	27.7	23.5	12.1	15.5	12.1	9.2	2.2	2.4	3.2	3.3
95	59.2	22.3	35.7	13.5	32.6	10.6	14.4	8.4	4.1	3.8	1.8	2.1	0.3	0.3	0.2	0.3
97	25.0	15.6	11.0	11.0	19.8	11.3	7.9	7.2	4.2	3.9	2.2	2.8	0.4	0.4	0.4	0.5
98A	25.5	16.3	10.8	10.8	21.0	14.6	6.9	6.9	4.7	3.8	2.0	3.0	0.3	0.3	0.3	0.4
490	6.1	2.6	5.5	2.6	3.9	1.7	2.9	2.0	1.0	1.0	1.0	1.0	0.1	0.1	0.2	0.2
492	9.2	5.3	9.2	5.1	7.7	4.1	7.7	3.0	2.2	2.1	1.5	1.5	0.3	0.2	0.4	0.3

Table 5.2: Actual emissions, 2017. (All concentrations are in ppb.) Background SO_2 concentrations of 5.53, 2.80, 1.74, and 0.47 ppb for 1-hour, 3-hour, 24-hour, and annual (and growing season) average, respectively, are not included in the SO_2 concentrations listed in the table. However, these background values are considered when evaluating the risk of impacts to vegetation.

	2017															
	1-hour Max				**3-hour Max**				**24-hour Max**				**Annual Average**			
Plots/ year	All Hours	All Dayligh	GS	GS Daylight	3-hour	All Daylight	GS	Day	24-hour	All Daylight	GS	Day	All Hours	All Daylight	GS	GS Daylight
1	168.0	208.7	168.0	168.0	163.6	114.6	68.4	57.4	41.0	57.6	21.8	26.8	7.1	6.6	3.2	2.5
20	309.1	309.1	303.4	120.9	191.5	133.1	121.4	97.6	66.3	85.4	38.5	52.7	9.2	11.6	6.3	8.1
37	548.8	548.8	548.8	548.8	212.2	312.5	212.2	212.2	33.9	57.3	33.9	57.3	2.6	3.5	3.6	4.9
39	70.8	70.8	50.9	50.9	35.8	45.8	35.8	40.2	15.5	21.9	15.5	21.9	4.2	5.7	6.3	8.7
42	281.1	281.1	99.6	98.8	190.0	121.9	50.6	53.1	27.0	45.6	21.3	29.1	5.1	6.4	4.5	6.1
43A	157.2	254.3	73.0	70.4	52.8	128.2	34.7	45.4	10.0	42.4	10.0	11.7	1.6	4.2	2.2	2.7
43B	162.1	149.2	162.1	86.8	63.2	75.7	63.2	56.0	11.6	13.6	11.6	16.3	1.8	2.3	2.6	3.0
44	254.3	47.4	123.2	96.1	171.7	30.4	59.1	56.5	30.9	13.5	18.0	28.9	3.0	2.3	3.8	5.4
44A	89.9	49.9	89.9	89.9	49.4	30.0	49.4	49.4	8.9	11.3	7.5	10.8	0.7	1.8	0.9	0.7
46	149.2	35.3	83.1	83.1	50.4	21.4	46.0	63.4	11.0	7.4	11.0	13.6	1.9	0.6	2.7	3.4
47B	36.3	54.8	32.9	32.9	23.5	30.7	21.3	25.0	9.8	6.2	9.8	12.6	2.8	0.5	3.9	4.9
52(A)	47.4	42.7	47.4	47.4	26.5	26.0	26.5	37.6	9.3	4.8	9.3	13.5	1.8	0.4	2.4	3.1
54	49.9	41.9	49.9	49.9	32.4	21.7	26.6	38.1	9.1	12.9	7.8	10.0	1.5	0.3	1.8	2.3
55	54.9	57.5	30.8	30.8	24.9	34.2	15.4	22.6	6.7	12.2	3.5	5.2	0.6	0.4	0.6	0.6
56(A)	76.6	17.2	34.3	17.5	56.9	10.2	18.1	13.4	11.0	5.7	3.5	4.1	0.6	0.2	0.5	0.4
57	58.2	42.7	24.4	15.0	43.6	34.1	11.9	11.4	8.5	14.6	2.9	3.7	0.5	3.6	0.4	0.4
68	41.9	34.3	11.3	11.3	24.9	21.3	7.6	8.0	8.1	14.5	2.7	3.5	0.3	2.9	0.2	0.3
69	67.8	54.0	14.9	14.9	34.9	48.9	8.7	8.7	7.6	13.1	2.9	3.4	0.3	2.1	0.3	0.3
70	17.2	6.4	10.1	10.1	8.3	4.9	7.9	7.9	3.7	2.7	1.9	2.4	0.2	0.4	0.2	0.2
78 (A)	42.5	6.8	42.5	30.2	23.6	5.2	23.6	18.6	8.5	2.9	7.5	9.1	2.4	0.6	3.1	3.5
79	95.4	73.6	95.4	41.9	39.3	49.8	39.3	28.0	11.7	32.0	11.7	14.6	3.2	3.7	4.6	5.4
80	41.0	56.2	41.0	33.5	31.6	44.5	25.1	18.4	13.9	28.1	8.8	10.8	2.6	3.1	3.4	3.7
81B	70.6	41.2	70.6	31.4	42.6	28.3	42.6	18.5	9.7	14.7	9.7	7.8	1.3	2.3	1.9	1.9
81C	55.1	33.8	55.1	36.8	37.2	26.1	37.2	17.6	8.5	8.4	8.5	6.8	1.1	1.0	1.5	1.6
82	78.0	35.2	78.0	35.5	49.0	26.7	49.0	22.7	13.6	10.4	13.6	9.0	2.3	2.6	3.2	2.9
84 (A) (B)	5.2	22.8	3.2	3.2	3.5	13.1	2.5	2.5	1.2	7.9	0.9	1.1	0.1	0.3	0.2	0.2
85	9.0	14.8	9.0	5.7	5.6	9.4	5.6	4.6	2.3	3.6	2.3	2.7	0.5	0.4	0.7	0.6
86	7.7	3.3	7.2	6.8	6.7	2.1	6.7	4.9	2.8	1.0	2.8	2.9	0.7	0.1	1.0	0.8
87	73.6	5.2	71.4	58.1	57.7	4.2	51.3	41.2	31.0	2.1	11.7	14.7	4.0	0.3	1.7	1.7
88	56.2	157.2	54.7	50.1	50.4	79.1	43.3	37.6	29.8	11.7	8.4	11.8	3.3	1.9	1.4	1.4
89	42.0	121.2	32.6	32.6	34.5	65.5	18.9	20.4	18.1	16.3	7.5	8.0	2.8	2.1	1.2	1.0
89A	42.8	89.9	33.2	33.2	34.4	57.6	18.9	20.8	18.0	10.8	7.5	8.0	2.8	0.6	1.2	1.0
90	41.4	36.3	41.4	17.8	31.0	27.5	31.0	14.4	8.2	14.0	7.0	5.1	1.1	3.5	1.6	1.4
91(A)	45.4	30.3	45.4	37.2	34.3	24.5	26.7	24.2	11.6	10.6	8.8	10.4	2.3	2.7	3.2	3.2
92	55.6	36.6	55.6	35.2	26.1	23.8	26.1	19.7	8.6	7.8	7.7	8.4	2.4	1.3	3.0	3.3
95	24.6	36.8	13.4	13.4	16.0	19.4	9.3	9.5	5.2	6.8	2.5	3.3	0.3	1.0	0.2	0.3
97	19.6	5.2	13.5	13.5	11.6	3.2	9.5	9.5	3.7	1.9	2.5	3.4	0.4	0.1	0.4	0.5
98A	16.6	41.1	12.8	12.8	10.0	28.2	10.0	10.0	2.1	14.8	2.1	3.1	0.3	2.3	0.3	0.4
490	4.7	37.2	3.2	3.2	2.3	23.3	2.2	1.8	0.9	10.4	0.8	1.0	0.1	2.3	0.1	0.2
492	5.9	12.8	5.9	4.1	4.7	9.4	4.7	3.1	2.1	3.2	1.5	1.2	0.3	0.3	0.4	0.3

Table 5.3: Actual emissions, 2018. (All concentrations are in ppb.) Background SO_2 concentrations of 5.53, 2.80, 1.74, and 0.47 ppb for 1-hour, 3-hour, 24-hour, and annual (and growing season) average, respectively, are not included in the SO_2 concentrations listed in the table. However, these background values are considered when evaluating the risk of impacts to vegetation.

	2018															
	1-hour Max				3-hour Max				24-hour Max				Annual Average			
Plots/ year	All Hours	All Daylight	GS	GS Daylight	3-hour	All Daylight	GS	GS Daylight	24-hour	All Daylight	GS	GS Daylight	All Hours	All Daylight	GS	GS Daylight
1	168.0	168.0	168.0	168.0	88.1	82.7	57.8	64.1	47.1	43.8	24.7	18.5	7.3	7.1	3.3	3.2
20	289.2	192.5	289.2	167.9	146.4	138.8	140.4	100.9	83.5	73.7	34.6	52.5	9.3	11.5	8.0	10.6
37	528.4	528.4	528.4	528.4	185.1	264.5	185.1	185.1	29.4	50.3	29.4	50.3	2.6	3.6	3.9	5.4
39	82.7	65.7	50.1	50.1	39.2	42.9	35.9	39.4	17.1	23.1	17.1	23.1	4.1	5.6	6.0	8.5
42	250.5	250.5	117.8	98.8	133.8	113.1	59.0	69.4	33.9	57.9	18.9	29.7	5.7	7.2	5.6	7.9
43A	349.0	102.0	120.7	81.8	232.5	54.9	47.7	43.7	30.1	20.5	15.2	20.5	2.1	2.1	2.9	3.2
43B	538.5	165.0	145.2	121.7	325.4	80.7	65.3	52.0	42.1	22.5	16.2	22.5	2.4	2.5	3.3	3.7
44	268.6	268.6	182.1	107.3	136.3	112.9	77.2	77.2	38.0	64.9	23.0	32.9	3.6	5.2	5.0	7.0
44A	70.2	50.5	70.2	50.0	40.2	27.8	40.2	22.3	6.9	9.1	6.9	9.1	0.8	0.7	1.1	0.9
46	335.3	100.9	117.2	89.4	220.1	65.5	46.2	45.7	28.4	22.8	16.3	22.8	2.3	2.5	3.3	3.8
47B	43.1	43.1	32.4	32.4	30.3	36.8	24.2	22.4	13.1	14.6	11.5	14.5	2.8	3.4	3.7	4.7
52(A)	57.7	43.1	43.1	43.1	32.4	35.7	28.6	42.3	13.2	18.4	8.1	11.6	2.0	2.6	2.4	3.3
54	63.8	40.4	40.4	40.4	43.2	31.6	26.2	39.1	9.5	14.9	8.1	13.2	1.7	2.1	1.9	2.5
55	31.7	27.7	23.0	23.0	23.3	19.4	16.0	21.3	8.6	8.3	3.8	5.5	0.7	0.8	0.7	0.8
56(A)	69.6	45.7	16.4	16.4	50.9	34.3	12.9	16.2	11.6	8.2	3.7	5.6	0.6	0.6	0.5	0.6
57	78.6	47.8	20.7	20.7	52.1	27.8	14.5	14.5	14.6	6.3	4.0	6.1	0.5	0.5	0.4	0.5
68	18.6	18.6	17.5	17.5	12.0	12.9	12.0	15.2	3.4	5.6	2.1	2.8	0.3	0.4	0.2	0.4
69	31.0	31.0	31.0	31.0	17.7	18.3	17.7	17.7	4.8	8.0	2.5	4.1	0.3	0.4	0.3	0.4
70	19.0	11.8	11.8	11.8	10.3	9.1	10.3	11.3	2.5	2.7	1.6	2.3	0.2	0.3	0.2	0.3
78 (A)	43.3	39.4	37.4	26.5	28.3	22.2	25.9	19.0	11.8	12.9	8.1	7.7	2.4	2.5	3.0	3.3
79	76.1	76.1	52.7	51.3	49.9	46.1	27.9	26.7	17.0	22.4	12.2	16.3	3.2	3.4	4.8	5.2
80	61.7	47.3	47.3	47.3	27.9	27.6	21.5	21.5	10.8	12.4	9.5	10.1	2.5	2.5	3.5	3.6
81B	119.0	67.2	119.0	25.7	84.8	33.9	84.8	21.0	12.9	17.8	12.9	11.8	1.5	1.1	2.3	1.6
81C	117.7	39.4	117.7	29.6	77.7	33.9	77.7	20.2	11.4	18.3	11.4	13.2	1.3	0.9	1.9	1.4
82	150.8	50.4	150.8	44.0	79.3	41.0	79.3	29.6	13.8	15.9	13.8	9.7	2.3	1.7	3.5	2.5
84 (A) (B)	6.0	6.0	4.0	3.2	4.3	4.2	2.8	2.8	1.8	1.5	0.8	0.9	0.1	0.1	0.1	0.1
85	10.0	9.8	10.0	4.7	7.8	7.2	7.8	4.2	2.2	2.3	2.2	2.0	0.5	0.4	0.7	0.5
86	12.8	9.9	10.2	6.0	10.8	5.9	7.0	5.0	4.0	2.8	3.1	2.8	0.7	0.6	0.9	0.7
87	97.8	97.8	64.8	64.8	56.5	53.3	39.5	53.7	26.6	28.3	9.2	10.2	3.8	3.8	1.7	1.9
88	67.3	67.3	38.4	38.4	56.6	44.5	27.8	37.4	18.6	18.4	6.9	7.6	3.0	3.1	1.3	1.6
89	51.5	51.5	51.5	51.5	30.1	30.3	29.8	38.5	17.8	16.3	5.9	7.9	2.7	2.4	1.2	1.2
89A	51.9	51.9	51.9	51.9	30.5	30.5	30.0	38.7	17.9	16.5	6.1	8.0	2.7	2.4	1.3	1.2
90	49.0	28.8	49.0	28.8	26.9	17.7	26.9	11.9	7.9	6.5	7.9	4.6	1.1	0.8	1.8	1.2
91(A)	94.2	44.6	94.2	44.6	52.7	32.0	52.7	20.6	11.8	16.7	11.8	11.2	2.2	1.9	3.4	2.9
92	39.7	36.8	39.7	22.5	25.6	22.8	25.6	17.1	11.1	12.2	8.2	7.6	2.3	2.4	3.0	3.1
95	13.6	13.6	13.3	13.3	8.4	10.2	8.4	11.5	2.5	4.0	2.1	2.7	0.2	0.3	0.2	0.3
97	28.9	19.7	16.6	16.6	25.3	16.5	9.1	10.6	7.1	5.0	3.2	3.6	0.5	0.5	0.5	0.6
98A	28.8	14.5	14.5	14.5	20.7	9.0	8.4	9.1	4.4	3.4	2.5	3.2	0.3	0.4	0.4	0.5
490	5.6	4.8	3.7	3.3	3.6	2.4	3.0	2.3	1.1	0.9	0.9	0.8	0.1	0.1	0.2	0.2
492	9.1	6.7	9.1	4.6	6.5	5.1	6.5	3.1	2.4	2.5	1.8	1.5	0.4	0.3	0.4	0.3

Table 5.4: 35 tpd scenario, 2016. (All concentrations are in ppb.) Background SO_2 concentrations of 5.53, 2.80, 1.74, and 0.47 ppb for 1-hour, 3-hour, 24-hour, and annual (and growing season) average, respectively, are not included in the SO_2 concentrations listed in the table. However, these background values are considered when evaluating the risk of impacts to vegetation.

	1-hour Max				3-hour Max				24-hour Max				Annual Average			
Plots/year	All Hours	All Daylight	GS	GS Daylight	3-hour	All Daylight	GS	GS Daylight	24-hour	All Daylight	GS	GS Daylight	All Hours	All Daylight	GS	GS Daylight
1	169.6	124.4	92.5	66.6	93.2	72.6	61.9	53.5	45.6	55.3	23.6	16.6	7.5	6.8	23.6	2.7
20	266.9	188.1	162.8	162.8	160.1	128.2	112.0	112.0	78.8	93.4	47.2	70.2	9.6	12.8	47.2	11.2
37	217.7	217.7	217.7	217.7	80.1	82.1	80.1	104.7	18.2	30.6	18.2	30.6	2.2	3.1	18.2	4.5
39	125.5	125.5	125.5	125.5	75.6	81.1	75.6	104.7	21.1	34.0	21.1	34.0	4.7	6.5	21.1	11.4
42	151.5	151.5	151.5	151.5	91.5	107.3	91.5	136.9	21.0	27.9	21.0	26.2	4.3	5.5	21.0	6.4
43A	78.5	78.5	78.5	78.5	51.4	49.3	51.4	56.3	15.6	24.2	15.6	24.2	1.4	1.8	15.6	2.5
43B	116.1	115.4	116.1	83.9	67.6	46.7	67.6	55.1	15.7	24.5	15.7	24.5	1.6	2.1	15.7	2.9
44	155.0	155.0	155.0	155.0	84.0	99.6	84.0	125.6	20.4	35.0	20.4	35.0	3.1	4.6	20.4	6.4
44A	109.9	109.9	109.9	109.9	38.1	56.5	38.1	38.1	9.9	11.7	7.6	11.7	0.7	0.6	7.6	0.7
46	85.0	85.0	84.5	84.5	54.9	52.4	54.9	61.0	16.2	25.2	16.2	25.2	1.6	2.2	16.2	3.0
47B	60.6	60.6	60.6	60.6	35.6	39.9	35.6	51.6	13.1	19.2	13.1	19.2	3.0	3.9	13.1	6.4
52(A)	60.9	60.9	60.9	60.9	39.0	48.6	39.0	56.1	12.3	18.9	12.3	18.9	2.0	2.6	12.3	4.1
54	56.7	56.7	56.7	56.7	31.4	40.6	31.4	44.7	10.6	15.7	10.6	15.7	1.6	2.1	10.6	3.0
55	40.7	38.0	40.7	38.0	29.3	18.3	29.3	18.9	5.9	7.1	5.9	7.1	0.7	0.8	5.9	1.0
56(A)	30.8	30.8	30.8	30.8	17.0	19.8	17.0	17.0	4.8	7.0	4.5	7.0	0.5	0.6	4.5	0.7
57	28.8	25.7	25.7	25.7	17.2	17.1	15.5	15.5	4.8	6.6	4.0	6.2	0.5	0.5	4.0	0.6
68	37.0	28.0	18.9	18.0	18.3	13.7	9.1	12.8	3.7	5.9	1.9	3.0	0.3	0.4	1.9	0.4
69	89.1	69.8	40.7	29.9	51.9	27.5	15.3	17.9	14.2	9.7	2.4	3.5	0.4	0.4	2.4	0.4
70	23.0	15.8	14.7	14.7	15.8	11.2	8.8	8.8	4.4	4.4	2.3	3.4	0.3	0.3	2.3	0.3
78 (A)	40.0	40.0	36.7	34.5	31.7	25.5	31.7	27.3	12.6	14.2	12.6	11.0	2.4	2.8	12.6	4.3
79	71.0	71.0	71.0	71.0	46.0	43.0	46.0	35.3	14.2	16.5	14.2	16.5	3.3	3.9	14.2	6.4
80	54.7	50.6	54.7	50.6	33.8	41.2	33.8	32.7	12.0	12.0	12.0	12.0	2.7	3.0	12.0	4.8
81B	147.9	97.3	147.9	37.2	85.8	78.5	85.8	35.3	15.7	13.0	15.7	13.0	1.4	1.4	15.7	2.1
81C	52.0	46.2	52.0	38.5	35.6	28.2	27.0	33.8	8.4	14.1	8.4	14.1	1.1	1.2	8.4	1.6
82	70.7	39.8	70.7	39.8	44.4	26.3	44.4	27.1	15.9	11.4	15.9	11.2	2.5	2.3	15.9	3.6
84 (A) (B)	8.0	8.0	7.7	7.7	5.1	5.9	5.1	4.3	1.6	2.4	1.0	1.6	0.2	0.2	1.0	0.2
85	14.4	8.0	14.4	8.0	10.2	5.5	10.2	6.7	2.6	2.4	2.6	2.3	0.6	0.5	2.6	0.7
86	12.8	7.9	12.8	7.9	8.9	5.8	8.9	5.7	3.5	3.7	3.5	2.7	0.8	0.7	3.5	1.0
87	112.3	112.3	49.5	49.5	54.6	42.2	37.8	44.0	18.9	19.6	12.0	13.8	3.7	3.3	12.0	1.6
88	70.8	70.8	47.6	47.6	37.5	31.9	33.6	33.6	14.7	18.5	10.7	11.9	2.8	2.5	10.7	1.3
89	65.8	65.8	39.8	39.8	35.3	28.8	26.4	21.5	16.0	15.9	9.7	6.4	2.9	2.3	9.7	0.9
89A	66.6	66.6	39.8	39.8	35.5	29.1	26.6	21.5	16.1	16.0	9.8	6.6	2.9	2.3	9.8	0.9
90	52.5	27.9	52.5	27.9	31.9	23.5	31.9	16.4	10.9	8.0	10.9	8.0	1.3	1.1	10.9	1.7
91(A)	72.0	39.5	72.0	39.5	40.8	28.5	40.8	30.1	16.3	11.6	16.3	11.6	2.5	2.5	16.3	4.0
92	46.4	46.4	39.2	39.2	30.8	35.8	30.8	29.7	13.1	14.4	13.1	10.6	2.4	2.7	13.1	4.1
95	47.1	23.6	29.9	18.1	19.0	10.5	12.9	11.1	4.2	4.2	1.8	2.9	0.3	0.3	1.8	0.3
97	17.3	13.5	13.5	13.5	12.7	9.7	9.5	9.4	3.6	4.7	3.0	3.7	0.4	0.5	3.0	0.6
98A	17.9	13.6	13.6	13.6	13.4	9.3	9.1	9.1	2.9	3.9	2.5	3.8	0.3	0.4	2.5	0.5
490	7.6	3.4	6.3	3.4	4.9	2.2	3.8	2.6	1.2	1.3	1.2	1.3	0.1	0.1	1.2	0.2
492	11.2	7.0	11.2	7.0	9.5	5.8	9.5	4.1	2.5	2.3	1.9	1.9	0.3	0.3	1.9	0.4

Table 5.5: 35 tpd scenario, 2017. (All concentrations are in ppb.) Background SO_2 concentrations of 5.53, 2.80, 1.74, and 0.47 ppb for 1-hour, 3-hour, 24-hour, and annual (and growing season) average, respectively, are not included in the SO_2 concentrations listed in the table. However, these background values are considered when evaluating the risk of impacts to vegetation.

	2017															
	1-hour Max				3-hour Max				24-hour Max				Annual Average			
	All Hours	All Daylight	GS	GS Daylight	3-hour	All Daylight	GS	GS Daylight	24-hour	All Daylight	GS	GS Daylight	All Hours	All Daylight	GS	GS Daylight
Plots/year																
1	299.2	299.2	111.8	111.8	222.8	168.0	75.7	61.1	64.8	90.9	27.5	31.8	7.7	7.1	4.1	3.2
20	356.7	356.7	345.0	145.9	258.9	236.5	127.0	109.1	87.5	113.5	43.2	71.3	10.1	13.3	8.3	11.1
37	209.4	209.4	133.4	133.4	133.9	95.8	71.6	82.0	18.5	31.1	17.4	28.6	2.6	3.5	3.8	5.2
39	63.4	63.4	63.4	63.4	37.8	51.6	37.8	54.7	16.8	23.5	16.8	23.5	4.6	6.4	7.4	10.4
42	322.9	322.9	173.7	93.5	213.5	128.5	84.9	56.9	29.9	50.6	16.4	21.9	4.4	5.6	4.8	6.5
43A	69.2	69.2	67.2	67.2	37.3	41.6	35.2	42.3	9.5	14.3	9.5	14.3	1.6	2.0	2.3	2.9
43B	86.0	86.0	82.1	82.1	53.4	52.4	37.6	46.0	11.8	16.4	11.8	15.5	1.8	2.2	2.6	3.3
44	301.8	301.8	225.4	111.3	195.4	121.2	101.2	48.9	27.2	45.9	19.4	32.8	3.0	4.2	4.2	5.9
44A	104.2	97.5	104.2	97.5	65.8	65.6	65.8	57.6	8.7	12.6	8.7	12.6	0.8	0.7	1.0	0.8
46	79.6	79.6	70.7	70.7	43.0	44.9	38.4	45.1	10.3	16.1	10.3	16.1	1.8	2.3	2.8	3.6
47B	39.4	39.4	39.4	39.4	26.0	31.0	23.1	30.8	11.1	15.0	11.1	15.0	3.1	4.0	4.6	5.9
52(A)	56.9	56.9	56.9	56.9	32.5	40.5	32.5	45.9	11.7	16.7	11.7	16.7	2.1	2.7	2.9	3.9
54	60.0	60.0	60.0	60.0	32.5	39.4	32.5	46.4	9.6	13.2	9.2	13.2	1.7	2.1	2.2	2.8
55	38.9	38.9	36.6	36.6	23.1	22.4	18.8	27.6	6.2	6.6	4.2	6.4	0.7	0.7	0.7	0.8
56(A)	64.4	45.2	38.7	23.9	47.1	20.4	19.0	14.4	9.1	6.5	4.2	4.8	0.6	0.5	0.6	0.6
57	51.1	32.5	28.8	20.1	43.7	20.1	14.8	12.4	7.4	6.2	3.6	4.0	0.5	0.5	0.5	0.5
68	51.1	51.1	15.5	15.5	33.7	29.4	9.8	11.0	10.7	17.1	3.6	4.6	0.3	0.4	0.3	0.4
69	96.3	96.3	19.0	19.0	50.4	54.4	11.1	11.1	10.9	17.7	3.9	4.4	0.4	0.4	0.4	0.4
70	26.6	26.6	14.7	14.7	11.4	15.3	9.5	9.5	4.6	7.2	2.6	2.8	0.2	0.3	0.3	0.3
78 (A)	35.6	35.6	34.2	30.6	26.8	23.7	21.7	21.6	8.9	10.9	8.9	9.3	2.6	3.1	3.6	4.3
79	49.7	49.7	49.7	49.7	37.6	30.9	28.5	35.5	11.5	17.2	11.5	17.2	3.4	4.2	5.3	6.6
80	39.2	39.2	35.4	31.5	24.2	23.0	22.3	24.2	10.0	12.5	9.5	12.5	2.8	3.2	4.0	4.5
81B	94.0	39.0	94.0	37.5	54.7	26.8	54.7	22.2	10.5	9.6	10.5	9.6	1.5	1.5	2.2	2.3
81C	69.2	38.3	69.2	38.3	40.0	20.1	40.0	20.7	9.0	8.3	9.0	8.3	1.2	1.2	1.8	1.8
82	117.7	57.8	117.7	57.8	60.6	51.2	60.6	27.4	16.0	16.0	16.0	11.2	2.6	2.4	3.8	3.6
84 (A) (B)	5.4	5.2	4.1	4.1	4.5	3.9	3.4	3.4	1.5	2.4	1.1	1.4	0.2	0.2	0.2	0.2
85	10.7	7.2	10.7	7.2	7.2	5.9	7.2	5.8	2.9	3.4	2.9	3.4	0.6	0.5	0.8	0.7
86	9.1	8.5	9.1	8.5	7.8	6.4	7.8	6.1	3.6	3.5	3.6	3.5	0.9	0.8	1.2	1.0
87	111.4	111.4	80.5	66.4	58.2	61.9	58.2	47.7	20.5	28.1	12.8	17.5	3.5	3.4	2.1	2.1
88	61.9	61.9	60.5	56.9	48.5	42.9	48.5	42.5	18.2	21.1	9.1	14.6	2.9	2.8	1.7	1.8
89	43.0	43.0	41.6	41.6	33.9	32.2	24.6	31.7	17.2	15.7	8.5	10.0	2.9	2.3	1.4	1.3
89A	42.8	42.8	42.3	42.3	33.9	32.2	24.7	31.7	17.2	15.7	8.6	10.0	2.9	2.4	1.4	1.3
90	55.5	36.9	55.5	18.8	37.2	27.6	37.2	15.9	8.5	11.7	7.4	6.4	1.2	1.2	1.8	1.7
91(A)	51.8	41.6	51.8	33.1	32.3	26.0	28.8	26.8	13.2	11.8	9.3	11.3	2.5	2.6	3.7	3.9
92	45.4	35.6	45.4	35.0	25.8	27.0	24.7	21.2	9.1	11.2	9.1	9.5	2.6	3.0	3.5	4.1
95	33.3	28.2	17.5	17.5	21.3	16.3	10.9	12.8	6.7	10.4	3.2	4.3	0.3	0.3	0.3	0.3
97	20.9	18.1	15.7	15.7	14.1	12.6	11.1	11.1	4.2	4.1	3.1	4.1	0.5	0.5	0.5	0.6
98A	17.2	17.2	17.2	17.2	11.8	11.6	11.8	11.8	2.6	3.8	2.6	3.8	0.3	0.4	0.4	0.5
490	6.1	4.4	4.4	4.4	3.2	2.7	2.9	2.4	1.2	1.3	1.0	1.2	0.1	0.1	0.2	0.2
492	8.9	6.5	8.5	5.1	5.6	5.6	5.6	3.7	2.6	2.7	1.8	1.5	0.4	0.3	0.5	0.4

Table 5.6: 35 tpd scenario, 2018. (All concentrations are in ppb.) Background SO_2 concentrations of 5.53, 2.80, 1.74, and 0.47 ppb for 1-hour, 3-hour, 24-hour, and annual (and growing season) average, respectively, are not included in the SO_2 concentrations listed in the table. However, these background values are considered when evaluating the risk of impacts to vegetation.

	2018															
	1-hour Max				3-hour Max				24-hour Max				Annual Average			
	All Hours	All Daylight	GS	GS Daylight	3-hour	All Daylight	GS	GS Daylight	24-hour	All Daylight	GS	GS Daylight	All Hours	All Daylight	GS	GS Daylight
Plots/year																
1	178.3	178.3	131.0	131.0	129.6	113.8	88.1	98.0	47.8	50.9	25.0	25.3	8.1	8.0	4.2	4.2
20	558.6	420.9	323.9	249.9	326.8	201.7	213.7	199.4	90.1	79.1	48.1	66.3	11.1	14.0	10.9	14.6
37	202.2	202.2	186.0	186.0	112.3	88.6	77.6	77.6	24.9	42.4	18.4	31.0	2.6	3.6	4.0	5.6
39	64.5	64.5	58.6	58.6	42.8	45.6	42.8	47.4	18.7	24.9	18.7	24.9	4.4	6.2	7.1	10.2
42	276.4	276.4	109.2	109.2	141.1	112.4	51.8	71.1	30.4	51.5	18.4	31.3	4.9	6.4	5.9	8.3
43A	93.1	93.1	93.1	93.1	47.2	43.5	47.2	47.2	15.7	22.1	15.7	22.1	1.9	2.2	2.9	3.5
43B	146.4	146.4	146.4	146.4	63.0	64.0	63.0	63.0	16.4	24.0	16.4	24.0	2.1	2.5	3.2	3.9
44	258.9	258.9	120.0	120.0	132.8	103.3	60.5	68.1	33.3	56.6	18.2	31.1	3.5	5.0	5.2	7.4
44A	84.0	41.4	84.0	41.4	56.0	23.7	56.0	26.4	9.4	10.7	9.4	10.7	0.9	0.7	1.3	1.0
46	99.0	99.0	99.0	99.0	49.0	48.0	49.0	49.0	16.6	24.1	16.6	24.1	2.1	2.5	3.2	4.1
47B	37.5	37.5	37.5	37.5	27.0	25.2	27.0	26.5	13.1	17.6	13.1	17.6	3.0	3.8	4.4	5.7
52(A)	51.5	51.5	51.5	51.5	34.7	43.1	34.7	51.3	10.4	15.6	10.4	13.9	2.2	2.9	2.9	4.1
54	48.9	48.9	48.9	48.9	32.4	39.0	32.4	48.2	9.6	15.5	9.6	15.5	1.8	2.4	2.3	3.2
55	32.6	32.6	26.6	26.6	19.9	21.8	19.9	25.6	6.4	8.8	4.7	6.5	0.8	1.0	0.8	1.1
56(A)	49.3	27.2	44.9	21.8	37.5	25.0	20.3	21.7	8.7	8.6	4.3	6.4	0.7	0.7	0.6	0.7
57	53.7	25.9	21.3	21.3	39.5	17.5	16.8	20.7	12.1	6.0	4.0	6.0	0.6	0.6	0.5	0.6
68	23.1	23.1	17.8	17.8	15.1	19.7	12.1	15.7	4.8	7.9	2.6	3.6	0.3	0.4	0.3	0.4
69	35.4	35.4	35.4	35.4	21.2	23.5	17.7	19.4	6.1	10.2	3.1	4.7	0.4	0.5	0.4	0.6
70	21.9	16.1	16.1	16.1	14.1	12.3	14.1	14.9	2.2	3.5	2.2	2.9	0.3	0.3	0.3	0.4
78 (A)	42.5	41.5	40.1	33.2	32.0	24.5	32.0	24.2	10.2	10.0	10.1	10.0	2.5	2.8	3.6	4.1
79	61.4	61.4	61.4	61.4	35.2	39.9	35.2	31.0	13.2	18.3	13.2	18.3	3.4	3.8	5.6	6.3
80	47.6	37.1	37.1	37.1	28.1	20.3	24.6	26.9	10.9	12.4	10.5	12.4	2.7	2.9	4.1	4.4
81B	175.3	71.9	175.3	34.4	125.7	31.3	125.7	27.4	18.7	15.1	18.7	15.1	1.7	1.3	2.7	1.9
81C	156.4	36.7	156.4	36.7	94.4	23.3	94.4	24.9	14.3	16.6	14.3	16.6	1.5	1.1	2.3	1.6
82	190.3	48.9	190.3	48.9	100.1	48.8	100.1	35.6	15.4	12.2	15.4	10.8	2.6	2.0	4.2	3.1
84 (A) (B)	7.8	7.8	5.0	4.4	5.9	5.1	3.0	3.1	2.3	1.8	0.8	1.1	0.1	0.2	0.1	0.2
85	11.3	11.3	11.2	5.8	9.5	8.4	9.5	4.9	3.0	3.0	3.0	2.4	0.6	0.5	0.8	0.6
86	17.6	12.1	10.9	7.1	15.1	7.5	9.9	5.9	5.5	3.5	3.8	3.5	0.8	0.7	1.2	0.9
87	107.1	107.1	87.1	87.1	79.2	73.1	53.7	70.9	19.1	31.0	10.0	13.5	3.6	3.8	2.1	2.4
88	73.8	73.8	47.8	47.8	54.7	51.2	33.9	47.6	14.1	22.9	7.6	10.4	2.8	3.0	1.7	2.1
89	58.5	58.5	58.5	58.5	33.6	35.2	33.6	44.3	14.5	14.8	7.9	9.3	2.8	2.5	1.5	1.4
89A	58.9	58.9	58.9	58.9	33.8	35.3	33.8	44.5	14.7	14.9	8.2	9.3	2.9	2.6	1.6	1.5
90	59.5	38.3	59.5	38.3	30.0	22.3	30.0	15.9	8.4	7.3	8.4	6.1	1.3	0.9	2.1	1.5
91(A)	120.0	46.3	120.0	38.8	66.0	36.9	66.0	22.8	13.8	12.9	13.8	12.9	2.4	2.2	3.9	3.5
92	41.8	41.8	37.4	29.3	32.8	28.5	32.8	22.3	10.3	10.7	10.3	9.6	2.5	2.7	3.5	3.9
95	17.9	17.9	13.8	13.8	10.9	15.6	9.9	12.0	3.6	5.8	2.6	3.4	0.3	0.4	0.3	0.3
97	37.1	28.5	19.5	18.6	32.5	23.4	11.0	12.1	9.5	6.9	4.2	4.6	0.6	0.6	0.6	0.8
98A	36.1	16.3	16.3	16.3	27.7	11.8	10.3	11.6	6.3	4.1	3.2	4.1	0.4	0.5	0.4	0.6
490	6.8	6.2	4.8	4.3	3.8	3.9	3.8	2.9	1.2	1.2	1.1	1.1	0.2	0.2	0.2	0.3
492	11.5	8.3	11.5	5.8	7.5	7.6	7.5	3.8	3.3	2.9	2.1	1.9	0.5	0.4	0.5	0.4

Table 5.7: 42 tpd scenario, 2016. (All concentrations are in ppb.) Background SO_2 concentrations of 5.53, 2.80, 1.74, and 0.47 ppb for 1-hour, 3-hour, 24-hour, and annual (and growing season) average, respectively, are not included in the SO_2 concentrations listed in the table. However, these background values are considered when evaluating the risk of impacts to vegetation.

	2016															
	1-hour Max				3-hour Max				24-hour Max				Annual Average			
	All Hours	All Daylight	GS	GS Daylight	3-hour	All Daylight	GS	GS Daylight	24-hour	All Daylight	GS	GS Daylight	All Hours	All Daylight	GS	GS Daylight
Plots/year																
1	203.9	156.2	115.5	80.3	113.4	91.1	77.5	65.0	57.2	69.5	29.2	20.3	9.3	8.4	4.7	3.3
20	334.9	236.2	204.2	204.2	200.7	161.0	139.9	139.9	98.9	117.3	58.9	88.1	11.9	16.0	9.5	14.0
37	260.3	260.3	260.3	260.3	96.1	99.7	96.1	126.6	22.1	37.1	22.1	37.1	2.7	3.8	3.8	5.6
39	150.8	150.8	150.8	150.8	90.7	97.1	90.7	125.5	25.4	40.7	25.4	40.7	5.6	7.9	9.7	13.7
42	179.8	179.8	179.8	179.8	109.0	127.8	109.0	163.1	25.1	33.4	25.1	31.1	5.2	6.7	5.5	7.8
43A	93.7	93.7	93.7	93.7	61.5	59.0	61.5	68.4	18.8	29.0	18.8	29.0	1.7	2.2	2.4	3.1
43B	139.0	137.4	139.0	100.4	81.0	56.4	81.0	67.3	18.9	29.5	18.9	29.5	2.0	2.6	2.7	3.5
44	183.9	183.9	183.9	183.9	100.1	118.6	100.1	149.6	24.3	41.7	24.3	41.7	3.8	5.5	5.1	7.8
44A	130.9	130.9	130.9	130.9	45.5	67.5	45.5	45.5	11.9	14.1	9.1	14.1	0.8	0.7	1.1	0.9
46	101.3	101.3	100.8	100.8	65.7	62.7	65.7	74.2	19.5	30.3	19.5	30.3	1.9	2.6	2.7	3.7
47B	72.5	72.5	72.5	72.5	42.6	47.7	42.6	61.8	15.7	23.0	15.7	23.0	3.6	4.7	5.9	7.7
52(A)	72.8	72.8	72.8	72.8	46.7	58.1	46.7	67.1	14.8	22.7	14.8	22.7	2.5	3.2	3.7	4.9
54	67.6	67.6	67.6	67.6	37.6	48.6	37.6	53.6	12.7	18.8	12.7	18.8	2.0	2.5	2.9	3.6
55	48.4	45.6	48.4	45.6	35.1	22.0	35.1	22.7	7.1	8.6	7.1	8.6	0.8	0.9	1.0	1.2
56(A)	37.1	37.1	37.1	37.1	20.4	23.8	20.4	20.4	5.8	8.4	5.5	8.4	0.6	0.7	0.7	0.8
57	35.9	30.9	30.9	30.9	21.2	20.6	18.6	18.6	5.9	7.9	4.8	7.4	0.6	0.6	0.6	0.7
68	44.8	34.9	22.5	21.5	22.0	16.6	10.9	15.4	4.5	7.1	2.2	3.6	0.4	0.4	0.4	0.4
69	107.2	83.9	49.1	37.2	62.5	33.0	18.5	22.1	17.1	11.7	2.9	4.2	0.5	0.5	0.4	0.5
70	28.1	19.1	17.6	17.6	19.2	13.5	10.6	10.6	5.3	5.3	2.7	4.1	0.3	0.4	0.3	0.4
78 (A)	48.0	48.0	43.9	41.3	38.0	30.4	38.0	32.8	15.1	17.2	15.1	13.1	2.9	3.4	4.6	5.2
79	86.4	86.4	86.4	86.4	55.2	52.3	55.2	43.0	17.2	19.9	17.2	19.9	3.9	4.6	6.6	7.7
80	65.4	60.7	65.4	60.7	40.5	49.8	40.5	39.4	14.6	14.4	14.6	14.4	3.3	3.6	5.3	5.7
81B	175.4	117.2	175.4	44.6	101.8	94.5	101.8	42.3	18.8	15.6	18.8	15.6	1.7	1.7	2.5	2.5
81C	64.8	55.4	64.8	46.5	42.7	34.6	32.7	40.6	10.1	16.9	10.1	16.9	1.4	1.4	1.8	2.0
82	84.7	47.4	84.7	47.4	53.0	32.1	53.0	32.6	19.1	14.0	19.1	13.4	3.0	2.7	5.2	4.3
84 (A) (B)	9.5	9.5	9.2	9.2	6.1	7.1	6.1	5.2	1.9	2.9	1.2	2.0	0.2	0.2	0.2	0.2
85	17.2	9.6	17.2	9.6	12.2	6.6	12.2	8.0	3.1	2.9	3.1	2.7	0.7	0.6	1.1	0.9
86	15.2	9.4	15.2	9.4	10.7	7.0	10.7	6.9	4.2	4.4	4.2	3.2	1.0	0.8	1.6	1.3
87	141.0	141.0	60.8	60.8	68.5	52.9	45.8	53.9	23.1	24.2	14.7	16.8	4.5	4.1	2.4	2.0
88	88.9	88.9	57.5	57.5	47.1	40.0	40.4	40.4	18.1	23.0	13.1	14.4	3.4	3.1	1.9	1.6
89	79.8	79.8	47.7	47.7	42.9	35.4	32.7	25.8	19.7	19.6	11.9	7.9	3.5	2.7	1.8	1.1
89A	80.7	80.7	47.7	47.7	43.1	35.7	32.9	25.7	19.8	19.7	12.0	8.1	3.6	2.8	1.8	1.1
90	62.6	33.4	62.6	33.4	38.2	28.3	38.2	19.7	13.0	9.6	13.0	9.6	1.6	1.3	2.9	2.1
91(A)	86.1	47.3	86.1	47.3	49.0	34.1	49.0	36.2	19.6	13.9	19.6	13.9	3.0	3.0	5.1	4.8
92	55.7	55.7	47.3	47.3	36.9	43.6	36.9	35.5	15.7	17.4	15.7	12.8	2.9	3.3	4.5	5.0
95	58.3	28.9	35.8	21.7	23.2	12.6	15.5	13.4	5.2	5.0	2.2	3.5	0.4	0.4	0.4	0.4
97	21.0	16.2	16.2	16.2	15.5	11.6	11.5	11.2	4.4	5.7	3.6	4.4	0.5	0.6	0.6	0.7
98A	22.2	16.3	16.3	16.3	16.4	11.2	10.9	10.9	3.5	4.6	3.1	4.5	0.4	0.5	0.5	0.6
490	9.0	4.0	7.6	4.0	5.8	2.6	4.5	3.2	1.4	1.6	1.4	1.6	0.2	0.2	0.2	0.3
492	13.3	8.3	13.3	8.3	11.3	6.9	11.3	4.8	3.0	2.8	2.2	2.3	0.4	0.3	0.6	0.4

Table 5.8: 42 tpd scenario, 2017. (All concentrations are in ppb.) Background SO_2 concentrations of 5.53, 2.80, 1.74, and 0.47 ppb for 1-hour, 3-hour, 24-hour, and annual (and growing season) average, respectively, are not included in the SO_2 concentrations listed in the table. However, these background values are considered when evaluating the risk of impacts to vegetation.

	2017															
	1-hour Max				3-hour Max				24-hour Max				Annual Average			
Plots/year	All Hours	All Daylight	GS	GS Daylight	3-hour	All Daylight	GS	GS Daylight	24-hour	All Daylight	GS	GS Daylight	All Hours	All Daylight	GS	GS Daylight
1	360.9	360.9	133.8	133.8	267.9	202.5	93.5	73.1	79.1	110.3	34.2	38.7	9.6	8.8	5.1	3.9
20	433.0	422.4	433.0	179.9	310.0	288.8	159.3	137.0	109.9	137.9	53.8	89.4	12.5	16.6	10.3	13.9
37	248.2	248.2	159.8	159.8	158.7	114.6	86.9	99.1	21.9	36.9	21.1	34.7	3.2	4.3	4.7	6.4
39	76.1	76.1	76.1	76.1	45.4	62.1	45.4	65.8	20.3	28.3	20.3	28.3	5.6	7.8	8.9	12.6
42	382.8	382.8	208.1	110.8	253.2	152.5	103.0	68.1	35.5	60.0	19.6	26.2	5.3	6.8	5.9	7.9
43A	83.9	83.9	81.5	81.5	45.4	50.5	42.5	51.3	11.5	17.2	11.5	17.2	1.9	2.4	2.8	3.5
43B	102.1	102.1	100.2	100.2	63.5	62.7	44.9	56.0	14.2	19.6	14.2	18.7	2.2	2.7	3.2	4.0
44	357.8	357.8	269.8	133.2	231.7	144.3	122.3	58.5	32.2	54.5	23.2	39.3	3.7	5.1	5.2	7.3
44A	130.8	117.4	130.8	117.4	81.1	79.0	81.1	69.3	10.4	15.2	10.4	15.2	0.9	0.8	1.2	1.0
46	95.4	95.4	85.8	85.8	52.2	54.5	46.3	54.7	12.4	19.6	12.4	19.6	2.2	2.8	3.4	4.3
47B	47.1	47.1	47.1	47.1	30.9	37.0	27.7	36.7	13.4	18.0	13.4	18.0	3.7	4.8	5.5	7.1
52(A)	67.6	67.6	67.6	67.6	38.7	48.2	38.7	54.6	14.1	20.0	14.1	20.0	2.5	3.3	3.5	4.7
54	71.2	71.2	71.2	71.2	38.7	47.0	38.7	55.2	11.7	15.9	11.1	15.9	2.1	2.6	2.7	3.4
55	46.8	46.8	43.6	43.6	27.9	26.7	22.5	32.9	7.5	7.9	5.1	7.7	0.8	0.9	0.9	1.0
56(A)	76.7	54.3	46.1	28.8	58.4	24.6	22.7	17.2	11.0	7.8	5.1	5.9	0.8	0.7	0.7	0.7
57	62.2	38.6	34.2	24.3	53.5	23.9	17.8	14.9	9.1	7.5	4.3	4.9	0.6	0.6	0.6	0.6
68	60.8	60.8	18.6	18.6	40.4	35.3	11.8	13.2	12.8	20.6	4.3	5.5	0.4	0.5	0.4	0.4
69	117.1	117.1	22.8	22.8	61.1	66.0	13.3	13.3	13.2	21.4	4.7	5.3	0.5	0.5	0.4	0.5
70	32.5	32.5	17.6	17.6	13.9	18.6	11.4	11.4	5.5	8.7	3.1	3.4	0.3	0.4	0.3	0.4
78 (A)	43.0	43.0	41.5	36.6	32.0	28.3	26.3	25.9	10.7	13.1	10.7	11.2	3.1	3.7	4.4	5.1
79	59.6	59.6	59.6	59.6	45.0	37.0	34.4	42.6	13.8	20.7	13.8	20.7	4.2	5.0	6.4	7.9
80	47.1	47.1	42.8	37.7	29.3	28.0	26.9	29.0	12.1	15.0	11.4	15.0	3.4	3.9	4.8	5.4
81B	115.6	46.9	115.6	44.7	66.8	32.2	66.8	26.7	12.8	11.6	12.8	11.6	1.8	1.8	2.7	2.8
81C	85.5	46.3	85.5	46.3	48.5	24.0	48.5	24.9	10.9	10.0	10.9	10.0	1.5	1.4	2.1	2.2
82	140.7	69.2	140.7	69.2	72.4	62.2	72.4	32.7	19.3	19.2	19.3	13.4	3.1	2.9	4.6	4.3
84 (A) (B)	6.4	6.2	5.0	5.0	5.3	4.7	4.0	4.0	1.8	2.8	1.3	1.7	0.2	0.2	0.2	0.3
85	12.7	8.6	12.7	8.6	8.6	7.1	8.6	6.9	3.4	4.0	3.4	4.0	0.7	0.7	1.0	0.9
86	10.9	10.2	10.9	10.2	9.4	7.7	9.4	7.4	4.3	4.2	4.3	4.2	1.0	0.9	1.4	1.2
87	134.8	134.8	98.7	79.5	70.2	74.5	70.2	57.6	25.4	33.9	15.6	21.2	4.3	4.1	2.5	2.5
88	74.5	74.5	72.5	68.4	58.2	51.7	58.2	51.0	22.6	25.5	11.1	17.7	3.5	3.4	2.0	2.2
89	51.6	51.6	50.4	50.4	40.6	38.9	29.9	38.4	20.7	18.9	10.3	12.0	3.5	2.8	1.7	1.6
89A	51.4	51.4	51.2	51.2	40.7	38.8	29.9	38.4	20.7	18.9	10.4	12.0	3.5	2.9	1.8	1.6
90	66.4	44.0	66.4	22.4	44.5	33.2	44.5	19.1	10.2	14.0	8.9	7.7	1.5	1.4	2.2	2.1
91(A)	62.0	50.5	62.0	39.6	39.5	31.6	34.8	32.1	16.0	14.3	11.3	13.6	3.0	3.2	4.5	4.7
92	55.3	42.8	55.3	41.9	30.8	32.3	29.9	25.5	11.0	13.4	11.0	11.4	3.1	3.6	4.3	4.9
95	39.6	33.7	21.0	21.0	25.6	19.5	13.0	15.3	8.1	12.5	3.9	5.1	0.4	0.4	0.3	0.4
97	25.1	21.9	18.9	18.9	17.1	15.0	13.3	13.3	5.1	4.9	3.7	4.9	0.6	0.6	0.6	0.7
98A	20.6	20.6	20.6	20.6	14.2	13.9	14.2	14.2	3.1	4.6	3.1	4.6	0.4	0.4	0.5	0.5
490	7.2	5.2	5.2	5.2	3.8	3.2	3.4	2.9	1.4	1.5	1.2	1.5	0.2	0.2	0.2	0.2
492	10.5	7.8	10.1	6.1	6.7	6.8	6.7	4.4	3.1	3.2	2.2	1.9	0.5	0.4	0.6	0.5

Table 5.9: 42 tpd scenario, 2018. (All concentrations are in ppb.) Background SO_2 concentrations of 5.53, 2.80, 1.74, and 0.47 ppb for 1-hour, 3-hour, 24-hour, and annual (and growing season) average, respectively, are not included in the SO_2 concentrations listed in the table. However, these background values are considered when evaluating the risk of impacts to vegetation.

	2018															
	1-hour Max				3-hour Max				24-hour Max				Annual Average			
	All Hours	All Daylight	GS	GS Daylight	3-hour	All Daylight	GS	GS Daylight	24-hour	All Daylight	GS	GS Daylight	All Hours	All Daylight	GS	GS Daylight
Plots/year																
1	213.6	213.6	163.8	163.0	156.7	140.0	110.0	121.2	59.8	62.0	31.1	31.1	10.1	9.9	5.2	5.1
20	701.5	528.5	406.3	311.6	410.4	248.8	268.0	247.9	111.7	99.0	60.0	82.6	13.8	17.4	13.5	18.2
37	239.5	239.5	221.8	221.8	133.1	105.8	93.5	93.5	29.8	50.6	22.2	37.6	3.2	4.4	4.9	6.9
39	78.0	78.0	70.2	70.2	51.3	54.5	51.3	57.4	22.5	29.9	22.5	29.9	5.4	7.5	8.5	12.3
42	327.3	327.3	131.2	131.2	167.3	133.3	61.5	86.0	36.3	61.6	22.3	38.0	5.9	7.7	7.1	10.1
43A	111.2	111.2	111.2	111.2	56.6	52.4	56.6	56.6	19.0	26.6	19.0	26.6	2.3	2.7	3.5	4.2
43B	174.6	174.6	174.6	174.6	75.2	76.4	75.2	75.2	19.8	28.9	19.8	28.9	2.6	3.1	3.9	4.8
44	306.6	306.6	144.0	144.0	157.5	123.3	72.1	82.3	39.8	67.6	22.1	37.7	4.3	6.1	6.4	9.0
44A	105.3	49.6	105.3	49.6	70.2	28.5	70.2	31.6	11.4	12.8	11.4	12.8	1.1	0.9	1.6	1.2
46	118.2	118.2	118.2	118.2	58.7	57.7	58.7	58.7	20.1	29.0	20.1	29.0	2.5	3.1	3.9	4.9
47B	44.9	44.9	44.9	44.9	33.1	30.3	33.1	31.9	15.7	21.1	15.7	21.1	3.6	4.5	5.3	6.9
52(A)	61.3	61.3	61.3	61.3	41.4	51.5	41.4	61.1	12.5	18.7	12.5	16.7	2.6	3.5	3.6	4.9
54	58.4	58.4	58.4	58.4	38.7	46.6	38.7	57.5	11.6	18.5	11.6	18.5	2.2	2.9	2.8	3.9
55	38.7	38.7	31.5	31.5	24.4	26.2	24.4	30.3	8.0	10.7	5.8	7.8	1.0	1.2	1.0	1.3
56(A)	59.3	33.0	53.7	26.1	45.2	30.4	24.5	26.1	10.6	10.4	5.2	7.7	0.8	0.8	0.7	0.9
57	64.4	31.3	25.4	25.4	47.9	21.1	20.2	24.9	14.6	7.2	4.9	7.2	0.7	0.7	0.6	0.8
68	28.1	28.1	21.7	21.7	18.3	23.9	14.8	18.9	5.8	9.6	3.1	4.3	0.4	0.5	0.4	0.5
69	42.7	42.7	42.7	42.7	25.3	28.1	21.6	23.4	7.3	12.2	3.7	5.6	0.5	0.6	0.5	0.7
70	26.2	19.4	19.4	19.4	17.0	14.9	17.0	17.9	2.6	4.2	2.6	3.5	0.3	0.4	0.3	0.5
78 (A)	51.9	51.9	48.0	39.5	38.3	29.4	38.3	28.9	12.3	11.9	12.1	11.9	3.1	3.4	4.3	4.9
79	73.5	73.5	73.5	73.5	43.3	47.9	43.3	37.2	15.9	22.0	15.9	22.0	4.1	4.6	6.8	7.6
80	57.5	44.4	44.4	44.4	33.9	24.3	30.0	32.2	13.3	14.9	12.6	14.9	3.3	3.5	4.9	5.2
81B	208.6	85.7	208.6	41.2	149.8	37.8	149.8	32.9	22.3	18.1	22.3	18.1	2.1	1.5	3.3	2.3
81C	187.0	44.0	187.0	44.0	112.5	28.0	112.5	29.9	17.2	19.9	17.2	19.9	1.8	1.3	2.7	2.0
82	226.6	58.4	226.6	58.4	119.1	58.4	119.1	42.6	18.5	14.6	18.5	13.0	3.1	2.4	5.0	3.7
84 (A) (B)	9.3	9.3	6.0	5.3	7.0	6.1	3.6	3.7	2.7	2.2	1.0	1.3	0.2	0.2	0.2	0.2
85	13.7	13.7	13.5	7.0	11.4	10.1	11.4	5.9	3.6	3.6	3.6	2.9	0.7	0.6	1.0	0.8
86	21.0	14.5	13.0	8.5	18.0	9.0	11.8	7.1	6.6	4.2	4.5	4.2	1.0	0.8	1.4	1.1
87	129.5	129.5	107.3	107.3	95.5	87.9	66.2	87.3	23.2	37.6	12.2	16.6	4.4	4.6	2.6	3.0
88	89.0	89.0	58.2	58.2	66.1	61.3	41.4	58.1	17.1	27.7	9.2	12.7	3.4	3.7	2.0	2.5
89	71.1	71.1	71.1	71.1	40.9	42.6	40.9	53.7	17.8	17.8	9.8	11.3	3.5	3.1	1.9	1.8
89A	71.5	71.5	71.5	71.5	41.1	42.8	41.1	53.9	18.1	17.9	10.1	11.3	3.5	3.1	1.9	1.8
90	70.9	45.5	70.9	45.5	36.1	26.5	36.1	18.9	10.1	8.7	10.1	7.3	1.5	1.1	2.6	1.8
91(A)	143.7	55.2	143.7	46.1	79.4	44.2	79.4	27.4	16.7	15.5	16.7	15.5	2.9	2.7	4.7	4.2
92	52.2	52.2	44.8	35.0	39.2	34.2	39.2	26.7	12.3	12.9	12.3	11.5	3.0	3.3	4.3	4.7
95	21.5	21.5	16.9	16.9	13.2	18.9	11.9	14.6	4.3	7.0	3.2	4.0	0.3	0.4	0.3	0.4
97	44.8	34.6	23.6	22.3	39.3	28.5	13.2	14.5	11.4	8.4	5.0	5.6	0.7	0.8	0.8	0.9
98A	43.9	19.4	19.4	19.4	33.7	14.0	12.3	13.8	7.7	4.9	3.9	4.9	0.5	0.6	0.5	0.7
490	8.1	7.4	5.7	5.1	4.5	4.6	4.5	3.4	1.4	1.4	1.3	1.3	0.2	0.2	0.3	0.3
492	13.6	9.8	13.6	6.9	8.9	9.0	8.9	4.6	4.0	3.5	2.5	2.3	0.6	0.5	0.6	0.5

5.2 Vegetation Site Evaluation Report, May 9, 2019

Evaluation of Sites for Future Sampling
John Laurence, Consulting Plant Pathologist

NOTE: This report was completed in September 2018 and submitted to Rio Tinto on October 6, 2018. It was subsequently submitted to ENV in May of 2019. Review comments were received from Dr. Adriana Almeida-Rodriguez on July 4, 2019. The purpose of the report was to evaluate sites for use in the 2019 sampling program. Dr. Almeida-Rodriguez's comments were incorporated into the 2019 sampling program and 7 sites proposed for removal (20, 70, 79, 84A, 85, 87, and 90) were retained. The purpose of including this report is to demonstrate the pre-KMP relationship between emissions of F and S from Rio Tinto and the accumulation of F and S in western hemlock needles. The analysis and report were completed in advance of the discussion of the TOR and new atmospheric dispersion modeling.

Background

In 2010, an evaluation of sampling and inspection sites for the Rio Tinto BC Works (RTBCW) vegetation program was conducted[1]. The evaluation used the entire available dataset—1970-2009—for analysis of the relationship of F emissions to F in western hemlock needles. As a result of that analysis, 17 sites were dropped from the program due to either poor correlation with F emissions from the smelter or redundancy due to close proximity. A set of 37 sites were retained. Site 89A was added when a sample tree couldn't be located; the original tree was located the next year, but sampling continued at site 89A. In 2016, at the request of the BC Ministry of Environment and Climate Change Strategy, sites 490 and 492 in the Williams Creek drainage were added as reference sites outside of the projected dispersion from the Kitimat Modernization Project (KMP). Those 40 sites are currently sampled and inspected as part of the vegetation monitoring program and the Environmental Effects Monitoring Plan (EEM) for the BC Works.

Beginning in 2010, the smelter at Kitimat began to reduce operations in preparation for the KMP. There was a substantial decline in emissions in 2010 and again in 2014-2015 when the original VSS operations ceased[2] [3].

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[1] Laurence, J. A. A Review of the Vegetation Monitoring and Assessment Program in the Vicinity of the Rio Tinto Alcan British Columbia Operations at Kitimat, British Columbia. Submitted to Rio Tinto Alcan British Columbia Operations Kitimat, BC. May 16, 2010. 141 p.

[2] Stantec Consulting, Ltd and J. Laurence. 2018. Vegetation Monitoring Report (Annual Report 2017). Submitted to Rio Tinto BC Works, May 4, 2018. 224 p.

[3] Beginning in 2014, results of F analyses conducted by the Rio Tinto laboratory in Jonquière, Québec began to differ substantially from the historical site means. Given the reduction in emissions, the results did not make sense. Over the next few years and many re-analyses, chemists at the laboratory identified a piece of equipment that was failing.
In 2018, RTBCW organized an interlaboratory study to assess variability in analyses at 3 laboratories. Results of that study showed that all 3 laboratories (including the Rio Tinto laboratory) produced similar results[3]. The Rio Tinto laboratory had not yet replaced the failing equipment, so they used an ion-specific electrode to measure F, the same method used by the other laboratories.
In order to clarify the results from 2014-2016, it would be best to have the Rio Tinto laboratory re-analyze the samples using the ion-specific electrode. The analysis of 2015 and 2016 is particularly important since 2015 represents a year with very low emissions (and thus a reasonable "background" level of F and S in vegetation) and 2016 is the first year of operations of KMP. Results from 2014 provide another year in which emissions were quite low compared to historical levels.
These results will be especially important in the comprehensive review of sites for the EEM that is scheduled for 2019. While the EEM covers SO_2 effects, F in vegetation is perhaps a more accurate indicator of dispersion as F is not an essential element for plant growth and it occurs

Given the reduction in F emissions from KMP and the implementation of the EEM for SO_2, it is an appropriate time to review the current array of sampling sites and assess their contribution to our understanding of the deposition of F and S in the Kitimat Valley.

I undertook an analysis to evaluate the efficacy of the sites with regard to their relationship to F emissions from RTBCW. This analysis allowed me to prioritize the sites to be re-analyzed as soon as possible to facilitate the comprehensive review of EEM. The same methodology was used to propose a new array of sampling sites based on the relationship of the sites to both F and S emissions from RTBCW.

Methods

I used the F and S analysis results from the vegetation monitoring program that both Stantec Consulting and I have used in past analyses. Emissions data were used to calculate loadings—tons of F and S released—for both annual and growing season (April 15-September 15) periods. Both annual and growing season loadings were used in the analysis.

Correlation of F and S emissions with F and S in western hemlock needles.

I first examined the correlation between F and S emissions (separately) reported by RTBCW and F and S (separately) in needles of western hemlock. Four time spans were used in the analysis: the full span of results since the beginning of the S dataset in 1998 through 2013 when emissions of F and S dropped substantially; 1998-2011, the range of years used to establish a historical mean in the Sulphur Technical Assessment Report (STAR)[4]; 2000-2009, a 10-year period of VSS smelter operation; and 2000-2010, a period that included reduced operations. The correlations were examined to determine which sites had consistent and high correlations (for this analysis, I used 0.6 as the lower limit for a high correlation). The analysis allows identification of sites that are not highly correlated with F or S emissions.

Correlation among sites for F and S concentrations in western hemlock needles.

In order to identify potential redundancies in what is learned from individual sites, I examined the correlation among sites—that is, is one site a good predictor of what the result at another site will be. The rationale is that if two sites are both correlated with F and/or S emissions, but are also highly correlated with each other, one site may be redundant primarily due to close proximity to the other. For this analysis, a threshold of 0.7 was used to examine correlated sites. Two time spans were used, 1998-2013 and 2000-2009. Additional time spans will be examined for the comprehensive review.

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at very low concentrations in leaves as compared to S which is essential and occurs at high concentrations that vary not only with atmospheric input, but also with soil S availability.

[4] ESSA et al. 2013. ESSA Technologies, J. Laurence, Limnotek, Risk Sciences International, Rio Tinto Alcan, Trent University, Trinity Consultants, and University of Illinois. 2013. Sulphur Dioxide Technical Assessment Report in Support of the 2013 Application to Amend the P2-00001 Multimedia Permit for the Kitimat Modernization Project. Volume 2: Final Technical Report. Prepared for Rio Tinto Alcan, Kitimat, B.C. 450 pp.

Results

Correlation of F and S emissions with F and S in western hemlock needles.

Results of the analysis for F in western hemlock needles related to F emissions are shown in Table 5.10. Some sites have consistently high correlations in all four time spans whereas some sites have a high correlation only when 1998-2000 is included or excluded. This is likely due to particularly high loadings in 1998. Seventeen sites (37, 39, 43B, 44, 46, 52, 54, 55, 56, 57, 68, 80, 81C, 86, 91A, 92, 95, and 98A) have consistently high correlations with growing season loadings of F.

Results for the analysis of S in western hemlock needles related to S emissions are shown in Table 5.11. Only 2 sites—78A and 80—have a consistently high correlation across the four time spans. As in past analyses, this is likely due to rather homogenous S concentrations in needles throughout the valley, with a few exceptions where concentrations of S have historically been greater than the mean, but not statistically greater.

Correlation among sites for F and S concentrations in western hemlock needles.

Results of the analysis of the correlations among sites for F in western hemlock needles are shown in Table 5.12 and Table 5.13, and for S in Table 5.14 and Table 5.15. These results, in conjunction with results of the correlations with loadings, may be used to determine whether sites are adding understanding or predictive capacity to the sampling array. For instance, sites 37 and 39 both have consistently high correlations with F loadings, and the results at the 2 sites are highly correlated, indicating that one or the other site could be used without sacrificing understanding of where F deposition is occurring—we may conclude that if site 37 is low, site 39 will be as well and vice-versa.

Recommendations

Based on this analysis and other factors (e.g. reference sites, socially important sites, etc.) the following 20 sites are recommended for continued sampling:

Site	Correlation with F	Correlation with S	Additional Factors
1	Low	Low	Proximity to RTBCW
37	High	Low	
43B	High	Low	
44	High	Low	
44A	Low	Low	High elevation
46	High	Low	
52A	High	Low	
56	High	Low	
68	High	Low	
69	Low	Low	East side of Minette
78A	Low	High	High elevation
80	High	High	
81B	Low	Low	High Elevation

Site	Correlation with F	Correlation with S	Additional Factors
81C	High	Low	
86	High	Low	
89	High	Low	
91A	High	Low	
98A	High	Low	
490	N/A	N/A	Reference site
492	N/A	N/A	Reference site

The following 20 sites are recommended to be discontinued:

Site	Correlation with F	Correlation with S	Additional Factors
20	Low	Low	
39	High	Low	Proximity to and correlation with 39
42	Low	Low	
43A	Low	Low	Proximity to 43B
47B	Low	Low	
54	High	Low	Proximity to and high correlation with 52A
55	High	Low	High correlation with 57
57	High	Low	High correlation with 56
70	Low	Low	
79	Low	Low	
82	Low	Low	
84A	Low	Low	Proximity to 86
85	Low	Low	Proximity to 86
87	Low	Low	
88	Low	Low	Safety consideration
89A		Low	Proximity to 89 (about 20 meters)
90	Low	Low	High correlation with 80 and 81C
92	High	Low	Proximity to and correlation with 80
95	Low	Low	Proximity to and correlation with 68
97	Low	Low	Proximity to 98A

The sites recommended for continued sampling provide geographic coverage that will allow an estimation of the extent of the dispersion from RTBCW as shown below:

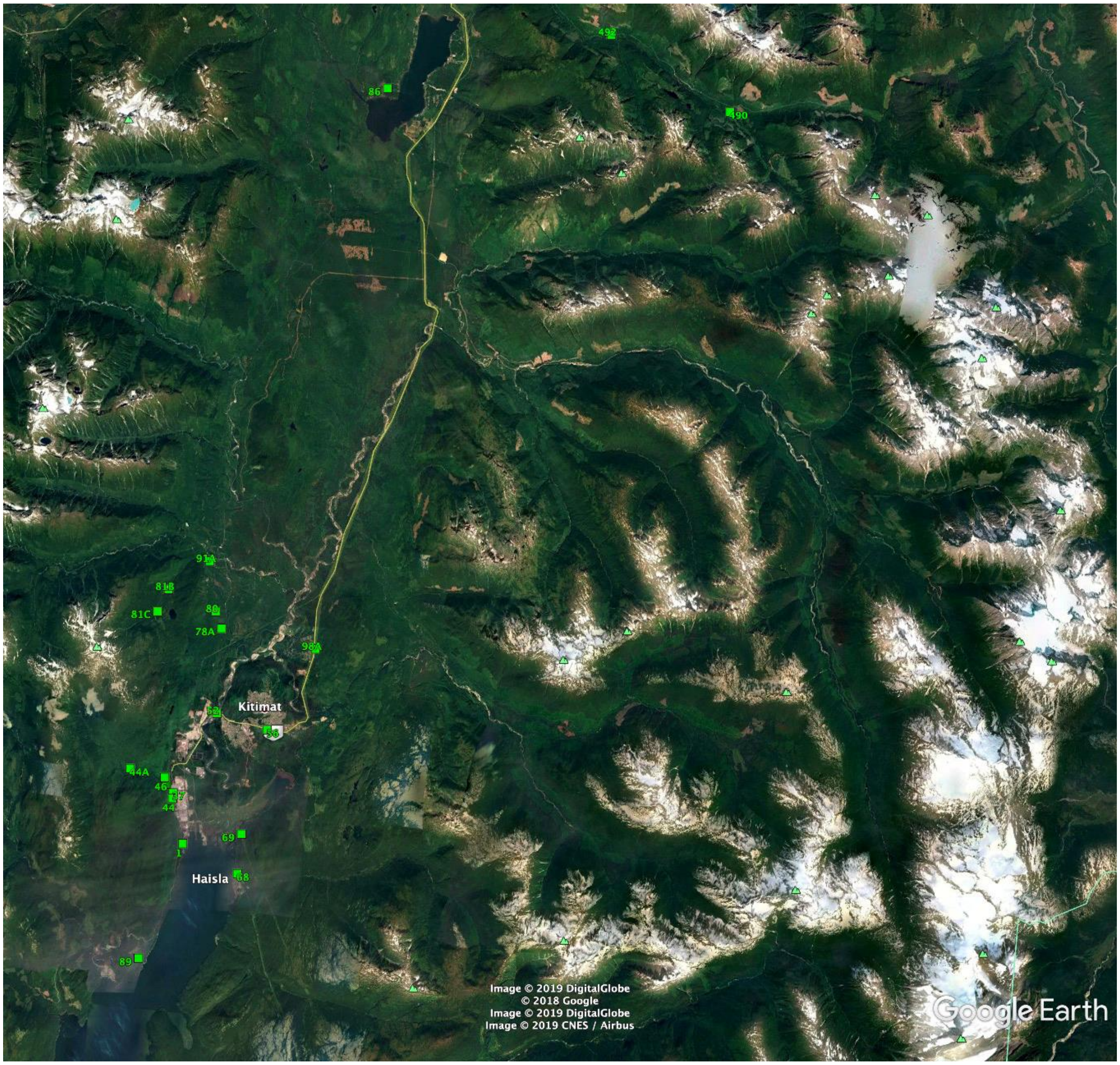

Table 5.10: Correlation between F loadings and F in needles of western hemlock for four time spans. Red shading identifies correlations greater than 0.6.

	Annual Loading					Growing Season Loading			
Site Identifier	FULL SPAN 1998-2013	STAR MEAN 1998-2011	2000-2009	2000-2010		FULL SPAN 1998-2013	STAR MEAN 1998-2011	2000-2009	2000-2010
1	0.741	0.735	-0.110	0.006		0.823	0.818	0.052	0.322
20	0.482	0.466	0.361	0.365		0.603	0.584	0.555	0.566
37	0.612	0.609	0.583	0.534		0.792	0.792	0.831	0.789
39	0.701	0.706	0.736	0.636		0.768	0.772	0.806	0.740
42	0.536	0.544	0.460	0.462		0.592	0.592	0.545	0.549
43A	0.874	0.876	0.390	0.419		0.923	0.927	0.241	0.589
43B	0.583	0.598	0.559	0.466		0.635	0.657	0.657	0.607
44	0.622	0.634	0.552	0.553		0.764	0.781	0.804	0.809
44A	0.574	0.554	0.756	0.688		0.510	0.482	0.694	0.578
46	0.815	0.809	0.681	0.657		0.855	0.850	0.885	0.815
47B	0.359	0.434	0.273	0.272		0.288	0.380	0.237	0.234
52(A)	0.545	0.599	0.768	0.737		0.575	0.645	0.885	0.872
54	0.789	0.799	0.608	0.546		0.829	0.846	0.765	0.723
55	0.349	0.329	0.550	0.516		0.471	0.444	0.681	0.669
56	0.627	0.668	-0.183	0.150		0.766	0.811	-0.022	0.611
57	0.536	0.533	0.505	0.545		0.597	0.606	0.638	0.710
68	0.098	0.126	0.545	0.487		0.238	0.275	0.720	0.680
69	0.474	0.468	0.442	0.349		0.555	0.552	0.639	0.464
70	0.229	0.238	0.350	0.271		0.274	0.282	0.507	0.442
78(A)	0.749	0.765	0.605	0.487		0.793	0.788	0.733	0.570
79	0.794	0.809	0.414	0.402		0.761	0.790	0.529	0.509
80	0.917	0.924	0.923	0.926		0.937	0.944	0.973	0.843
81B	0.463	0.446	-0.080	-0.087		0.549	0.530	0.160	0.137
81C	0.467	0.698	0.669	0.460		0.538	0.817	0.780	0.836
82	0.682	0.695	0.363	0.312		0.692	0.689	0.396	0.301
84 (A) (B)	-0.134	-0.137	0.388	0.362		-0.038	-0.037	0.593	0.533
85	-0.066	-0.052	0.341	0.322		0.011	0.035	0.490	0.443
86	0.284	0.284	0.472	0.472		0.382	0.385	0.611	0.611
87	0.840	0.853	0.653	0.654		0.779	0.781	0.470	0.475
88	0.878	0.884	0.816	0.740		0.834	0.832	0.693	0.544
89/89 (A)	0.566	0.575	0.643	0.607		0.546	0.531	0.633	0.568
90	0.628	0.626	0.588	0.586		0.374	0.355	0.291	0.286
91(A)	0.650	0.713	0.748	0.747		0.695	0.762	0.788	0.780
92	0.548	0.557	0.753	0.753		0.611	0.610	0.768	0.768
95	0.188	0.179	0.385	0.388		0.395	0.397	0.598	0.610
97	0.475	0.566	0.826	0.811		0.328	0.404	0.601	0.571
98A	0.680	0.677	0.774	0.694		0.639	0.642	0.702	0.659
490	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
492	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 5.11: Correlation between S loadings and S in needles of western hemlock for four time spans. Red shading identifies correlations greater than 0.6.

	Annual Loading				Growing Season Loading			
	FULL SPAN 1998-2013	STAR MEAN 1998-2011	2000-2009	2000-2010	FULL SPAN 1998-2013	STAR MEAN 1998-2011	2000-2009	2000-2010
1	0.789	0.715	-0.209	0.303	0.784	0.683	-0.280	0.223
20	0.724	0.641	-0.196	0.336	0.649	0.546	-0.260	0.232
37	0.642	0.517	-0.224	0.152	0.570	0.426	-0.257	0.076
39	0.716	0.577	-0.111	0.283	0.656	0.484	-0.194	0.173
42	0.727	0.620	0.121	0.459	0.702	0.588	0.179	0.452
43A	0.622	0.429	-0.807	-0.365	0.627	0.406	-0.791	-0.390
43B	0.717	0.630	-0.167	0.363	0.655	0.558	-0.149	0.304
44	0.596	0.539	-0.012	0.331	0.495	0.424	-0.118	0.212
44A	0.507	0.407	-0.159	0.020	0.464	0.365	-0.132	0.021
46	0.511	0.326	-0.483	0.007	0.468	0.263	-0.385	-0.004
47B	0.681	0.551	0.044	0.337	0.616	0.463	-0.009	0.260
52(A)	0.532	0.380	-0.338	0.075	0.452	0.271	-0.410	-0.035
54	0.491	0.204	-0.501	-0.206	0.416	0.089	-0.603	-0.339
55	0.303	0.121	0.133	-0.022	0.258	0.051	0.014	-0.097
56	0.729	0.650	-1.000	0.152	0.696	0.598	-0.996	0.096
57	0.568	0.405	0.483	-0.126	0.554	0.375	0.417	-0.123
68	0.806	0.772	0.562	0.601	0.736	0.681	0.409	0.486
69	0.524	0.395	0.117	0.169	0.459	0.299	-0.020	0.051
70	0.618	0.550	0.289	0.265	0.527	0.441	0.124	0.137
78 (A)	0.909	0.922	0.683	0.863	0.860	0.872	0.648	0.806
79	0.661	0.591	0.258	0.403	0.578	0.489	0.121	0.280
80	0.789	0.908	1.000	0.947	0.738	0.889	0.996	0.961
81B	0.739	0.692	0.607	0.581	0.724	0.684	0.573	0.572
81C	0.401	0.338	0.483	-0.432	0.385	0.323	0.417	-0.402
82	0.747	0.646	0.140	0.403	0.680	0.556	0.056	0.308
84 (A) (B)	0.685	0.529	-0.010	0.257	0.609	0.414	-0.136	0.125
85	0.509	0.384	0.414	0.296	0.498	0.362	0.349	0.268
86	0.531	0.497	0.473	0.278	0.526	0.488	0.463	0.308
87	0.670	0.610	0.466	0.485	0.613	0.545	0.378	0.422
88	0.275	0.060	-0.198	-0.109	0.251	0.017	-0.229	-0.148
89/89 (A)	0.753	0.688	0.558	0.624	0.706	0.639	0.480	0.565
90	0.398	0.351	0.091	0.199	0.316	0.270	0.007	0.117
91(A)	0.195	0.178	0.191	0.060	0.155	0.115	0.092	0.000
92	0.203	0.359	0.084	0.084	0.098	0.238	-0.037	-0.037
95	0.727	0.690	0.553	0.581	0.681	0.634	0.477	0.529
97	0.727	0.631	0.541	0.438	0.684	0.573	0.452	0.393
98A	0.394	0.301	0.207	0.186	0.282	0.166	-0.007	0.032
490								
492								

Table 5.12: Correlations for F in western hemlock needles among sampling sites for the period 1998-2013. Yellow identifies sites with a correlation greater than 0.7, blue for sites greater than 0.8, and green for sites with greater than 0.9. Sites listed as 42A and 56A are the same as sites 42 and 56.

SITE	1	20	37	39	42(A)	43A	43B	44	44A	46	47B	52(A)	54	55	(56 A)	57	68	69	70	78(A)	79	80	81B	81C	82	84 (A)	85	86	87	88	89/89 (	90	91(A)	92	95	97	98A
1	1	0.624	0.662	0.577	0.076	0.591	0.36	0.628	0.249	0.403	0.42	0.438	0.55	0.293	0.219	0.03	0.271	-0.04	0.364	0.57	0.385	0.234	0.579	0.262	0.415	0.106	0.011	0.253	0.368	0.245	0.579	0.21	0.318	0.129	0.183	0.081	0.186
20		1	0.574	0.39	0.502	0.539	0.17	0.766	0.446	0.388	0.056	0.26	0.18	0.173	-0.04	-0.16	0.234	-0.05	0.158	0.495	0.565	0.34	0.762	0.354	0.572	0.015	-0.07	0.251	0.63	0.623	0.652	0.315	0.124	0.057	-0.01	0.036	0.18
37			1	0.764	0.611	0.879	0.783	0.773	0.53	0.749	0.478	0.845	0.745	0.482	0.161	-0.12	0.466	0.069	0.674	0.51	0.553	0.532	0.332	0.52	0.166	0.086	-0.06	0.241	0.394	0.345	0.521	0.218	0.569	0.359	0.239	-0.02	0.523
39				1	0.645	0.59	0.81	0.589	0.153	0.445	0.378	0.719	0.809	0.695	0.529	0.285	0.647	0.2	0.498	0.341	0.447	0.426	0.016	0.447	0.205	0.319	0.169	0.539	0.462	0.297	0.395	0.381	0.741	0.709	0.415	0.432	0.696
42(A)					1	0.459	0.63	0.586	0.318	0.676	0.415	0.587	0.403	0.331	-0.25	-0.56	0.213	0.028	0.227	0.658	0.641	0.211	0.203	-0.35	0.365	-0	-0.19	0.103	0.494	0.464	0.565	0.318	0.639	0.314	-0.02	0.082	0.291
43A						1	0.711	0.81	0.673	0.773	0.666	0.878	0.611	0.134	-0.04	-0.25	0.177	-0.23	0.774	-0.33	0.477	0.61	0.554	0.476	-0.04	-0.21	-0.29	-0.17	0.457	0.34	0.402	0.419	0.496	-0.24	-0.18	-0.2	0.047
43B							1	0.458	0.371	0.629	0.526	0.875	0.74	0.459	0.222	-0.12	0.425	-0.01	0.608	0.267	0.427	0.494	0.023	0.517	-0.02	0.105	0.007	0.127	0.194	0.066	0.236	0.274	0.582	0.357	0.262	0.066	0.579
44								1	0.419	0.608	0.311	0.684	0.596	0.409	0.477	0.155	0.501	0.256	0.416	0.581	0.74	0.771	0.575	0.792	0.328	0.255	0.161	0.402	0.519	0.481	0.569	0.243	0.534	0.344	0.275	0.209	0.377
44A									1	0.709	0.547	0.595	0.01	-0.09	-0.22	-0.34	-0.29	-0.18	0.545	0.676	0.387	0.709	0.768	0.044	0.234	-0.21	-0.33	-0.27	0.57	0.587	0.465	0.496	0.116	-0.28	-0.35	-0.22	0.109
46										1	0.559	0.777	0.387	0.159	-0.27	-0.46	0.012	0.054	0.376	0.854	0.535	0.702	0.349	0.101	0.376	-0.07	-0.22	-0.05	0.387	0.508	0.628	0.304	0.609	0.22	-0.01	-0.08	0.097
47B											1	0.69	0.442	0.095	-0.18	-0.22	-0.03	0.1	0.328	0.254	0.651	0.572	0.035	0.381	-0.06	0.046	-0.15	0.092	0.291	0.328	0.285	0.394	0.364	0.077	-0.07	-0.04	0.239
52(A)												1	0.764	0.403	0.216	-0.09	0.398	0.155	0.704	0.35	0.625	0.823	0.106	0.535	-0.03	0.143	0.017	0.193	0.396	0.307	0.393	0.323	0.671	0.363	0.186	0.139	0.553
54													1	0.739	0.658	0.443	0.814	0.44	0.611	0.168	0.464	0.439	-0.07	0.78	-0.02	0.45	0.365	0.619	0.121	-0.01	0.291	0.104	0.696	0.768	0.615	0.29	0.734
55														1	0.932	0.836	0.851	0.726	0.498	0.254	0.156	0.362	-0	0.396	0.254	0.791	0.696	0.854	0.135	0.111	0.397	0.178	0.55	0.887	0.838	0.475	0.865
(56 A)															1	0.885	0.865	0.811	0.422	-0.01	0.029	0.416	0.03	0.399	0.07	0.932	0.928	0.949	-0.03	-0.1	0.105	0.027	0.473	0.897	0.928	0.607	0.914
57																1	0.693	0.905	0.137	0.146	-0.16	0.259	-0.02	0.388	0.203	0.928	0.93	0.95	-0.1	-0.07	0.07	0.112	0.277	0.971	0.9	0.597	0.762
68																	1	0.6	0.486	-0.03	0.335	0.298	-0.01	0.611	0.085	0.696	0.697	0.865	0.049	-0.03	0.256	0.008	0.492	0.836	0.811	0.493	0.874
69																		1	0.139	0.283	0.173	0.368	0.006	0.279	0.223	0.911	0.853	0.915	-0.09	0.049	0.292	0.042	0.404	0.82	0.806	0.501	0.572
70																			1	-0.31	0.081	0.724	0.156	0.449	-0.09	0.185	0.141	0.216	0.251	0.102	0.219	0.143	0.25	0.201	0.194	-0.07	0.66
78(A)																				1	0.422	-0.22	0.466	-0.27	0.691	0.152	-0.03	0.177	0.471	0.654	0.677	0.46	0.526	0.378	0.2	0.107	0.082
79																					1	0.492	0.441	0.483	0.293	0.203	0.066	0.36	0.552	0.582	0.508	0.523	0.453	0.228	0.13	0.27	0.22
80																						1	0.628	0.389	0.262	0.388	0.331	0.369	0.506	0.537	0.601	0.535	0.605	0.266	0.185	0.317	0.746
81B																							1	0.409	0.621	0.042	-0	0.097	0.382	0.434	0.511	0.348	-0.15	-0.26	-0.08	-0.21	-0.16
81C																								1	-0.22	0.358	0.406	0.462	-0.11	-0.07	0.054	0.2	0.123	0.257	0.533	0.064	0.527
82																									1	0.193	0.124	0.304	0.547	0.593	0.792	0.494	0.198	0.321	0.079	0.218	-0.02
84 (A) (B)																										1	0.95	0.941	-0.02	0.091	0.249	0.135	0.309	0.714	0.882	0.634	0.771
85																											1	0.874	-0.12	-0.03	0.147	0.029	0.15	0.652	0.871	0.608	0.707
86																												1	0.158	0.231	0.397	0.17	0.372	0.774	0.84	0.667	0.9
87																													1	0.875	0.693	0.715	0.298	0.153	-0.22	0.389	0.349
88																														1	0.797	0.764	0.293	0.182	-0.14	0.385	0.361
89/89 (A)																															1	0.529	0.389	0.481	0.171	0.255	0.306
90																																1	0.294	0.131	-0.04	0.414	0.474
91(A)																																	1	0.748	0.392	0.519	0.432
92																																		1	0.791	0.696	0.794
95																																			1	0.517	0.888
97																																				1	0.759
98A																																					1

Table 5.13: Correlations for F in western hemlock needles among sampling sites for the period 2000-2009. Yellow identifies sites with a correlation greater than 0.7, blue for sites greater than 0.8, and green for sites with greater than 0.9. Sites listed as 42A and 56A are the same as sites 42 and 56.

SITE	1	20	37	39	42(A)	43A	43B	44	44A	46	47B	52(A)	54	55	(56 A)	57	68	69	70	78(A)	79	80	81B	81C	82	84 (A) (B)	85	86	87	88	89/89 (A)	90	91(A)	92	95	97	98A
1	1.000	0.674	0.709	0.542	-0.738	0.801	0.064	0.743	0.792	1.000	0.644	0.567	0.739	0.649	0.729	0.977	0.515	0.469	0.485	1.000	1.000	0.867	0.999	0.618	0.849	0.939	0.831	1.000	0.867	0.826	0.955	0.785	0.905	1.000	0.797	0.893	-1.000
20		1.000	0.582	0.409	0.414	0.696	0.053	0.854	0.505	0.206	0.089	0.361	0.362	0.357	0.997	0.817	0.556	0.256	0.335	0.241	0.729	0.953	0.710	0.997	0.451	0.445	0.302	0.714	0.902	0.704	0.533	0.327	0.210	0.207	0.172	0.350	0.322
37			1.000	0.922	0.594	0.943	0.740	0.774	0.398	0.607	0.483	0.918	0.935	0.890	1.000	0.844	0.853	0.343	0.691	0.370	0.567	0.966	0.030	0.993	0.184	0.552	0.242	0.807	0.733	0.476	0.523	0.513	0.767	0.852	0.768	0.694	0.878
39				1.000	0.674	0.898	0.901	0.580	0.090	0.541	0.543	0.894	0.921	0.880	0.970	0.710	0.794	0.181	0.647	0.311	0.542	0.888	-0.136	0.996	0.117	0.431	0.064	0.684	0.536	0.186	0.334	0.507	0.761	0.822	0.691	0.583	0.791
42(A)					1.000	0.238	0.675	0.561	-0.012	0.620	0.661	0.708	0.587	0.638	-0.076	-0.576	0.474	0.412	0.194	0.663	0.820	-0.304	-0.011	0.074	0.259	0.456	-0.016	0.476	0.511	0.422	0.487	0.496	0.710	0.558	0.329	0.346	0.546
43A						1.000	0.648	0.931	0.064	1.000	0.359	0.942	0.969	0.956	0.994	0.911	0.812	-0.269	0.864	-0.482	0.839	0.993	0.378	0.966	-0.029	0.181	-0.052	0.623	0.914	0.201	0.378	0.995	0.983	0.623	0.772	0.325	1.000
43B							1.000	0.302	-0.119	0.483	0.407	0.865	0.817	0.779	0.730	0.277	0.648	0.002	0.579	0.214	0.278	0.553	-0.363	0.824	-0.060	0.183	0.008	0.282	0.192	-0.218	0.071	0.511	0.705	0.754	0.601	0.424	0.750
44								1.000	0.717	0.584	0.236	0.691	0.601	0.546	1.000	0.870	0.628	0.446	0.394	0.587	0.715	0.978	0.556	0.985	0.418	0.519	0.325	0.661	0.868	0.697	0.595	0.502	0.574	0.478	0.452	0.532	0.404
44A									1.000	0.610	-0.030	0.367	0.193	0.155	0.160	0.643	0.127	0.571	-0.081	0.608	0.188	0.383	0.597	0.011	0.207	0.484	0.430	0.369	0.431	0.742	0.390	0.266	0.503	0.440	0.554	0.726	-0.127
46										1.000	0.674	0.792	0.614	0.589	1.000	1.000	0.396	0.799	0.042	0.901	0.522	1.000	-0.025	1.000	0.470	0.701	0.460	0.579	0.374	0.551	0.626	0.432	0.914	0.872	0.705	0.746	0.302
47B											1.000	0.548	0.557	0.537	-0.055	0.464	0.203	0.448	0.030	0.581	0.587	0.177	-0.265	-0.204	0.220	0.438	-0.230	0.477	0.360	0.285	0.451	0.259	0.612	0.557	0.284	0.239	0.342
52(A)												1.000	0.929	0.870	0.977	0.731	0.749	0.421	0.588	0.530	0.513	0.902	-0.122	0.998	0.162	0.491	0.225	0.577	0.578	0.323	0.511	0.482	0.874	0.883	0.767	0.636	0.729
54													1.000	0.959	1.000	0.867	0.870	0.367	0.765	0.296	0.485	0.976	-0.088	0.986	0.240	0.528	0.275	0.745	0.605	0.279	0.547	0.571	0.788	0.954	0.802	0.593	0.790
55														1.000	0.994	0.798	0.909	0.448	0.748	0.248	0.542	0.942	-0.122	0.999	0.273	0.647	0.366	0.787	0.568	0.414	0.616	0.660	0.805	0.953	0.844	0.665	0.856
(56 A)															1.000	0.859	0.962	-0.263	0.952	-1.000	0.720	0.973	0.704	0.989	0.257	0.449	0.987	1.000	0.973	0.216	0.493	0.996	0.951	1.000	0.994	0.959	1.000
57																1.000	0.687	0.268	0.662	-1.000	0.974	0.954	0.968	0.773	0.715	0.843	0.931	1.000	0.954	0.685	0.869	0.900	0.975	1.000	0.908	0.969	1.000
68																	1.000	0.303	0.884	-0.021	0.482	0.874	0.125	0.992	0.314	0.561	0.526	0.842	0.669	0.433	0.586	0.620	0.585	0.829	0.761	0.602	0.825
69																		1.000	-0.055	0.742	0.574	-0.033	0.199	-0.404	0.714	0.888	0.639	0.856	0.401	0.714	0.861	0.473	0.659	0.914	0.569	0.642	0.063
70																			1.000	-0.411	0.113	0.856	-0.003	0.987	0.022	0.166	0.342	0.632	0.499	0.114	0.311	0.395	0.289	0.741	0.567	0.270	0.645
78(A)																				1.000	0.644	-1.000	0.134	-1.000	0.490	0.607	0.015	0.424	0.319	0.503	0.489	0.342	0.733	0.556	0.311	0.491	0.027
79																					1.000	0.861	0.490	0.608	0.636	0.687	0.178	0.761	0.731	0.699	0.677	0.598	0.582	0.461	0.274	0.414	0.292
80																						1.000	0.849	0.928	0.472	0.643	0.998	1.000	1.000	0.435	0.680	0.989	0.997	1.000	0.992	0.999	1.000
81B																							1.000	0.590	0.660	0.216	0.337	0.314	0.496	0.373	0.309	0.368	-0.127	-0.213	-0.171	-0.045	-0.610
81C																								1.000	0.109	0.311	0.951	1.000	0.928	0.067	0.357	0.972	0.894	1.000	0.967	0.906	1.000
82																									1.000	0.704	0.620	0.711	0.463	0.494	0.729	0.525	0.308	0.409	0.248	0.300	-0.360
84 (A) (B)																										1.000	0.654	0.931	0.512	0.788	0.836	0.619	0.709	0.815	0.719	0.821	0.405
85																											1.000	0.589	0.336	0.495	0.694	0.320	0.264	0.582	0.572	0.555	0.110
86																												1.000	0.820	0.870	0.893	0.502	0.564	0.712	0.623	0.695	0.736
87																													1.000	0.719	0.730	0.330	0.368	0.480	0.325	0.365	0.444
88																														1.000	0.801	0.362	0.450	0.558	0.382	0.637	0.391
89/89 (A)																															1.000	0.450	0.537	0.787	0.533	0.527	0.278
90																																1.000	0.660	0.461	0.581	0.483	0.203
91(A)																																	1.000	0.855	0.826	0.783	0.586
92																																		1.000	0.895	0.779	0.811
95																																			1.000	0.890	0.774
97																																				1.000	0.706
98A																																					1.000

Table 5.14: Correlations for S in western hemlock needles among sampling sites for the period 1998-2013. Yellow identifies sites with a correlation greater than 0.7, blue for sites greater than 0.8, and green for sites with greater than 0.9. Sites listed as 42A and 56A are the same as sites 42 and 56.

SITE	1	20	37	39	42(A)	43A	43B	44	44A	46	47B	52(A)	54	55	(56 A)	57	68	69	70	78(A)	79	80	81B	81C	82	84 (A)	85	86	87	88	89/89	90	91(A)	92	95	97	98A
1	1.000	0.832	0.890	0.945	0.851	0.925	0.894	0.693	0.730	0.769	0.823	0.908	0.907	0.620	0.863	0.679	0.756	0.816	0.750	0.783	0.779	0.536	0.709	0.481	0.880	0.934	0.650	0.647	0.747	0.756	0.750	0.594	0.356	0.319	0.725	0.706	-0.391
20		1.000	0.842	0.861	0.801	0.779	0.782	0.680	0.740	0.745	0.883	0.738	0.659	0.275	0.936	0.494	0.698	0.466	0.629	0.908	0.625	0.723	0.488	0.354	0.757	0.714	0.359	0.398	0.637	0.502	0.642	0.481	0.062	0.317	0.564	0.476	0.219
37			1.000	0.841	0.783	0.855	0.812	0.820	0.628	0.748	0.810	0.740	0.669	0.393	0.960	0.691	0.668	0.610	0.523	0.854	0.628	0.711	0.600	0.569	0.787	0.683	0.530	0.526	0.656	0.492	0.666	0.590	0.344	0.402	0.670	0.649	0.401
39				1.000	0.820	0.811	0.827	0.634	0.686	0.806	0.852	0.872	0.858	0.558	0.919	0.686	0.738	0.709	0.728	0.885	0.774	0.670	0.531	0.413	0.840	0.884	0.584	0.542	0.642	0.629	0.628	0.671	0.393	0.424	0.662	0.649	0.498
42(A)					1.000	0.784	0.863	0.590	0.542	0.811	0.675	0.749	0.559	0.178	0.851	0.563	0.597	0.465	0.449	0.871	0.706	0.652	0.522	0.326	0.783	0.646	0.439	0.455	0.584	0.396	0.700	0.436	0.307	0.299	0.545	0.513	0.305
43A						1.000	0.809	0.688	0.699	0.736	0.701	0.759	0.873	0.391	0.900	0.666	0.539	0.559	0.458	0.844	0.629	0.449	0.593	0.516	0.755	0.807	0.485	0.451	0.358	0.633	0.679	0.311	-0.053	0.000	0.520	0.570	-0.398
43B							1.000	0.753	0.552	0.761	0.686	0.780	0.698	0.303	0.916	0.608	0.628	0.501	0.560	0.820	0.728	0.717	0.507	0.470	0.883	0.761	0.365	0.470	0.621	0.296	0.646	0.554	0.335	0.436	0.649	0.620	0.520
44								1.000	0.482	0.593	0.599	0.652	0.600	0.291	0.838	0.558	0.584	0.491	0.506	0.813	0.673	0.759	0.681	0.561	0.729	0.682	0.390	0.339	0.701	0.204	0.802	0.491	0.262	0.570	0.638	0.667	0.652
44A									1.000	0.781	0.867	0.672	0.682	0.541	0.895	0.646	0.571	0.377	0.669	0.740	0.477	0.683	0.426	0.484	0.673	0.732	0.351	0.594	0.384	0.757	0.321	0.598	-0.034	0.365	0.559	0.527	-0.099
46										1.000	0.775	0.863	0.665	0.603	0.786	0.612	0.543	0.515	0.520	0.820	0.865	0.351	0.536	0.392	0.826	0.779	0.690	0.698	0.579	0.657	0.554	0.584	0.511	0.581	0.768	0.706	0.544
47B											1.000	0.682	0.642	0.556	0.928	0.635	0.687	0.481	0.675	0.895	0.612	0.684	0.496	0.413	0.746	0.734	0.493	0.593	0.669	0.691	0.566	0.635	0.154	0.368	0.661	0.577	0.180
52(A)												1.000	0.810	0.592	0.833	0.588	0.682	0.773	0.686	0.705	0.794	0.511	0.397	0.371	0.771	0.893	0.504	0.436	0.527	0.537	0.479	0.532	0.508	0.505	0.615	0.602	0.607
54													1.000	0.551	0.856	0.715	0.628	0.694	0.703	0.652	0.696	0.579	0.475	0.438	0.792	0.903	0.451	0.361	0.355	0.628	0.432	0.640	0.302	0.423	0.515	0.642	0.662
55														1.000	0.505	0.733	0.568	0.707	0.652	0.119	0.644	0.302	0.354	0.569	0.477	0.702	0.703	0.681	0.414	0.552	0.196	0.524	0.614	0.451	0.704	0.686	0.693
(56 A)															1.000	0.664	0.644	0.573	0.706	0.933	0.511	0.706	0.509	0.508	0.783	0.877	0.362	0.490	0.837	0.615	0.805	0.495	0.010	0.143	0.550	0.554	-0.612
57																1.000	0.745	0.775	0.815	0.348	0.644	0.645	0.765	0.884	0.772	0.768	0.742	0.825	0.763	0.611	0.836	0.604	0.630	0.541	0.724	0.889	0.526
68																	1.000	0.823	0.888	0.705	0.869	0.794	0.699	0.611	0.811	0.793	0.661	0.652	0.600	0.452	0.591	0.611	0.516	0.522	0.829	0.856	0.746
69																		1.000	0.769	0.399	0.711	0.576	0.495	0.597	0.639	0.778	0.688	0.514	0.476	0.414	0.371	0.540	0.775	0.465	0.679	0.761	0.768
70																			1.000	0.594	0.793	0.857	0.500	0.637	0.714	0.814	0.503	0.554	0.613	0.527	0.474	0.678	0.506	0.634	0.646	0.710	0.760
78(A)																				1.000	0.674	0.821	0.684	0.307	0.809	0.725	0.391	0.423	0.756	0.484	0.878	0.516	0.034	0.367	0.620	0.569	0.293
79																					1.000	0.438	0.721	0.470	0.896	0.839	0.767	0.724	0.565	0.534	0.730	0.687	0.589	0.772	0.913	0.811	0.843
80																						1.000	0.655	0.562	0.681	0.657	0.303	0.492	0.882	0.302	0.897	0.640	0.168	0.378	0.550	0.626	-0.167
81B																							1.000	0.692	0.732	0.587	0.810	0.720	0.556	0.414	0.781	0.542	0.301	0.509	0.824	0.863	0.578
81C																								1.000	0.558	0.512	0.606	0.768	0.692	0.291	0.614	0.369	0.576	0.562	0.655	0.761	0.557
82																									1.000	0.855	0.629	0.670	0.534	0.597	0.702	0.725	0.411	0.619	0.803	0.826	0.702
84 (A) (B)																										1.000	0.569	0.517	0.554	0.550	0.565	0.587	0.423	0.467	0.729	0.792	0.737
85																											1.000	0.850	0.492	0.554	0.530	0.585	0.662	0.535	0.853	0.797	0.585
86																												1.000	0.487	0.578	0.441	0.659	0.576	0.617	0.869	0.762	0.396
87																													1.000	0.241	0.840	0.419	0.417	0.502	0.581	0.544	0.491
88																														1.000	0.218	0.703	0.188	0.480	0.431	0.409	0.019
89/89 (A)																															1.000	0.417	0.282	0.496	0.619	0.640	0.579
90																																1.000	0.470	0.810	0.621	0.597	0.575
91(A)																																	1.000	0.653	0.544	0.558	0.732
92																																		1.000	0.572	0.522	0.721
95																																			1.000	0.912	0.725
97																																				1.000	0.799
98A																																					1.000

Table 5.15: Correlations for S in western hemlock needles among sampling sites for the period 2000-2009. Yellow identifies sites with a correlation greater than 0.7, blue for sites greater than 0.8, and green for sites with greater than 0.9. Sites listed as 42A and 56A are the same as sites 42 and 56.

SITE	1	20	37	39	42(A)	43A	43B	44	44A	46	47B	52(A)	54	55	(56 A)	57	68	69	70	78(A)	79	80	81B	81C	82	84 (A) (	85	86	87	88	89/89 (A	90	91(A)	92	95	97	98A
1	1.000	0.189	0.945	0.982	1.000	0.500	0.996	0.945	0.945	1.000	0.982	0.990	0.996	0.891	0.189	0.756	0.327	0.577	0.500		1.000	-0.189	0.676	0.756	0.929	0.929	0.849	0.866	-0.189	0.999	0.500	0.877	0.756	0.963	0.756	0.619	
20		1.000	0.305	0.515	0.277	0.000	-0.458	-0.101	0.420	0.349	0.767	0.212	0.020	0.091	1.000	-0.500	0.088	-0.025	0.198	0.463	0.104	-1.000	-0.221	-0.500	-0.081	-0.035	0.129	0.019	0.315	0.450	0.139	0.135	-0.090	0.146	-0.090	-0.359	-0.256
37			1.000	0.451	0.398	0.739	0.178	0.497	-0.223	0.175	0.292	0.317	0.125	0.171	0.500	0.500	0.105	0.418	-0.064	0.358	0.221	-0.500	0.260	0.500	0.214	-0.082	0.505	0.303	0.326	0.423	0.293	0.409	0.488	0.376	0.255	0.160	0.170
39				1.000	0.602	-0.106	0.231	0.060	0.308	0.678	0.605	0.791	0.530	0.750	0.000	0.866	0.423	0.602	0.605	0.504	0.651	0.000	-0.010	0.866	0.493	0.567	0.531	0.502	0.402	0.610	0.158	0.699	0.706	0.706	0.352	0.181	0.495
42(A)					1.000	0.167	0.474	-0.161	-0.140	0.576	0.190	0.407	-0.145	0.188	0.189	0.756	0.050	0.182	-0.082	0.511	0.396	-0.189	0.109	0.756	0.208	0.010	0.511	0.532	0.256	0.149	0.240	0.226	0.500	0.206	0.345	0.059	-0.022
43A						1.000	0.577	0.786	0.348	1.000	-0.276	0.297	0.408	-0.129	0.945	-0.189	-0.577	-0.414	-0.629	-1.000	0.896	-0.945	0.101	-0.189	0.187	0.000	0.087	0.000	-0.782	0.303	-0.375	-0.117	-0.289	0.079	0.000	-0.099	
43B							1.000	0.159	-0.407	0.262	-0.494	0.292	0.235	0.127	0.277	0.693	-0.109	0.163	-0.200	-0.350	0.468	-0.277	0.049	0.693	0.528	0.179	0.275	0.333	-0.254	-0.158	0.084	0.259	0.608	0.340	0.339	0.268	0.522
44								1.000	-0.370	-0.129	-0.131	0.260	0.256	0.324	0.500	0.500	0.185	0.405	0.121	0.244	0.460	-0.500	0.556	0.500	0.280	0.312	0.415	0.112	0.506	-0.093	0.657	0.118	0.418	0.517	0.413	0.489	0.805
44A									1.000	0.631	0.709	0.274	0.510	0.422	0.500	0.500	0.034	-0.163	0.332	0.332	0.111	-0.500	0.053	0.500	0.220	0.364	0.071	0.330	-0.156	0.927	-0.303	0.391	-0.278	0.261	-0.007	-0.050	-0.676
46										1.000	0.310	0.687	0.420	0.520	1.000		-0.296	0.000	-0.089	0.596	0.690	-1.000	-0.070		0.537	0.383	0.533	0.520	-0.198	0.627	-0.150	0.290	0.190	0.582	0.334	-0.258	-0.282
47B											1.000	0.153	0.131	0.373	0.000	0.866	0.272	0.057	0.444	0.750	0.220	0.000	0.087	0.866	0.211	0.080	0.310	0.413	0.408	0.787	0.165	0.576	0.044	0.444	0.122	-0.085	-0.341
52(A)												1.000	0.758	0.773	0.327	0.655	0.307	0.710	0.502	0.056	0.625	-0.327	-0.040	0.655	0.401	0.794	0.391	0.213	0.165	0.397	-0.002	0.406	0.666	0.584	0.269	0.259	0.599
54													1.000	0.727	0.277	0.693	0.297	0.583	0.561	-0.476	0.527	-0.277	-0.051	0.693	0.571	0.816	0.197	0.110	-0.176	0.543	-0.243	0.552	0.426	0.625	0.181	0.293	0.717
55														1.000	-0.277	0.971	0.686	0.768	0.840	0.305	0.830	0.277	0.384	0.971	0.702	0.908	0.632	0.569	0.376	0.579	0.265	0.733	0.725	0.863	0.615	0.641	0.802
(56 A)															1.000	-0.500	-0.866	-0.693	-0.756			-1.000	-0.596	-0.500	-0.189	-0.189	-0.359	-0.327	-1.000	0.240	-0.756	-0.305	-0.500	-0.082	-0.500	-0.655	
57																1.000	0.866	0.971	0.945		1.000	0.500	0.993	1.000	0.945	0.945	0.988	0.982	0.500	0.721	0.945	0.977	1.000	0.904	1.000	0.982	
68																	1.000	0.770	0.816	0.241	0.829	0.866	0.526	0.866	0.564	0.588	0.650	0.494	0.317	0.268	0.331	0.581	0.589	0.535	0.704	0.761	0.835
69																		1.000	0.700	0.007	0.625	0.693	0.277	0.971	0.484	0.714	0.561	0.306	0.274	0.206	0.159	0.546	0.839	0.577	0.520	0.649	0.762
70																			1.000	0.185	0.712	0.756	0.183	0.945	0.475	0.781	0.365	0.317	0.388	0.416	0.165	0.618	0.535	0.645	0.405	0.480	0.794
78(A)																				1.000	0.308		0.527		0.076	-0.078	0.555	0.627	0.820	0.629	0.752	0.309	0.202	0.410	0.401	0.168	-0.172
79																					1.000		0.574	1.000	0.880	0.760	0.836	0.742	0.327	0.428	0.535	0.685	0.736	0.868	0.867	0.750	0.863
80																						1.000	0.596	0.500	0.189	0.189	0.359	0.327	1.000	-0.240	0.756	0.305	0.500	0.082	0.500	0.655	
81B																							1.000	0.993	0.586	0.244	0.851	0.749	0.342	0.225	0.695	0.368	0.311	0.508	0.875	0.869	0.508
81C																								1.000	0.945	0.945	0.988	0.982	0.500	0.721	0.945	0.977	1.000	0.904	1.000	0.982	
82																									1.000	0.609	0.768	0.791	0.045	0.547	0.308	0.822	0.615	0.842	0.822	0.746	0.831
84 (A) (B)																										1.000	0.414	0.290	0.158	0.372	0.115	0.480	0.598	0.703	0.477	0.570	0.828
85																											1.000	0.875	0.409	0.444	0.635	0.654	0.675	0.733	0.943	0.798	0.570
86																												1.000	0.321	0.557	0.495	0.758	0.555	0.706	0.849	0.668	0.340
87																													1.000	0.009	0.813	0.194	0.441	0.472	0.339	0.231	0.348
88																														1.000	-0.071	0.785	0.138	0.605	0.293	0.172	-0.157
89/89 (A)																															1.000	0.151	0.387	0.505	0.654	0.501	0.503
90																																1.000	0.628	0.828	0.590	0.525	0.557
91(A)																																	1.000	0.713	0.637	0.626	0.790
92																																		1.000	0.706	0.626	0.822
95																																			1.000	0.912	0.698
97																																				1.000	0.799
98A																																					1.000

5.3 Off-site Maximums

Table 5.16, Table 5.17 and Table 5.18 provide, for each emissions scenario, the maximum CALPUFF-modelled SO_2 concentrations (and where they occurred) in ppb 1-hour, 3-hour, 24-hour, annual, and growing season averages for all hours of the day and for daylight hours. Although provided, the daylight hours should only be used with the growing season statistics as the hours were not adjusted for short winter days. Background SO_2 concentrations of 5.53, 2.80, 1.74, and 0.47 ppb for 1-hour, 3-hour, 24-hour, and annual (and growing season) average, respectively, are not included in the SO_2 concentrations listed in the table. However, these background values are considered when evaluating the risk of impacts to vegetation.

Table 5.16: Maximum CALPUFF-modelled SO_2 concentrations in ppb, and where they occurred, in 1-hour, 3-hour, 24-hour, annual, and growing season averages for all hours of the day and for daylight hours, under the actual emission scenario.

Regional 500m Receptor Grid, Offsite & Fenceline receptors only, Discrete & Onsite receptors omitted.

		all hours, all seasons			all hours, growing season			daylight hours, all seasons			daylight hours, growing season		
Avg. Period	Year	CONC (ppb)	UTM X (km)	UTM Y (km)	CONC (ppb)	UTM X (km)	UTM Y (km)	CONC (ppb)	UTM X (km)	UTM Y (km)	CONC (ppb)	UTM X (km)	UTM Y (km)
1hr	2016	780.0	518.709	5984.689	759.8	518.262	5984.605	584.4	519.163	5983.139	399.8	518.531	5984.693
	2017	890.6	518.500	5985.000	890.6	518.500	5985.000	570.7	518.974	5983.510	413.8	516.000	5987.500
	2018	859.0	518.500	5985.000	859.0	518.500	5985.000	802.3	518.441	5984.695	265.2	518.000	5987.500
3hr	2016	465.3	518.979	5984.883	334.0	518.352	5984.696	380.4	518.978	5985.066	180.9	518.891	5983.842
	2017	373.6	519.000	5982.500	373.6	519.000	5982.500	294.8	518.978	5984.976	190.6	516.000	5987.500
	2018	584.0	518.500	5985.000	316.8	518.000	5985.500	657.3	518.500	5985.000	137.2	518.799	5984.688
24hr	2016	179.8	518.978	5984.976	68.5	518.441	5984.695	270.4	518.978	5984.976	56.5	518.709	5984.689
	2017	176.8	518.978	5985.066	65.2	519.000	5982.500	200.0	518.978	5985.066	47.9	518.620	5984.691
	2018	137.6	518.978	5984.976	67.6	518.000	5985.500	136.1	518.978	5984.976	44.3	518.620	5984.691
All hours	2016	14.5	519.161	5982.368	12.6	519.267	5987.193	11.1	519.161	5982.368	15.5	519.267	5987.193
	2017	14.9	519.149	5981.875	12.4	519.173	5987.193	11.1	519.161	5982.368	15.6	519.173	5987.193
	2018	15.5	519.149	5981.875	12.7	519.173	5987.193	11.7	519.158	5982.270	15.6	519.173	5987.193

Table 5.17. Maximum CALPUFF-modelled SO_2 concentrations in ppb, and where they occurred, in 1-hour, 3-hour, 24-hour, annual, and growing season averages for all hours of the day and for daylight hours, under the 35 tpd emission scenario.

Regional 500m Receptor Grid. Offsite & Fenceline receptors only, Discrete & Onsite receptors omitted

		all hours, all seasons			all hours, growing season			daylight hours, all seasons			daylight hours, growing season		
		aa			ag			da			dg		
Avg. Period	Year	CONC (ppb)	UTM X (km)	UTM Y (km)	CONC (ppb)	UTM X (km)	UTM Y (km)	CONC (ppb)	UTM X (km)	UTM Y (km)	CONC (ppb)	UTM X (km)	UTM Y (km)
1hr	2016	1083.1	518.709	5984.689	943.5	518.352	5984.696	708.6	518.973	5983.429	411.7	518.531	5984.693
	2017	869.7	518.500	5985.000	869.7	518.500	5985.000	632.8	519.000	5983.000	513.7	516.000	5987.500
	2018	995.4	518.500	5985.000	995.4	518.500	5985.000	587.0	518.974	5983.510	294.3	518.352	5984.696
3hr	2016	517.7	518.973	5983.429	414.2	518.352	5984.696	354.3	518.973	5983.429	197.7	518.891	5983.842
	2017	561.3	519.000	5983.000	427.8	519.000	5982.500	603.1	519.000	5983.000	239.1	516.000	5987.500
	2018	477.9	518.973	5983.429	477.9	518.973	5983.429	389.2	518.973	5983.429	182.5	519.163	5983.139
24hr	2016	104.7	518.973	5983.429	84.9	519.158	5982.949	108.2	518.978	5984.976	56.2	518.709	5984.689
	2017	119.9	519.000	5983.000	72.9	519.000	5982.500	127.9	519.000	5983.000	52.8	518.500	5983.500
	2018	112.6	518.978	5984.976	87.7	518.973	5983.429	114.8	518.978	5984.976	51.9	519.000	5987.500
All hours	2016	15.4	519.149	5981.875	13.2	519.267	5987.193	11.3	519.161	5982.368	16.9	519.267	5987.193
	2017	15.7	519.149	5981.875	13.0	519.173	5987.193	11.4	519.158	5982.270	17.0	519.173	5987.193
	2018	16.8	519.149	5981.875	13.4	519.173	5987.193	12.4	519.158	5982.270	17.2	519.173	5987.193

Table 5.18. Maximum CALPUFF-modelled SO2 concentrations in ppb, and where they occurred, in 1-hour, 3-hour, 24-hour, annual, and growing season averages for all hours of the day and for daylight hours, under the 42 tpd emission scenario.

Regional 500m Receptor Grid, Offsite & Fenceline receptors only, Discrete & Onsite receptors omitted

		all hours, all seasons aa			all hours, growing season ag			daylight hours, all seasons da			daylight hours, growing season dg		
Avg. Period	Year	CONC (ppb)	UTM X (km)	UTM Y (km)	CONC (ppb)	UTM X (km)	UTM Y (km)	CONC (ppb)	UTM X (km)	UTM Y (km)	CONC (ppb)	UTM X (km)	UTM Y (km)
1hr	2016	1297.8	518.709	5984.689	1122.1	518.441	5984.695	838.0	518.973	5983.429	494.6	518.500	5983.500
	2017	1028.6	518.500	5985.000	1028.6	518.500	5985.000	749.0	519.000	5983.000	610.7	516.000	5987.500
	2018	1177.0	518.500	5985.000	1177.0	518.500	5985.000	732.5	518.974	5983.510	350.8	518.000	5988.000
3hr	2016	616.9	518.973	5983.429	489.8	518.352	5984.696	419.0	518.973	5983.429	234.0	518.891	5983.842
	2017	664.4	519.000	5983.000	514.3	519.000	5982.500	713.8	519.000	5983.000	284.1	516.000	5987.500
	2018	595.1	518.973	5983.429	595.1	518.973	5983.429	488.1	518.973	5983.429	228.0	519.163	5983.139
24hr	2016	124.6	518.973	5983.429	105.8	519.158	5982.949	129.5	518.978	5984.976	66.5	518.709	5984.689
	2017	142.2	519.000	5983.000	87.6	519.000	5982.500	151.7	519.000	5983.000	63.1	518.500	5983.500
	2018	134.8	518.978	5984.976	108.4	518.973	5983.429	137.4	518.978	5984.976	62.3	519.000	5987.500
All hours	2016	18.6	519.158	5982.270	15.8	519.267	5987.193	13.7	519.161	5982.368	20.4	519.267	5987.193
	2017	19.0	519.149	5981.875	15.6	519.173	5987.193	13.8	519.158	5982.270	20.5	519.173	5987.193
	2018	20.3	519.149	5981.875	16.1	519.173	5987.193	15.0	519.158	5982.270	20.7	519.173	5987.193

5.4 Field Sampling and Inspection Protocols

This report has been inserted in its original format on the subsequent pages, and as such does not have the correct figure and table numbering format that the rest of the appendices have.

Field Manual for Vegetation Sampling and Inspection in the Vicinity of Rio Tinto—BC Works, Kitimat, BC[5]

Introduction

Background

The vegetation sampling and inspection program is composed of two components: annual sampling of vegetation, and a biennial inspection of vegetation. The purpose of the vegetation sampling and inspection program is to 1) document the accumulation of fluoride (F^-, hereafter F) and sulphur (S) in needles of western hemlock as a method of estimating dispersion and potential effects of hydrogen fluoride gas (HF) and sulphur dioxide (SO_2) on the health of vegetation; and 2) assess the health of vegetation as affected by emissions from the smelter as well as other stressors through a biennial inspection by a qualified professional (QP).

Formal sampling and inspection of vegetation to assess the concentration of F in foliage and the effects of F on vegetation near the aluminium smelter in Kitimat, BC began around 1970. Vegetation sampling occurred before that time, but the protocols are not documented. F is measured in the needles of western hemlock (*Tsuga heterophylla*) in part to serve as a biomonitor of F, but also as a method of estimating the dispersion of the plume from the Alcan smelter, now the Rio Tinto BC Works (RTBCW). Analysis of foliage for S began in 1997. Over the years, sampling has been carried out by company personnel as well as consultants, but the recent sampling program has been implemented by contracted consultants, currently Stantec Consulting Ltd.

Western hemlock was chosen as a bioaccumulator because it is ubiquitous in the Kitimat Valley, and it is not particularly sensitive to either pollutant. Since it is not sensitive, it was rarely injured, even when emissions were substantially greater than today, thus it continued to accumulate both F and S over the course of the growing season. As emissions of F were reduced over the years, visible injury no longer occurs. Visible injury of western hemlock due to SO_2 has never been documented in the area.

A biennial inspection of vegetation to assess the effects of pollutants as well as other stressors such as insects, pathogens, and environmental conditions, is conducted by RTBCW's QP.

[5] This manual was compiled by John Laurence, RT Vegetation QP, and Nicole Glover and Meghan O'Neill of Stantec Consulting, Ltd.

The vegetation sampling and inspection program has been reviewed and revised periodically[6,7]. The current methods for the program are documented here.

Vegetation Sampling

Safety

Safety is a critical component of the vegetation sampling program. Sampling takes place under a variety of outdoor conditions, utilizes sharp tools, requires travel on foot over uneven and slippery terrain, may involve wildlife encounters, and requires both truck and aircraft operations. The vegetation sampling contractor operates an independent safety program but is also required to assess and mitigate risk using the RTBCW health and safety program. Requirements are listed under Field Preparation.

Field Preparation

Field preparation for the vegetation sampling program includes submitting necessary safety paperwork to RTBCW, completing contractor inductions, finalizing the field schedule (including having RTBCW book the helicopter), gathering field supplies, and liaising with RTBCW and their QP during preparations and planning. Prior to field work with RTBCW, a Contractor Safe Work Plan must be submitted to RTBCW. RTBCW will schedule a kick-off meeting the morning of the first day of field work to review the field program and safety requirements, and to issue a work permit for the field program.

Site List

The current array of sample sites was chosen to provide a range of locations across the Kitimat Valley, both near and far from RTBCW. Some sites have been in use since 1970, while others have been added to address specific concerns (e.g. reference sites outside the dispersion of the plume, helicopter accessible sites on the valley hillslope, etc.). In each case, one or more western hemlock trees are chosen for sampling. Because of the nature of sampling, new trees are periodically sampled when appropriate branches on sample trees are no longer accessible. A procedure for replacing sample trees and sites is detailed below.

The Site List and Location Descriptions are found in Appendix A. The site list includes the UTM coordinates for each site, as well as a brief site access description.

RTBCW's QP conducts a visual inspection of vegetation every second year. The QP accompanies the vegetation sampling field crew in their fleet vehicle for field site visits. The field work schedule must be coordinated with the QP well before the proposed sampling date.

Field Supplies

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6 Laurence, J. A. 2010. A Review of the Vegetation Monitoring and Assessment Program in the Vicinity of the Rio Tinto Alcan British Columbia Operations at Kitimat, British Columbia. Submitted to Rio Tinto Alcan British Columbia Operations, May 16, 2010. 92 p. and appendices 49 p.

7 ESSA Technologies, J. Laurence, Risk Sciences International, Trent University, and Trinity Consultants. 2019. 2019 Comprehensive Review of Sulphur Dioxide Environmental Effects Monitoring for the Kitimat Modernization Project – Volume 2: Draft Report. Prepared October 31, 2019 for Rio Tinto, B.C. Works, Kitimat, B.C.

Tools required for the field Program include the following:

- Pole Pruners
- Hand Pruning Shears
- Loppers
- Clean Tarp (to be purchased annually)
- 50 Large Sample (lawn waste) Bags
- Heavy Duty Stapler and Staples
- Orange and Red Flagging Tape
- Aluminum Scratch Tags
- Nails and Hammer
- Colored Stickers (5 colors, used to mark bags by date when put into storage)

Pole pruners, hand pruners and loppers should be inspected for damage, debris, and blade sharpness before use. The blades of these tools are to be cleaned and sharpened if required. A new tarp must be purchased for each field season to ensure that it is free from dust, dirt, or other contaminants. Mark the side of the tarp to be in as the ground contact side to keep the sample contact surface of the tarp clean.

Vegetation Sampling Field Work

Safety

The approved safety protocols, including check-in/check-out, tailgate safety sessions, periodic assessments during the day, and an end-of-the-day safety debrief must be followed in the field.

Maintenance

At each vegetation sample site, determine the presence and condition of flagging and tree tags. If missing or damaged, replace flagging and aluminum scratch tree ID tags. Hang orange and red colored flagging from a visible height on the tree. ID tags and flagging should be labelled with the site number. Write the ID of the new location on the tree tag with ballpoint pen and nail it to trunk of the sample tree(s). If a site needs to be moved, remove and dispose of flagging and tree ID tags from the old location.

Sampling Procedures

Generally, one field member will collect the sample while the other takes photographs and fills out the field form. The camera must have the time and date stamp feature turned on with the correct time, and date settings. Photographs are all to be taken in landscape format.

Place the tarp on the ground close to the tree so that it collects the sample clippings as they fall. Make every effort to keep the sample clippings from contacting the ground.

Collect sample material using pruners, shears, or loppers, dropping sample material on the tarp. Good samples tend to be collected using the pole pruners from higher up in the tree on specifically exposed aspects. Select boughs with long leader lengths and vigorous growth. Trim the ends of boughs, not entire branches from the tree so that the tree can be sampled for multiple years. When samples of poor or moderate growth, collect additional material so that the sample will yield a minimum of 20 g dry weight of processed needles. Figure 1 shows an example of an ideal sample and Figure 2 shows an example of a poor sample.

Once an adequate sample has been collected, transfer the material to a paper sample bag. Label the sample bag in large letters. After the sample is transferred to the sample bag, roll the top of the bag over and staple it shut.

Figure 1: Good quality field sample. Note the long leader lengths and that all clippings are from the ends of the tree boughs

Figure 2: Poor quality field sample. Note the short leader lengths, clippings are large and include the inner boughs and foliage. Note the previously clipped bough.

Photographs

Check that the camera time and date stamp are correct and turned on for all field photographs. The following photos should be taken at each site:

- **Sample Label:** A close photo of the sampling bag with sample site number, date, and crew written in large print
- **Tree Prior to Sampling:** A landscape photo which includes the sampling tree prior to removing and sample
- **Tree During Sampling:** A landscape photo of the sampling personnel clipping sample vegetation from the tree
- **North:** A landscape photo showing the north from the sample location
- **East:** A landscape photo showing the east from the sample location
- **South:** A landscape photo showing the south from the sample location
- **West:** A landscape photograph showing the west from the sample location
- **Sample Prior to Bagging:** A photo from above of the sample on the tarp. Flip a representative bough upside down on the top of the sample for this photo.
- **Sample Close Up:** A close up of a few boughs of the sample. Flip a representative bough upside down on the top of the sample for this photo and include the leader of that bough included in the photo.
- **Other Photos:** Photograph damage, evidence of insect infestation, symptoms of disease, discolored foliage, or other interesting findings.

Field Forms

The Field Form documents conditions of the site and the sample tree at the time of sampling and includes checklists and direction on data to be recorded. At the end of each day all completed field forms should be removed from the field clipboard, scanned and saved, and left at the office. The current Field Form can be found in Appendix B.

Record any defoliation, insects, foliar pests (e.g., woolly adelgid, looper larvae), dwarf mistletoe, porcupine scarring, rubs/scars, decay/fungi, root diseases, or abiotic signs such as drought. Record and photograph the location of pests/damage on the tree. If there are no signs of pests or disease, record the general health and condition of the trees and justify why you are assessing something as healthy or not healthy. Estimate the percent of the branch and tree that is affected. Note if neighboring trees display similar symptoms or signs of insect, disease, and other stresses.

When a Site is Lost or Needs to be Moved

When a sample tree is no longer adequate for sampling or is lost to unforeseen circumstances such as brushing and clearing, blowdown, or industry. The following three scenarios describe how to assign sample site numbers to a site when the coordinates change.

- When a new site is selected and is within 100 meters of the previous tree or coordinate (if the tree is lost), a new tree(s) should be selected, and the coordinates updated on the field form. The site number will not change in this scenario.
- When a new site is selected and is greater than 100 meters away from the previous tree or coordinate (if the tree is lost), but less than 300 meters away, a new tree(s) should be selected, and the coordinates updated on the field form. The site number will have a letter added to it. If the sample site number already has a letter, then you will select the next sequential letter. Check the sample site list to be certain that a site name is not duplicated.
- When a new site is located that is greater than 300 meters away, or a new site is added to the Program, a new sample site number is selected, and the coordinates recorded on the field form. The sample site number should be greater than 100 in order to avoid duplicating sample sites from historical data sets that have been dropped.

Select only healthy trees for sampling. The RTBCW QP should be consulted in new site selection if they are present at the site. All new sample trees should each be marked with orange and red flagging tape and have an aluminum scratch tag attached to the trunk. The following factors should be considered when selecting new sample tree(s) (Laurence, 2010):

- Two to five trees should be selected for each site and the crown height of these trees should be greater than 6 meters
- Sample trees should be located away from rock faces or other features that may affect wind dispersion patterns
- Sample trees should be in an open canopy area and exposed to ambient air flows
- Sample trees should have accessible foliage, and ideally have one aspect of the tree that is fully exposed to ambient air and light
- Avoid trees with damaged boughs, defoliation, insect infestations, damaged terminal leaders/apical stems

Sample Storage and Daily Post Field

Samples are to be transported to a refrigerated cooler for storage the same day that they are collected. If sample bags are dirty or wet, transfer the sample into a fresh bag for storage in the cooler. Mark the sample bags with a colored sticker (with a unique color assigned for each sample day) to assist in retrieving samples in the same order that they are stored in. Samples will be processed in the order that they are collected, first-in-first-out.

Back up photos and return and scan completed field forms to the office. Fill out the Chain of Custody form at the end of each day.

Lab Procedures

Preparation consists of clipping the current years' growth, drying the vegetation samples, grinding the samples, measuring and packaging sample units, and shipping to a lab for further analysis. Laboratory methods and quality control measures are consistent with the Standard

Operating Procedure for Processing of Vegetation Samples Prior to Analysis[8]. This standard procedure is intended to provide consistency and uniformity of drying and grinding preparations among samples.

Lab Set Up

The lab is to be set up in a secure room, free of wind, dust, and contamination. The room must be kept locked overnight. The work bench in this room should be equipped with scales, metal mixing bowls, Pyrex baking dishes, small hand clippers, tweezer, bags and labels.

A second area should be set up with a drying oven and wash station. The work bench in this area must be in a well-ventilated area and was equipped with the drying oven, Alconox powdered soap, paper towels and sponge, dust masks, beaker, grinder and sink with wash basin.

Prior to starting the sampling clipping, the drying oven, Pyrex baking dishes, metal mixing bowls, tweezers, hand clippers, and the work bench should be cleaned with a solution of Alconox and water. Equipment should be left to air dry or was dried in the drying oven.

Sample Clipping

Samples are to be collected from the storage cooler on the same day that they are to be prepared in the lab and processed in in the same order in which they are collected in the field. The sample clipping will follow the steps outlined below. Refer to Figure 5.1 which shows how to determine the current annual growth from previous year's growth.

Sample clipping must be done according to the following steps:

- Clean the work bench and wash hands before starting each new sample
- Complete the sample clipping fields for date and crew on the Chain of Custody
- Attach a piece of masking tape to the outside of each metal bowl and weigh. Mark the weight of the bowl on the masking tape and tare the scale.
- Remove the current year's growth from the stems (Figure 5.1) and place into the metal mixing bowl. Collect between 100 and 125 grams of needles for each sample so there is enough sample for a duplicate analysis. Samples with more woody stems (i.e., those with abundant growth and long leaders) will have a higher stem to needle ratio and will require closer to 125 grams.
- Weigh and record clipped sample weight on the Chain of Custody form. Transfer the clippings to a Pyrex baking dish and label the dish using masking tape and marker with the sample site number and weight.

During the clipping process, record on the Chain of Custody form any relevant observations of the sample condition such as wooly adelgid infestations, looper larvae, fungus etc.

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[8] Ontario Ministry of Environment, Environmental Monitoring, and Reporting Branch. 2015. Standard Operating Procedure for Processing of Vegetation Samples Prior to Analysis.

Figure 5.1 Growth leaders, showing the annual growth to be clipped off in the lab (marked in red)

Sample Dehydrating

Dehydrate samples in the drying oven for 24 hours at 38ºC (100ºF) in the labeled Pyrex dishes. Drying time was recorded on the COC form. The needles should be crispy, and brownish green. If needles still have a waxy texture, are deep green, or do not easily come off the stem, they need more time in the oven.

Sample Cleaning and Grinding

To clean the samples, pour the sample into a clean Pyrex dish and use a clean pair of tweezers to remove stems or other debris, leaving only the dried foliage. When the sample is clean, weigh it and record the clean sample weight on the Chain of Custody.

To grind the sample:

- Pour the sample into the clean lid of the grinder.
- Continue grinding until all the sample is ground into a powder9.
- Place a clean 50 mL beaker on the scale and tare it. Slowly add small amounts of the sample to the beaker using a clean spoon until 10 g is reached. Transfer the sample into a small plastic sample bag.
- Label the 10 g sample bag as part of Sample Set A for shipment to the lab
- Repeat the above steps, adding the remainder of the sample into a beaker, then weighing and transferring the sample to a small plastic sample bag.

[9] This is a rough preparation. Starting in 2018, an additional processing step has been added by the RT lab – fine grinding of the sample to a maximum particle size of 0.1 to 0.15mm, using a Wiley mill.

- Label the bag of remaining sample as part of Sample Set B (for sample duplicates and sample retention).
- Complete the Chain of Custody form for both Sample Set A and Sample Set B.
- Clean the work bench, scale, grinder, grinder lid, spoon and beaker using the Alconox solution before moving to the next sample.
- Package duplicates of 3 samples to send with Sample Set A and sent to the lab for quality control purposes.

Sample Shipping and Retention

Sample set A is to be shipped to the lab. Prior to shipping, confirm with RTBCW that the RT lab in Québec ready to receive the samples.

Sample set B is to be provided to RTBCW for indefinite retention. These samples should be stored in a cool dark place, out of direct sunlight in an area where they cannot be tampered with or contaminated.

Reporting

The sampling contractor works with the QP and RTBCW Primary Project Contact to report the results of the sampling and analysis. The QP has the lead for integrating the results of the sampling, site and tree condition data collected by the sampling team, and the results of the inspection. In years when the inspection is not conducted, the QP works with the sampling team to help interpret the condition data that was recorded.

Vegetation Inspection

Safety

Safety is a critical component of the vegetation inspection program. The QP works with the Primary Project Contact from RTBCW to complete a separate HSE risk assessment since, although most of the hazards are the same as for the sampling team, some differ. The QP does not remain at the sampling site and so may encounter different field travel conditions, wildlife encounters, traffic hazards, overhead hazards, and so on.

In addition to the separate HSE risk assessment, the QP follows the contractor's safety plan since they travel together and work in the same general environment. Following the contractor's safety plan also allows common check-in/check-out procedures, tailgate sessions, mid-day assessments, etc.

Field Preparation

The QP must be prepared for variable, and sometimes very uncomfortable field conditions including heavy rain, cold, slippery, and boggy conditions. Field data sheets (shown in Appendix C) should be printed on water resistant paper. Camera equipment should be waterproof or protected from the elements.

The QP should be knowledgeable about the ecology and plant taxonomy of the area, as well as the signs and symptoms of plant pathogens, pollution injury and insect pests. In addition, it is helpful to review previous reports to understand the conditions observed during the last few sampling and inspection visits. This is particularly important since the QP visits on a biennial frequency, thus it will likely have been 2 years since the last inspection.

The QP should communicate with both the RTBCW Program Project Manager and the contractor's field lead well in advance (at least 3 months) of the inspection. Adequate lead time allows development of a workable schedule by all involved.

Site Location

The inspection sites are the same as the sampling sites with a few additions. Historically, observations have been made in Kitamaat Village, at the Minette Bay overlook on the east side of the bay, at the RTBCW administration building, at Moore Creek Falls overlook, and in neighborhoods of Kitimat. Samples are not taken at those locations.

The purpose of the observations in Kitamaat Village and in Kitimat is to document conditions of both ornamental and native vegetation in the area. The focus of the observations is to identify any significant problems with vegetation (particularly insect infestation, disease, or drought) that may be confused or associated symptoms that might be caused by smelter operations.

Visual Assessment Field Work

General Site Conditions At each site an assessment of general conditions should be made. This assessment includes the general appearance of the site (e.g. green, healthy vegetation; droughty conditions; insect infestation; dusty; industrial activity such as logging, transmission line maintenance, construction, etc.). A general site photo is taken to support the description.

Survey of Signs and Symptoms A survey of vegetation in the area of the sample site is made. This survey notes the presence of symptoms or signs of pests, pathogens, and other stressors on any vegetation at the site. If the site is along a road, the survey usually covers 100-200 meters in either direction from the sample tree. The survey should extend as far into the surrounding terrain as is practicable and necessary to examine the variety of species at the site. Symptoms are noted on the field data sheet. If symptoms of F or S injury are present, the affected area of individual leaves and the percentage of the plant that is affected should be estimated for calculation of an injury index[10]. The intensity of other symptoms such as insect feeding, fungal leaf spots, etc. are qualitatively assessed—slight, moderate, or severe. The QP should define those categories. In the case of an insect outbreak or disease epidemic, the injury index can be calculated using incidence and severity to provide a more quantitative assessment.

While the inspection and survey should be thorough, it does not require documenting every species present at the site. Particular attention should be paid to species that are common to a large number of sites (e.g. western hemlock, western redcedar, Sitka spruce, elderberry, red-osier dogwood, balsam poplar, thimble berry, salmon berry, and others). Other species that are known to be sensitive to HF and SO_2 such as lodgepole pine, *Rubus sp.*, white pine, and *Salix sp.* should be noted if present.

Observations of Sample Tree and Samples The sampling team makes detailed observations of the sample tree and records that data on their field data form. It is important for the QP to

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[10] Laurence, J. A. 2010. A Review of the Vegetation Monitoring and Assessment Program in the Vicinity of the Rio Tinto Alcan British Columbia Operations at Kitimat, British Columbia. Submitted to Rio Tinto Alcan British Columbia Operations, May 16, 2010. 92 p. and appendices 49 p.

observe the sample tree and note any signs or symptoms to confirm the sample team observations and provide a consistent assessment of the sample tree.

Presence/Absence of Species of Interest A list of species that have been reported to be sensitive to SO_2 can be found in Appendix D. This list was compiled from a source reference[11] by the BC Ministry of the Environment and, at their request, the QP notes the presence of the species at a site. While presence is noted, the lack of a notation does not mean the species wasn't present, just that it wasn't observed during the inspection.

Digital Images

Digital images are used to document the general conditions and any signs or symptoms of stressors such as insects, pathogens, air pollutants, physical injury, or other environmental stressors. Digital images should be geo-referenced, and date/time stamped to assure accurate site location information. Data sheets should be photographed in the field when the site inspection is completed. At the end of the day, all digital images should be backed up to an appropriate device for safe keeping.

A digital image archive is maintained along with the report of the inspection by RTBCW.

Reporting

The QP provides a stand-alone report of the vegetation inspection to the Primary Project Contact and the Senior Environmental Advisor. The QP also works with the sampling team to interpret the results of the sampling and inspection for the overall annual report of the vegetation sampling and inspection program. Examples of both reports are on file with RTBCW.

In addition to the reports of the vegetation sampling and inspection reports, the QP works with the Environmental Effects Monitoring (EEM) team to address the vegetation aspects of the EEM.

[11] The list is derived from "Sulfur Dioxide" by A. H. Legge, H-J Jager, and S. V. Krupa in Recognition of Air Pollution Injury to Vegetation: A Pictorial Atlas, Second Addition, edited by R. B. Flagler and published by the Air and Waste Management Association in 1998. The reference does quantify the response of plants reported to be sensitive nor the exposure concentration and duration that caused the observed response.

Appendices

Appendix A - Sample Site Locations and Example Field Sampling Schedule

Site #	zone	Easting (mE)	Northing (mN)	Elevation (m)	Access Description
Close to Smelter Site					
44	9U	519031	5985223	66	Gravel access road south of Anderson Creek (gated), walk or drive up steep road to water tower; site is on the south-east side of the water tower overlooking steep drop.
1	9U	519811	5982791	6	Smelter site road to Hospital Beach. Across from Hospital Beach entrance.
20A	9U	519718	5983429	20	Smeltersite road to ~250m south of RTA contractor gate. Moved site in 2017 as previous site was lost due to brushing. Site is located on east side of road.
37	9U	518423	5986410	31	Up Anderson Creek intake road (south of Anderson Creek), turn left; site is on north margin of large clearing (old rifle range).
39	9U	519822	5987826	15	Turn onto Eurocan road, take an immediate left before the rail tracks; ~500 m south on the east side of the access road which parallels the rail tracks to the west and the Smelter Site Road to the east.
42	9U	519033	5985220	34	West side of Smelter site road, ~200m north of KMP gate.
43A	9U	518422	5986420	140	Turn west off Smelter Site road ~500m north of the KMP camp; turn left on steep, overgrown access road across from the Minette substation; ~800m up access road
43B	9U	518621	5986006	118	Left up overgrown access road across from Minette substation, drive for ~1km, turn right on access road just before powerline
46	9U	518509	5986364	126	Left ~80 m up overgrown access road across from Minette substation, drive for ~800m up road, quad trail flagged on the left
47B	9U	520329	5990897	13	Through industrial park toward Wedeene FSR; before FSR entrance, turn right at PNG compound; left along small access road up on PNG ROW
Helicopter Access					
44A	9U	520330	5990896	192	Helicopter access to subalpine wetland; site on the north margin of the wetland.
78A	9U	520856	5994845	26	Helicopter access to a wetland located west of Claque Trail road. Site is on the edge of a smaller wetland (~80 m X 25 m) in second growth stand.
81B	9U	517867	5996764	344	Helicopter access; land in creek bed of Bowbye Creek downhill from Bowbye trail
81C	9U	517377	5995487	394	Helicopter access to wetland clearing near base of old ski hill; located west of Bowbye Lake and east of Minifie Creek bridge on Bowbye road

Site #	zone	Easting (mE)	Northing (mN)	Elevation (m)	Access Description
	Bish FSR				
87	9U	519591	5980745	42	3 km on Bish FSR, walk ~30m up an overgrown branch road (BR100)
88	9U	519312	5979512	45	4.5 km up Bish FSR; site is on west side of road behind old Skeena Sawmills sign
89	9U	517963	5976266	93	Bish Cove access road at km 7 turn left (KBR area H) to North Cove trail; walk south east on trail for ~300m
89A	9U	517954	5976290	84	Bish Cove access road at km 7 turn left (KBR area H) to North Cove trail; walk south east on trail for ~300m; Site 89A is ~30 up-trail (northwest) of Site 89
	Cable Car				
97	9U	526234	5996927	41	Right on North Hirsch FSR; ~100m down on the right
98A	9U	526151	5994156	39	Turn east off Highway 37 onto access road opposite Cablecar entrance; turn right just past PNG compound; ~50m on the left
	Minette Bay / Kitimaat Village				
68	9U	522993	5981428	10	Kitimat Village road to MK Bay marina; site is on the east side of the village road across from the MK Bay Marina and approximately 30 m north of "Welcome to Kitimaat Village" sign
69	9U	523008	5983628	46	Kitimaat Village road to transmission line crossing over road; ~50m north of access road on the east side of Kitimaat Village road
70	9U	525773	5986706	9	Kitimaat Village road to Minette Bay; ~50m north of Minette Creek bridge on east side of Kitimaat Village road
95	9U	523640	5980346	87	Through Kitimaat Village, uphill, left on Raven Road, right on small access road (before white house on the right); up to a small gravel pit on the left
	Wedeene FSR				
79	9U	519318	5992584	86	Take Wedeene FSR to Clauge Mountain road (turn off Wedeene at ~36km); ~1.5 km up Clauge Mountain road. Turn right just before trailhead and site is on margin of clearing
80	9U	520481	5995782	57	Wedeene FSR to km 33; pull off at Site 92; walk ~550m down a deactivated spur road (cross small creek at start)
82	9U	519788	5999711	164	Wedeene FSR to 28.5 km at crest of hill on curve; turn left (west) onto narrow branch road and drive up ~500m to fork; site is on spur forking north (right) on east side of the spur.

Site #	zone	Easting (mE)	Northing (mN)	Elevation (m)	Access Description
90	9U	520068	6006716	124	Wedeene FSR at ~20.5 km; site is located on west shoulder of road
91A	9U	519891	5998473	96	Wedeene FSR to Bowbyes Lake access road at ~31 km; go ~1.5 km up Bowbyes road; site is on left before big dip in the road
92	9U	520922	5995706	38	Wedeene FSR at ~32.8 km, turn west onto branch road; ~20m from entrance on right
	Williams Creek FSR				
490	9U	546187	6025665	466	Follow Williams Creek FSR approximately 14.5 km, keep right when you encounter a fork in the road, park approx. 25 m north (small pullout) before the bridge crossing, sample tree will be on the west side of the road.
492	9U	539294	6029344	329	Follow Williams Creek FSR approximately 7 km, keep left when you encounter a fork in the road. A pullout is located on the south side of the road approximately 50 m east of the sample site location. The sample trees are on the south side of the road.
	Kitimat				
52	9U	520979	5990124	18	Drive through Radley Park to boat launch; site is west side of the parking lot on the edge of a cleared area
54	9U	521347	5990154	27	Turn right into Rod and Gun Club (before the Kitimat River bridge); site is immediately on the right at entrance to parking lot
55	9U	522924	5989734	60	Park on Albatross Cres. at top of park; walk down paved footpath. Site is ~50m from pedestrian overpass up a dirt path.
56	9U	523871	5989511	102	Across the street from the firehall, walk ~50m downslope along the powerline
57	9U	524285	5989347	93	West side of Lookout Park in Kitimat; walk down the west side of the cleared area; site is at the south side (downslope) of clearing
	Beam Station Road				
84A	9U	516906	6033624	62	Whitebottom FSR to 3km; left on spur road; site is on northwest corner of quarry
85	9U	526774	6032743	189	North of powerlines, just east of Beam station road on northeast side of clearing
86	9U	527263	6025385	77	Take Beam Station road to Beam Station FSR; site is located at a pull-out right before the pavement ends

Appendix B - Vegetation Sampling Field Form developed by Stantec Consulting Ltd.

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2018 Vegetation Inspection, Monitoring and Assessment Program

Site No:

Tree Factors

Tree ID Tag Replaced?	☐ *Yes* ☐ *No*	Tree in exposed location?	☐ ☐
Height of Sample Tree(s):	m	If not, distance to nearest tree (m):	
Height to Base of Live Crown:	m		

Damage:

Frost Crack	Broken Top	Scar	Root Disruption	Other
☐	☐	☐	☐	☐

Comments on condition of sample tree(s)

Pests/Pathogens:

Wooly Adelgid	Budworm	H. Looper	Mistletoe	Other
☐	☐	☐	☐	☐

Estimate percentage of individual branch and tree affected, as well as percentage of neighbouring trees affected

Signs and Symptoms:

Shedding Needles	Discolouration	Dying Branches	Top Dieback	Other
☐	☐	☐	☐	☐

Estimate percentage of individual branch and tree affected, as well as percentage of neighbouring trees affected

Sample

Longest terminal growth: cm	Growth Rating: *Circle rating and estimate average* *Poor = little terminal growth, all < 4cm* *Moderate = terminal growth > 4cm and < 10cm* *Good = terminal growth >= 10cm*
Colour of Current Year Growth *Green (normal)* *Off-colour (abnormal)*	Bare Twigs ☐ *Estimate percentage of sample that is bare twigs*
Deposits (sap, road dust, soot, etc):	

Comments on sample observations

Photos	
Sample Label	
Tree Prior to Sampling	
Tree During Sampling	
North	
East	
South	
West	
Sample Prior to Bagging	
Sample Close Up	

Did the sample come into contact with the ground? y
Was the sample dry when bagged? y
How many trees were sampled? _________
What is the sample height range? ____to____

Additional Notes: *Site moved and rationale, etc.*

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Appendix C - Field Data Sheets for Vegetation Inspection

Site #	Date	Site Photo					
Species	Symptom	% of Leaf Affected	% of Plant Affected	Cause	Comments	F rating	Photo (Y/N)

Presence or absence:

Species	P/A	Species	P/A
Amelanchier alnifolia		*Abies amabilis*	
Aralia nudicaulis		*Abies lasiocarpa*	
Cornus stolonifera		*Acer glabrum*	
Disporum hookeri		*Alnus crispa*	
Dryopteris expansa		*Alnus tenuifolia*	
Epilobium angustifolium		*Betula papyrifera*	
Lycopodium clavatum		*Crataegus douglasii*	
Menziesia ferruginea		*Pinus contorta*	
Pteridium aquilinum		*Populus tremuloides*	
Rosa acicularis		*Populus trichocarpa*	
Rubus parviflorus		*Prunus pennsylvanica*	
Rubus spectabilis		*Prunus virginiana*	
Senecio triangularis		*Sorbus scopulina*	
Symphoricarpos albus		*Sorbus sitchensis*	
Vaccinium alaskaense		*Tsuga heterophylla*	
Vaccinium membranaceum			
Vaccinium ovalifolium			
Vicia americana			

Lichen presence:

Species	Present or Absent	Host
L. oregana		
L. pulmonaria		

Appendix D - Presence of Species Reported to be Sensitive to SO_2

Presence of species reported to be sensitive to SO_2 in scientific or anecdotal literature at vegetation inspection and collection sites in 2018. Presence is indicated by an x. Absence does not mean that the species is not present in the area of the site, only that it was not observed during the inspection. NV=not visited

Species\Site	*1*	*20A*	*37*	*39*	*42*	*43A*	*43B*	*44*	*44A*	*46*	*47B*	*52*	*54*	*55*	*56*	*57*	*68*	*69*	*70*	*78A*	*79*	*80*	*81B*	*81C*	*82*	*84A*	*85*	*86*	*87*	*88*	*89A*	*90*	*91A*	*92*	*95*	*97*	*98A*	*490*	*492*
Shrubs and small stature plants																																							
Amelanchier alnifolia			X								X						X	X																					
Aralia nudicaulis																																							
Cornus stolonifera	X	X		X	X		X	X			X	X	X				X		X							X		X					X		X	X	X		X
Disporum hookeri																																							
Dryopteris epansa										X																					X								
Epilobium angustifolium	X	X	X	X	X			X			X	X	X				X	X	X							X		X			X	X	X	X	X	X	X	X	X
Lycopodium clavatum																																							
Menziesia ferruginea										X						X						X		X	X	X	X		X		X	X		X		X		X	
Pteridium aquilinum																		X		X	X	X				X					X		X	X		X			
Rosa acicularis																																							
Rubus parviflorus	X	X		X	X	X	X	X		X	X	X	X		X	X	X	X	X				X			X		X	X	X		X	X	X	X	X	X		X
Rubus spectabilis	X	X		X	X	X	X			X		X			X		X	X	X		X	X	X	X	X				X	X	X	X	X	X	X	X	X		X
Senecio triangularis																																							
Symphoricarpos albus																																							
Vaccinium alaskaense																X							X	X	X		X				X								
Vaccinium membranaceum																X							X	X			X												
Vaccinium ovalifolium																X							X	X			X				X								
Vicia americana																												X											

Trees																																							
Species\Site	*1*	*20A*	*37*	*39*	*42*	*43A*	*43B*	*44*	*44A*	*46*	*47B*	*52*	*54*	*55*	*56*	*57*	*68*	*69*	*70*	*78A*	*79*	*80*	*81B*	*81C*	*82*	*84A*	*85*	*86*	*87*	*88*	*89A*	*90*	*91A*	*92*	*95*	*97*	*98A*	*490*	*492*
Abies amabilis																															X								X
Abies lasiocarpa																																							
Acer glabrum												X	X																									X	
Alnus crispa	X	X		X	X														X		X		X	X			X		X	X	X	X		X			X	X	X
Alnus tenuifolia																																							
Betula papyrifera															X			X																					
Crataegus douglasii																																							
Pinus contorta								X						X		X		X		X					X		X												X
Populus tremuloides															X		X	X									X	X											X
Populus trichocarpa	X	X	X	X			X	X			X	X	X						X		X		X					X		X		X			X			X	
Prunus pennsylvanica								X																															
Prunus virginiana								X																															
Sorbus scopulina																																							
Sorbus sitchensis	X	X	X	X	X	X	X	X		X	X			X	X	X		X			X			X		X					X			X	X		X		
Tsuga heterophylla	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

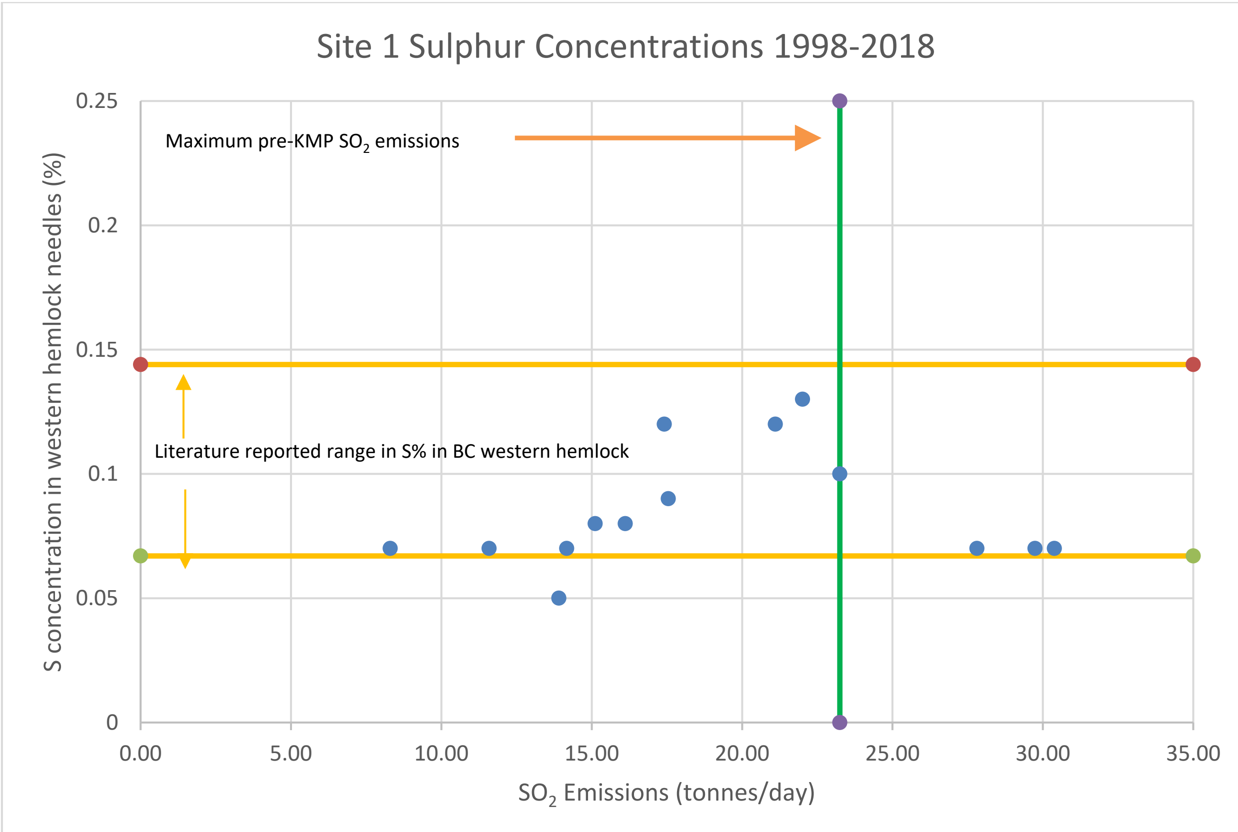
5.5 Sulfur in Western Hemlock Data, Site Graphs, and Box and Whisker Diagrams

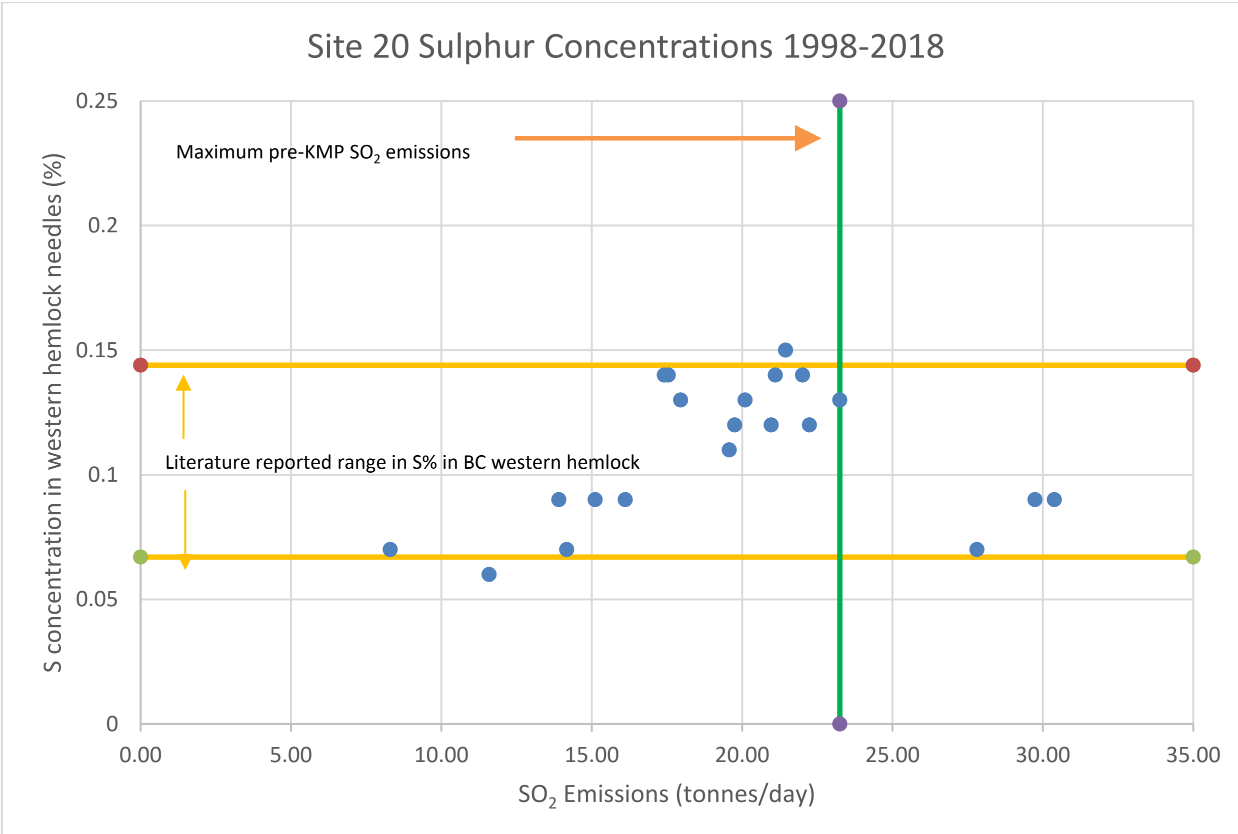
This appendix includes all %S in western hemlock needle data from 1998 to 2018, graphs of the %S in western hemlock needles versus smelter emissions of SO_2 for the 40 sampling sites, and Box and Whisker plots of %S data for each site for the pre-KMP baseline (1998-2011), all years (1998-2018), and post-KMP (2016-2018). The graphs of %S in western hemlock needles versus smelter emissions of SO_2 are not in chronological order—the order depends on the emissions. However, on every graph, the minimum emission level is from 2015 when the smelter operations were vastly curtailed. The maximum pre-KMP emissions of 23.25 tonnes per day of SO_2 occurred in 2000.

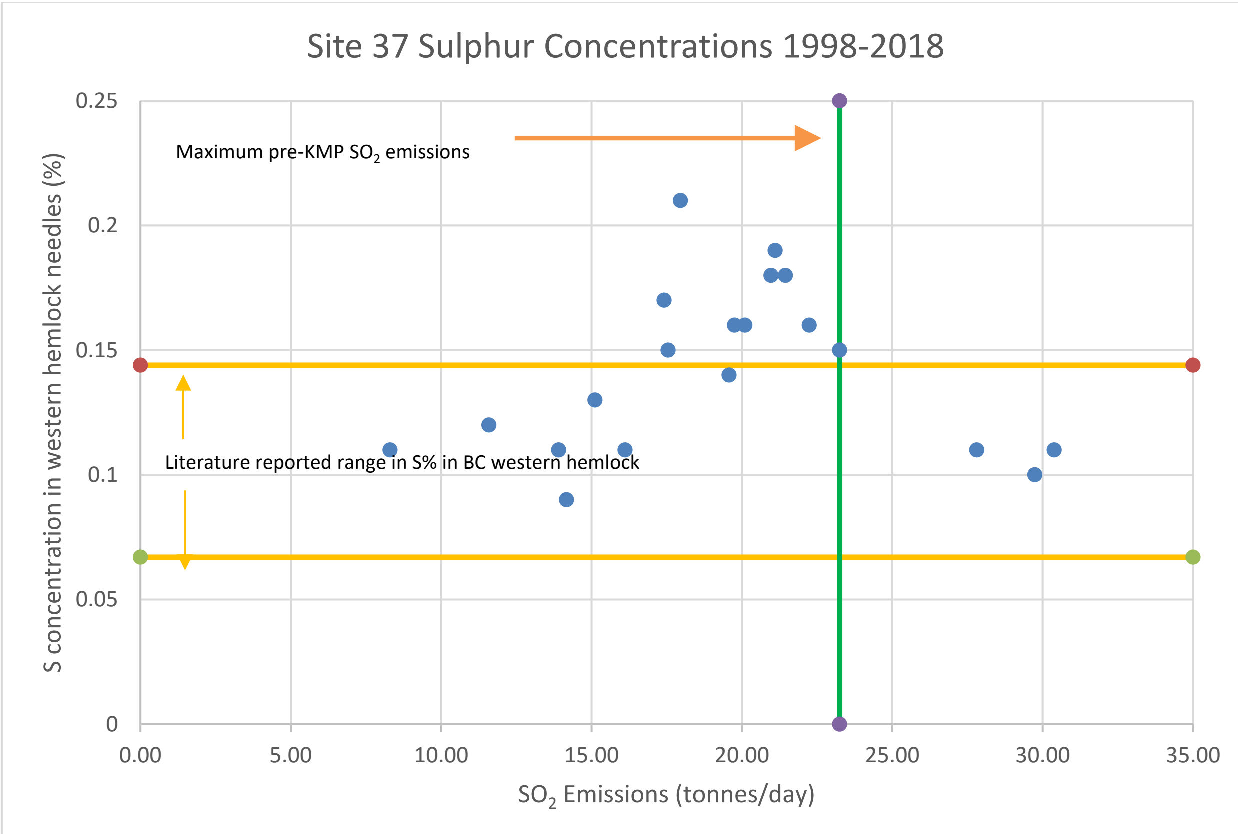
Table 5.19: Concentrations of sulfur in western hemlock in the Kitimat Valley from 1998 to 2018. No entry is a cell indicates a sample was not taken that year. Measurement in in %S.

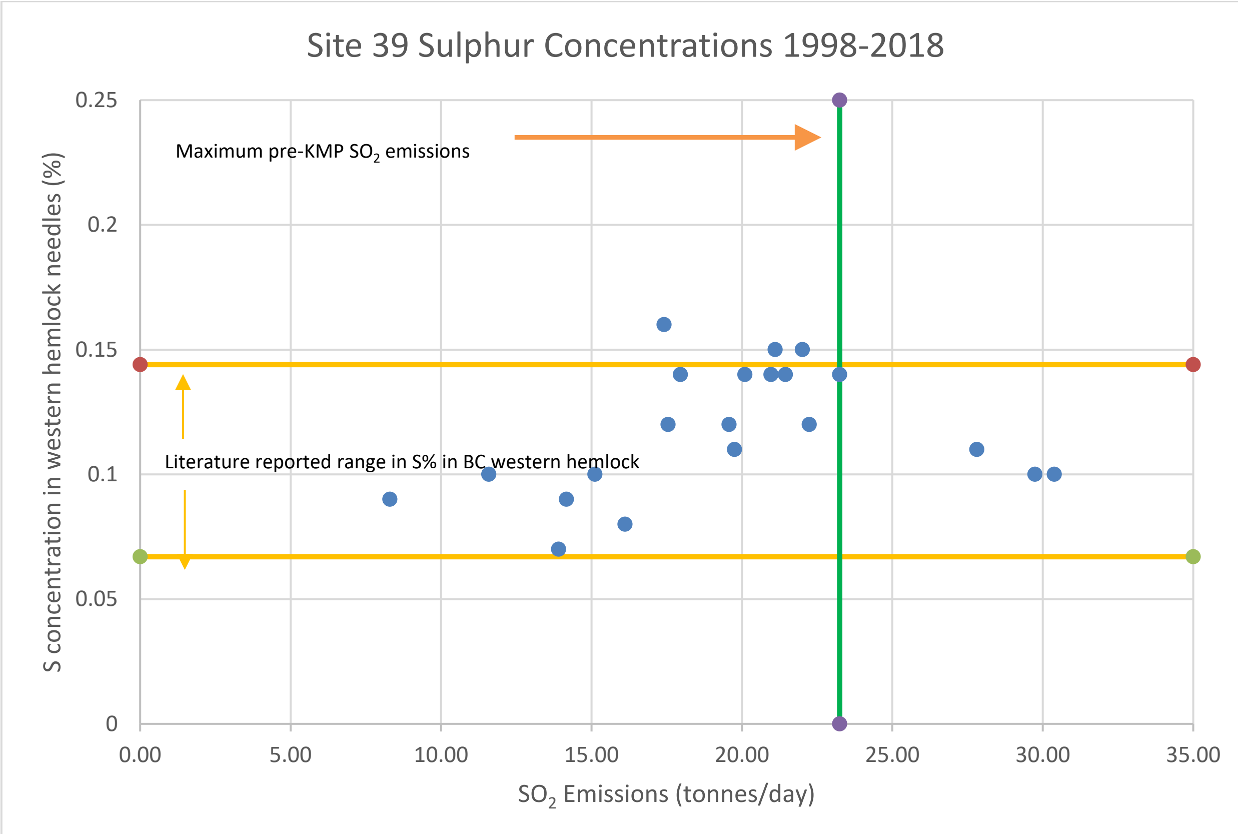
Plots/year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
1	0.13	0.12	0.1	0.12	0.09								0.08	0.07	0.08	0.05	0.07	0.07	0.07	0.07	0.07
20	0.14	0.14	0.13	0.14	0.14	0.12	0.15	0.12	0.12	0.11	0.13	0.13	0.09	0.07	0.09	0.09	0.06	0.07	0.07	0.09	0.09
37		0.19	0.15	0.17	0.15	0.16	0.18	0.18	0.16	0.14	0.16	0.21	0.13	0.09	0.11	0.11	0.12	0.11	0.11	0.1	0.11
39	0.15	0.15	0.14	0.16	0.12	0.11	0.14	0.14	0.12	0.12	0.14	0.14	0.1	0.09	0.08	0.07	0.1	0.09	0.11	0.1	0.1
42	0.17	0.15	0.17	0.19	0.16	0.16	0.17	0.2	0.18	0.13	0.2	0.17	0.12	0.09	0.12	0.1	0.09	0.12	0.1	0.08	0.1
43A	0.17	0.16	0.13	0.16	0.15	0.16							0.14	0.12	0.12	0.1	0.11	0.11	0.1	0.12	0.13
43B	0.17	0.18	0.15	0.18	0.14		0.14		0.18	0.17	0.2	0.18	0.1	0.07	0.1	0.1	0.14	0.07	0.09	0.1	0.12
44	0.15	0.18	0.13	0.15	0.13	0.16	0.21	0.18	0.16	0.2	0.17	0.2	0.11	0.08	0.09	0.13	0.11	0.09	0.13	0.12	0.12
44A	0.16	0.22	0.18	0.23	0.18	0.17	0.18				0.12	0.14	0.15	0.09	0.11	0.13	0.12	0.11	0.13	0.09	0.11
46	0.14	0.18	0.14	0.22			0.17	0.19	0.16	0.15	0.17	0.15	0.13	0.1	0.13	0.1	0.08	0.13	0.11	0.11	0.11
47B	0.12	0.16	0.14	0.15	0.13	0.11	0.15	0.12	0.13	0.11	0.11	0.13	0.1	0.08	0.09	0.08	0.09	0.09	0.1	0.1	0.11
52A	0.11	0.12	0.1	0.14	0.09	0.09	0.11	0.13	0.07	0.11	0.12	0.11	0.07	0.06	0.06	0.08	0.05	0.08	0.08	0.1	0.1
54	0.12	0.11	0.1	0.13	0.09	0.1	0.1	0.1	0.08	0.12	0.1	0.11	0.09	0.08	0.08	0.06	0.05	0.06	0.05	0.05	0.07
55	0.09	0.13	0.1	0.11	0.07	0.08	0.1	0.1	0.08	0.1	0.09	0.09	0.1	0.09	0.09	0.09	0.06	0.07	0.07	0.07	0.08
56	0.1	0.11	0.09	0.1	0.1								0.08	0.06	0.06	0.06	0.07	0.06	0.06	0.08	0.06
57	0.1	0.11	0.1	0.1	0.06								0.12	0.05	0.05	0.06	0.05	0.05	0.05	0.07	0.06
68	0.1	0.1	0.11	0.09	0.07	0.09	0.1	0.09	0.08	0.09	0.09	0.09	0.08	0.06	0.06	0.08	0.06	0.07	0.06	0.09	0.08
69	0.1	0.1	0.1	0.09	0.06	0.08	0.09	0.1	0.06	0.09	0.09	0.1	0.08	0.07	0.07	0.08	0.05	0.06	0.07	0.08	0.08
70	0.1	0.1	0.11	0.1	0.08	0.08	0.1	0.09	0.08	0.1	0.09	0.09	0.09	0.07	0.07	0.08	0.06	0.06	0.07	0.08	0.08

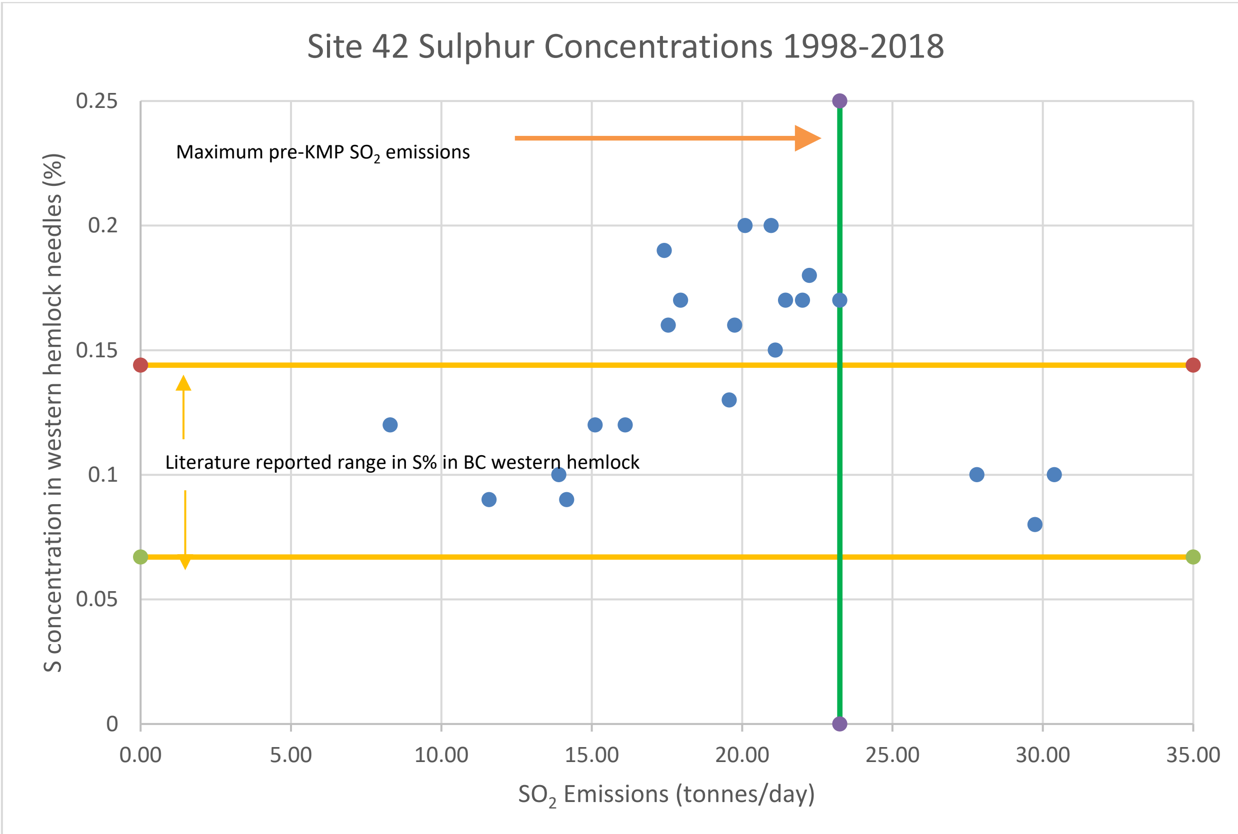
Plots/year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
78A	0.16				0.14	0.13	0.17	0.16	0.16	0.13	0.14	0.14	0.09	0.07	0.07	0.07	0.09	0.06	0.09	0.12	0.09
79	0.14			0.16	0.07	0.12	0.15	0.13	0.12	0.13	0.15	0.12	0.1	0.08	0.08	0.1	0.08	0.1	0.1	0.11	0.12
80	0.12	0.12	0.13	0.11	0.11								0.11	0.09	0.09	0.09	0.1	0.07	0.09	0.12	0.08
81B	0.17	0.15	0.14	0.13	0.06	0.17	0.19	0.16	0.17		0.12	0.13	0.12	0.09	0.09	0.09	0.07	0.06	0.08	0.1	0.1
81C	0.13	0.14	0.11	0.11	0.09								0.15	0.07	0.07	0.1	0.09	0.09	0.12	0.09	0.12
82	0.12	0.12	0.12	0.14	0.08	0.12	0.12	0.11	0.12	0.12	0.12	0.12	0.09	0.06	0.06	0.08	0.08	0.07	0.1	0.1	0.1
84AB	0.09	0.1	0.09	0.1	0.07	0.08	0.09	0.09	0.07	0.1	0.09	0.08	0.07	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.07
85	0.09	0.1	0.08	0.09	0.03	0.08	0.1	0.09	0.08	0.06	0.08	0.08	0.08	0.07	0.07	0.07	0.05	0.05	0.06	0.06	0.07
86	0.09	0.11	0.09	0.1	0.05	0.08	0.09	0.09	0.1	0.07	0.08	0.08	0.09	0.06	0.06	0.08	0.06	0.08	0.07	0.07	0.07
87	0.14	0.16	0.15	0.12	0.12	0.07	0.21	0.17	0.16	0.14	0.15	0.15	0.12	0.08	0.08	0.1	0.09	0.12	0.12	0.14	0.11
88	0.14	0.14	0.14	0.19	0.12	0.13	0.15	0.13	0.13	0.12	0.1		0.13	0.12	0.12	0.12	0.12	0.09	0.09	0.11	0.1
89		0.13	0.14	0.13	0.11	0.13	0.21	0.16	0.18	0.15	0.17	0.15	0.12	0.09	0.09	0.09	0.11	0.1	0.1	0.11	0.12
89A													0.12	0.09	0.09	0.09	0.11	0.1	0.11	0.11	0.12
90		0.12	0.13	0.15	0.06	0.09	0.11	0.1	0.11	0.1	0.09	0.13	0.09	0.08	0.08	0.06	0.06	0.08	0.08	0.09	0.11
91A		0.11	0.11	0.11	0.06	0.08	0.1	0.12	0.09	0.1	0.12	0.12	0.11	0.09	0.09	0.11	0.08	0.14	0.1	0.1	0.09
92		0.1	0.1	0.13	0.06	0.08	0.12	0.1	0.1	0.11	0.1	0.11		0.07	0.07		0.11	0.09	0.09	0.09	0.08
95		0.12	0.09	0.09	0.04	0.09	0.1	0.09	0.09	0.08	0.09	0.08	0.07	0.05	0.05	0.07	0.07	0.07	0.08	0.06	0.08
97		0.11	0.1	0.09	0.05	0.1	0.1	0.1	0.09	0.1	0.09	0.09	0.09	0.06	0.06	0.07	0.06	0.09	0.07	0.08	0.08
98A					0.05		0.09	0.08	0.07	0.1	0.1	0.09	0.08	0.07	0.07	0.07	0.07	0.08	0.07	0.06	0.07
490																			0.07	0.06	0.07
492																			0.06	0.06	0.08

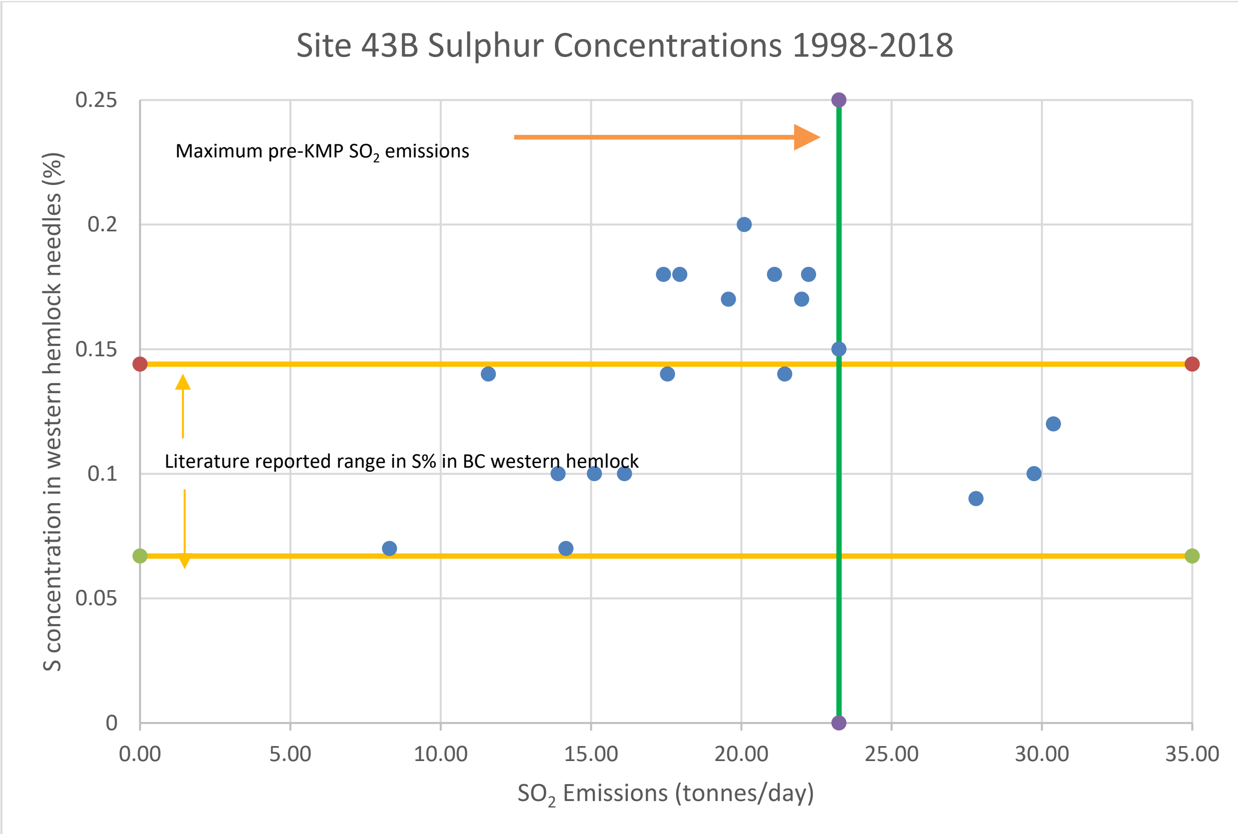

Site 1 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

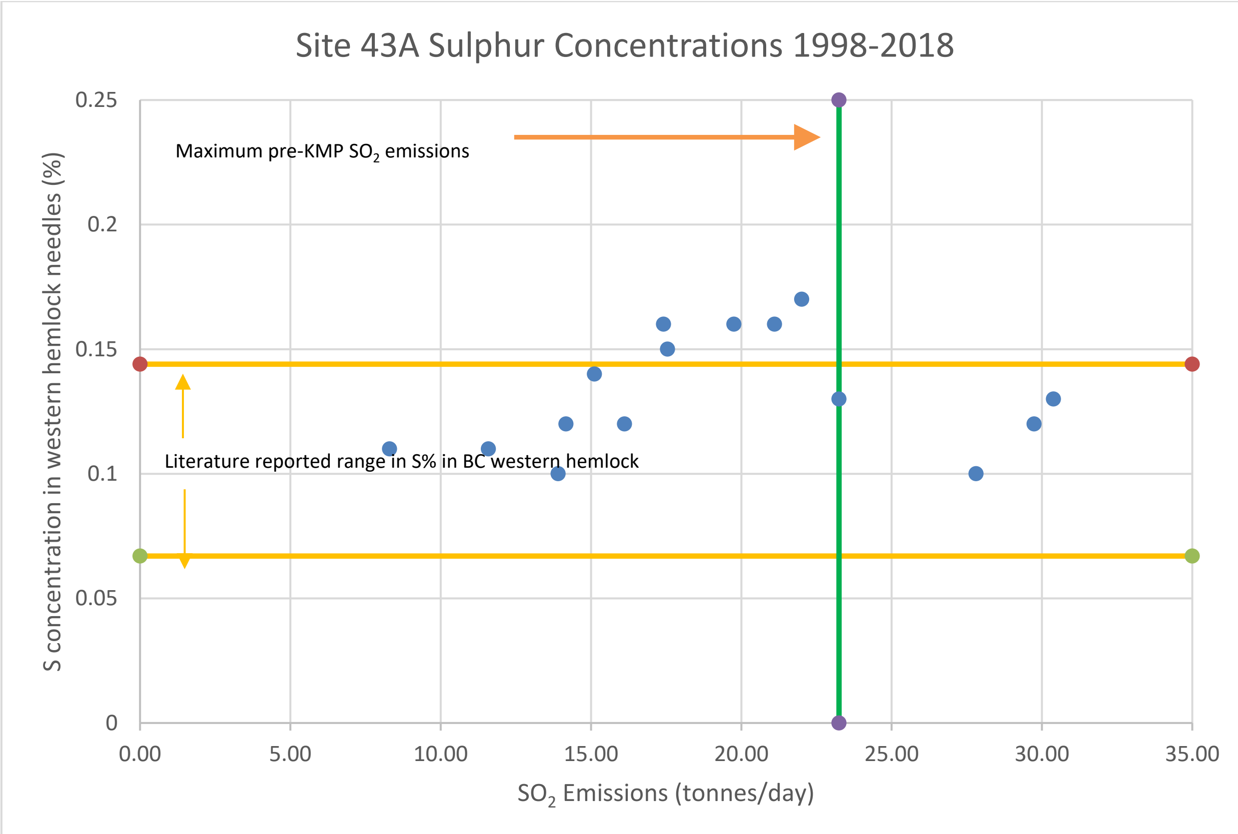

Site 20 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO_2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO_2 Emissions (tonnes/day)

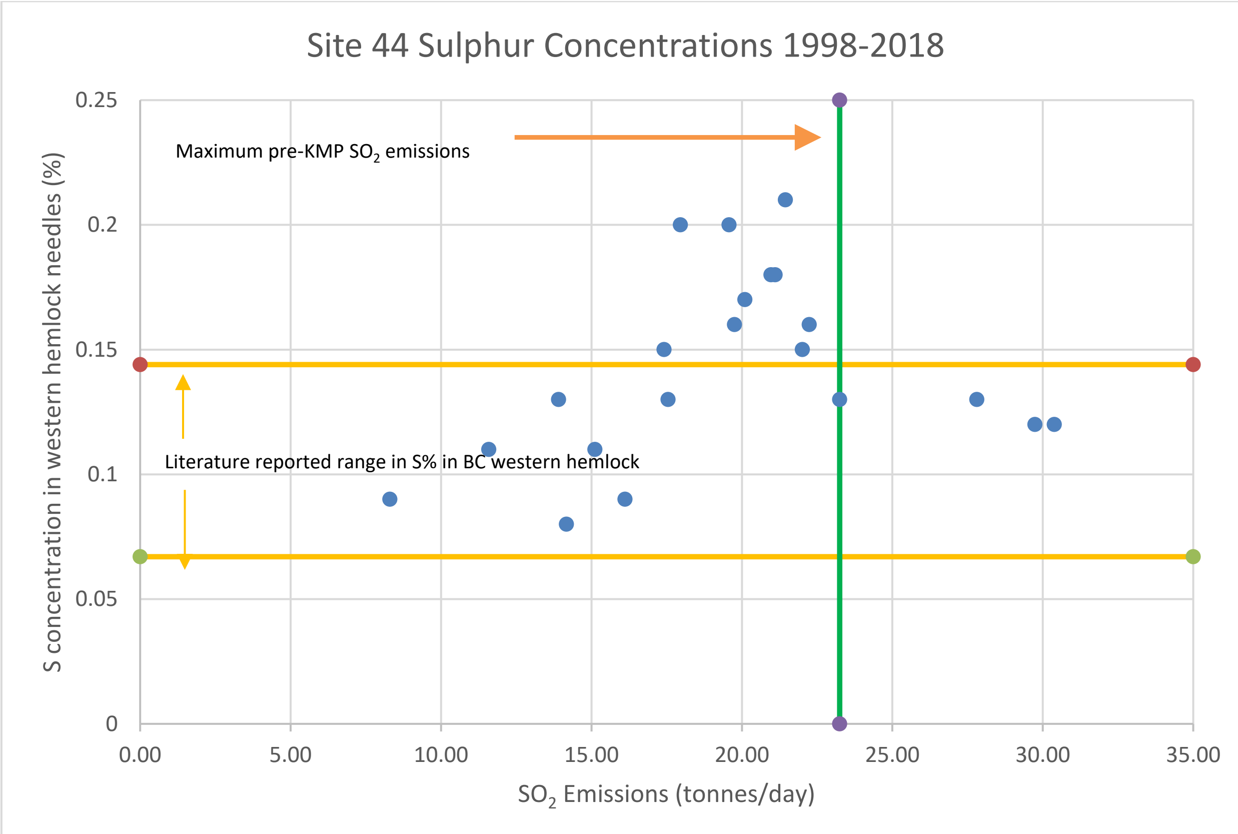

Site 37 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

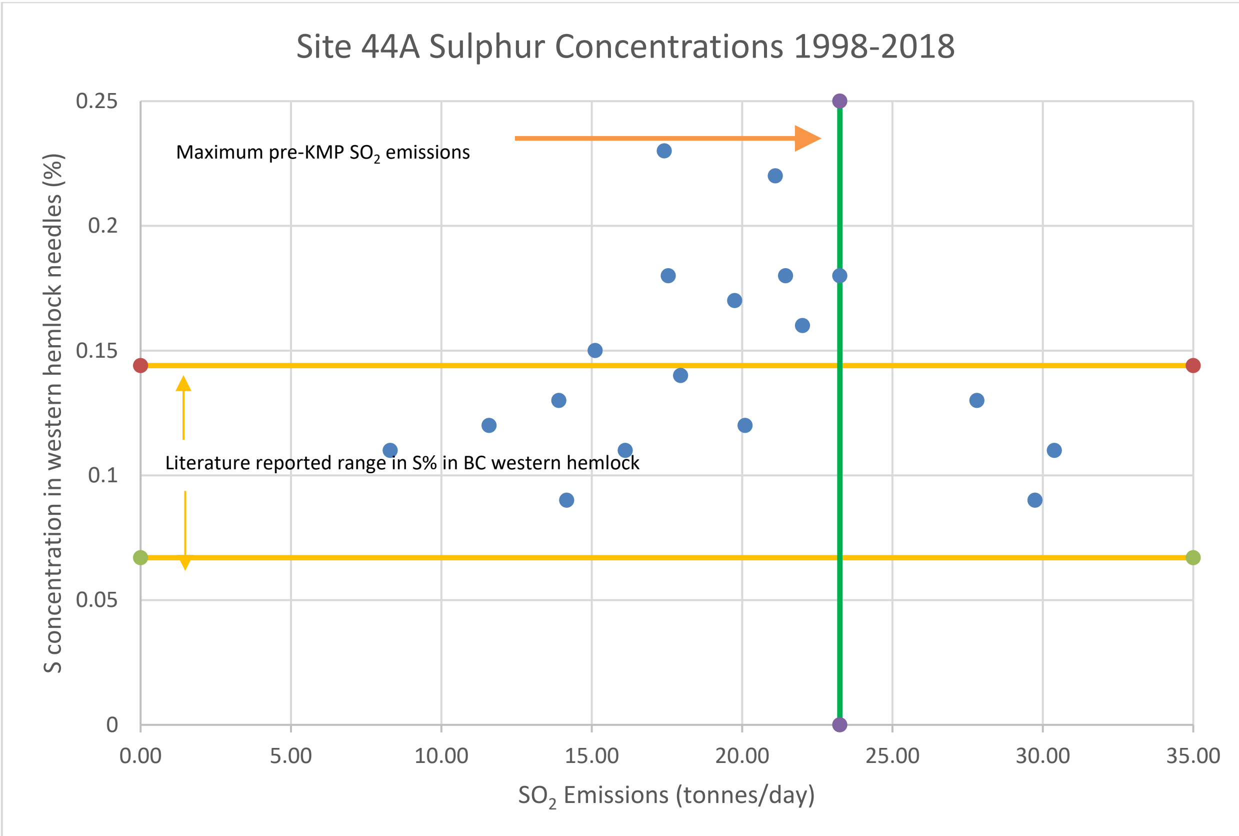

Site 39 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

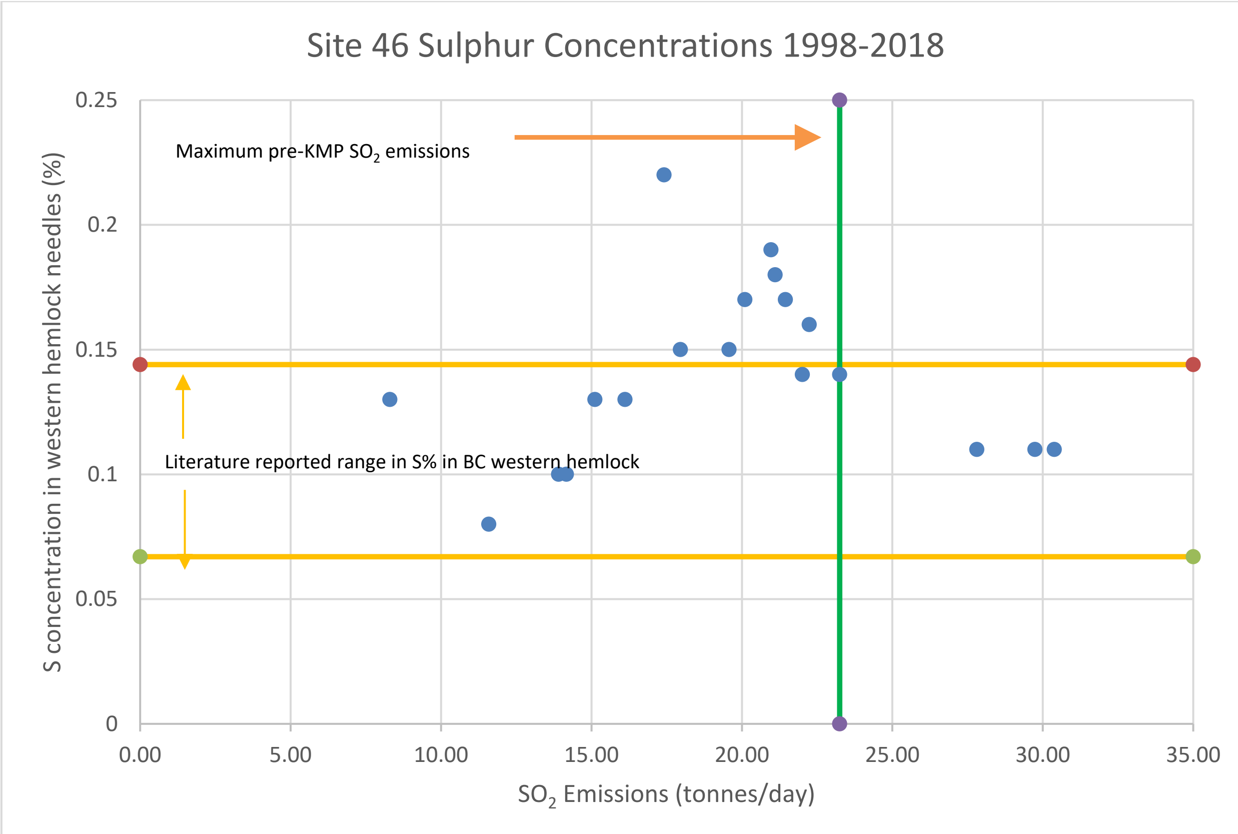

Site 42 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

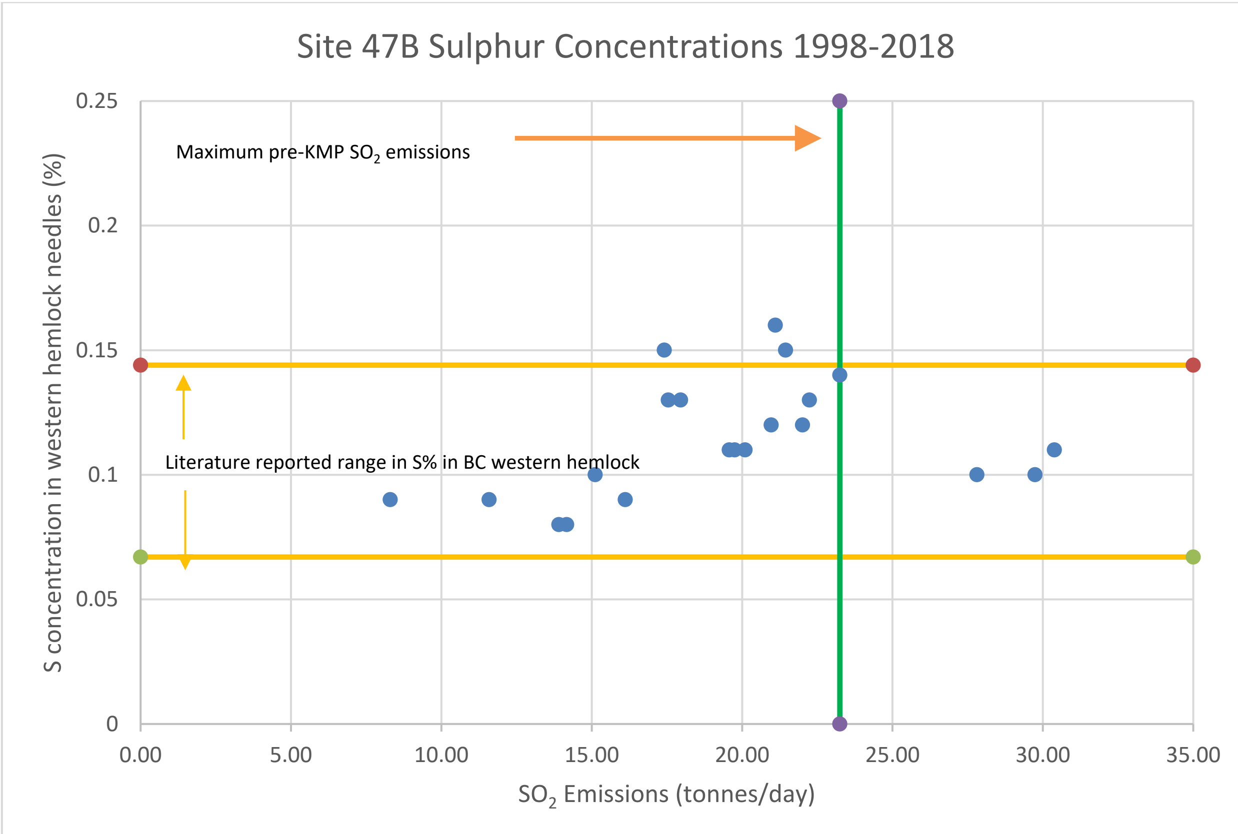

Site 43B Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

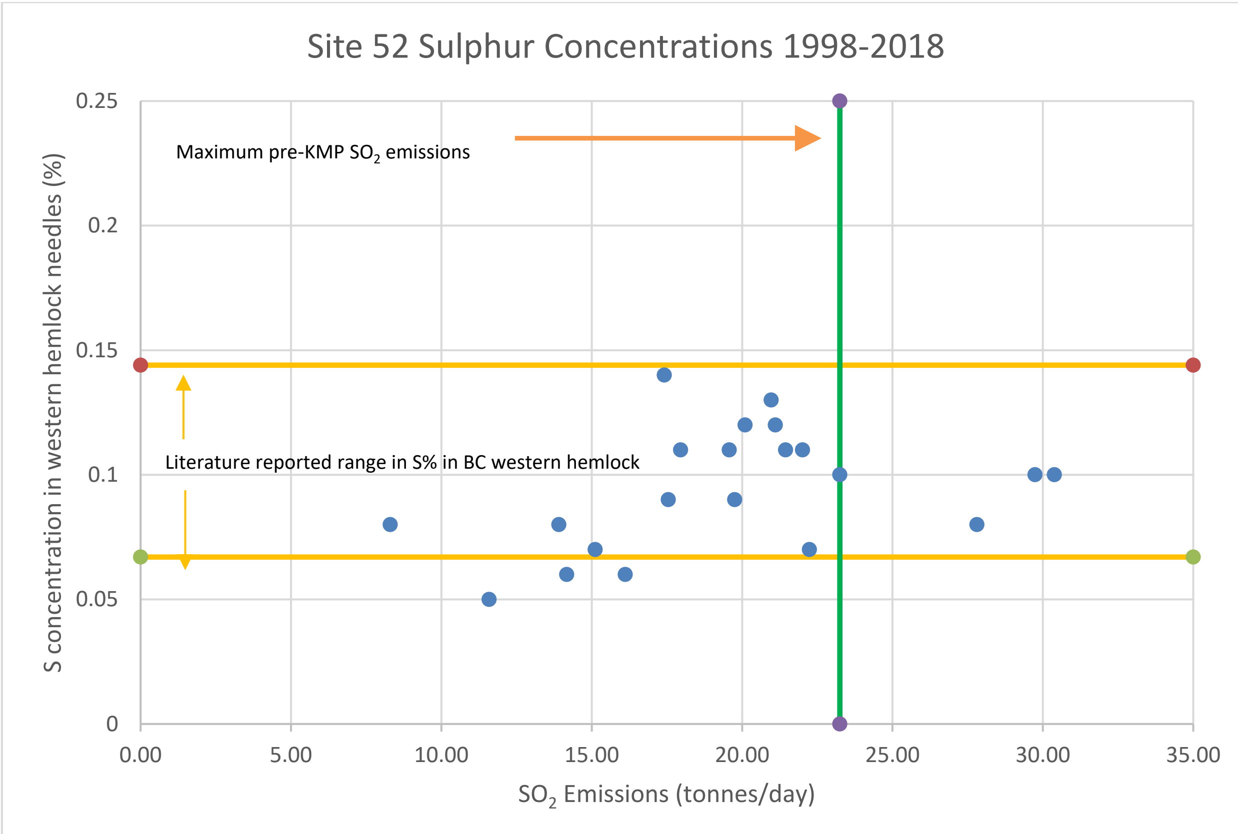

Site 43A Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

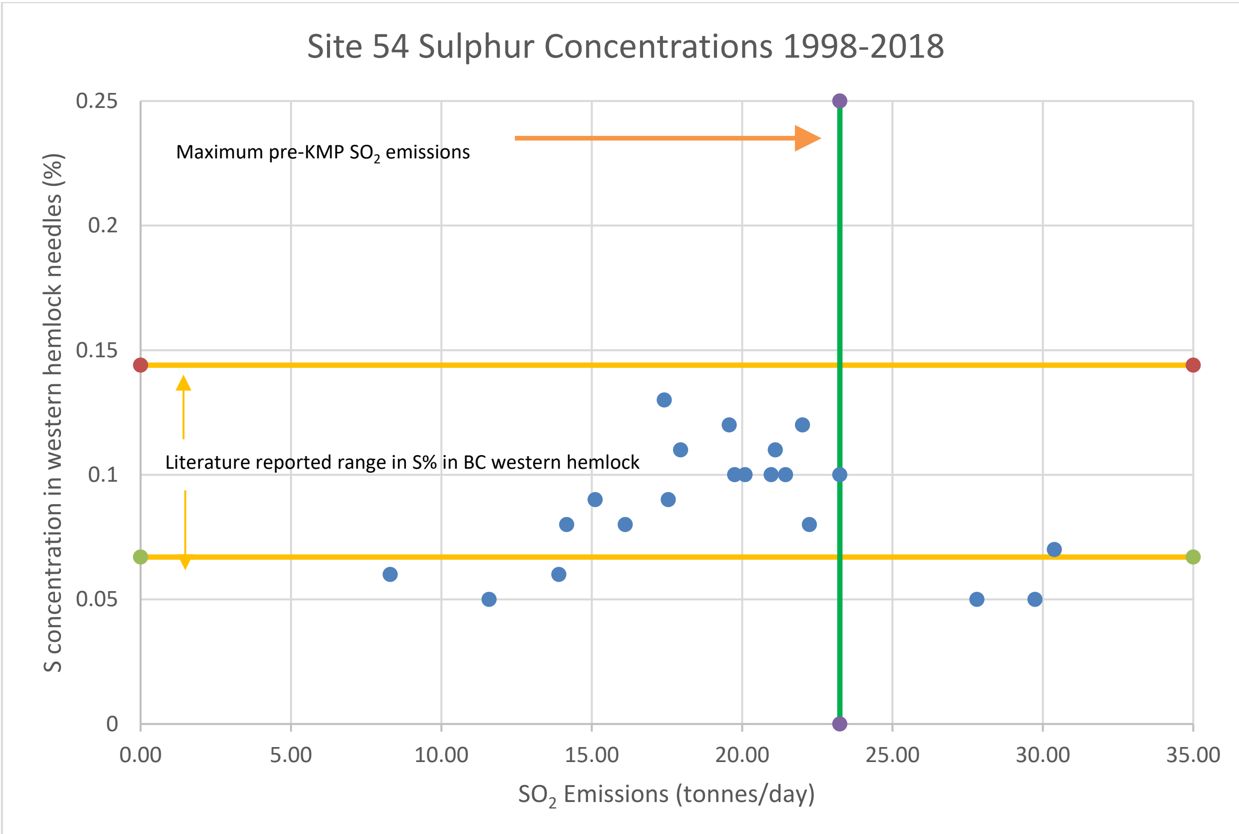

Site 44 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
SO2 Emissions (tonnes/day)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00

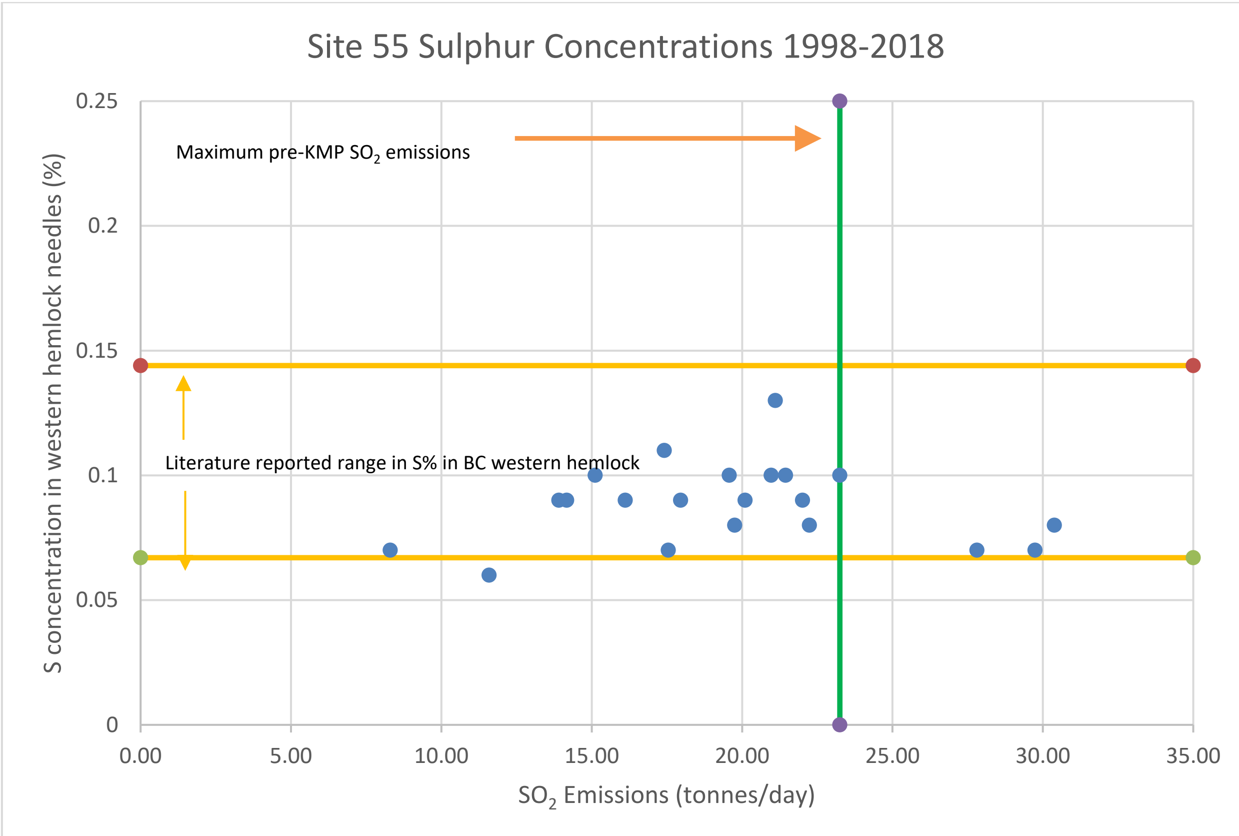

Site 44A Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

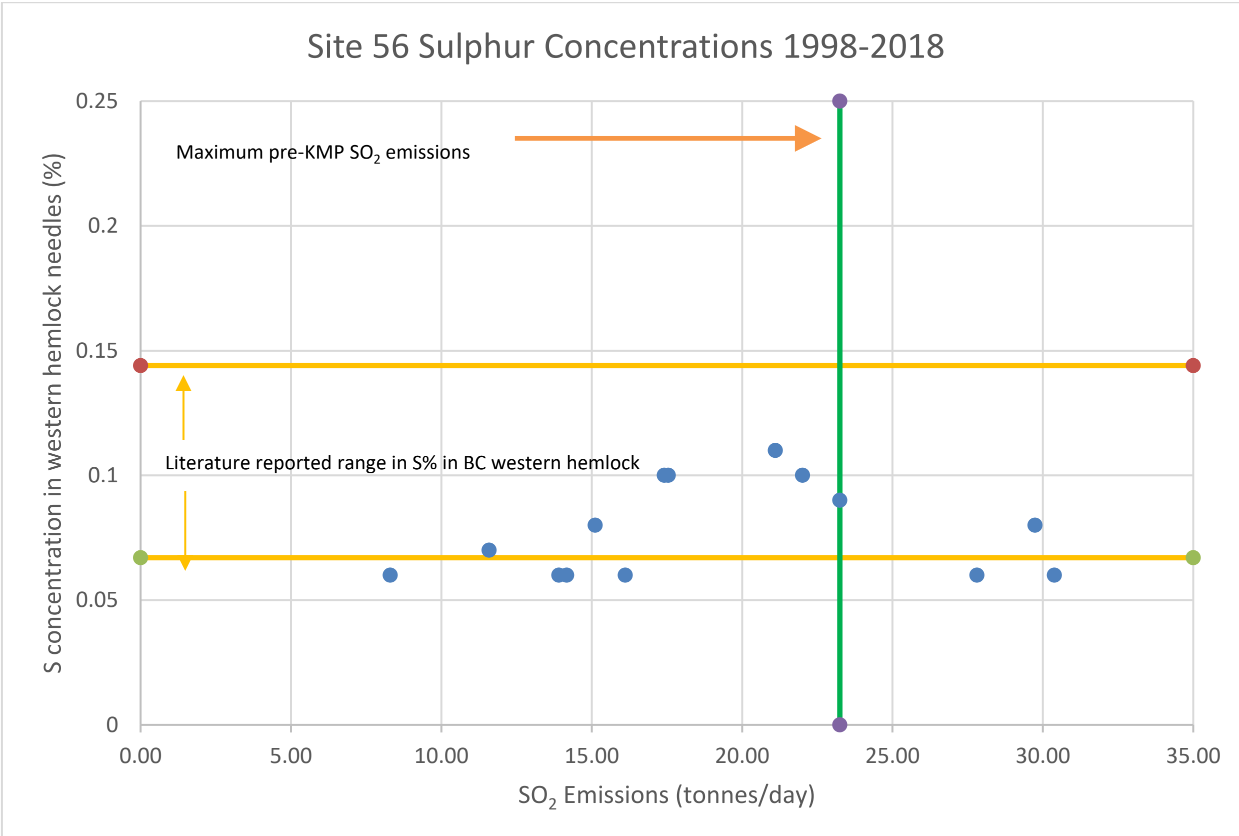

Site 46 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
SO2 Emissions (tonnes/day)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00

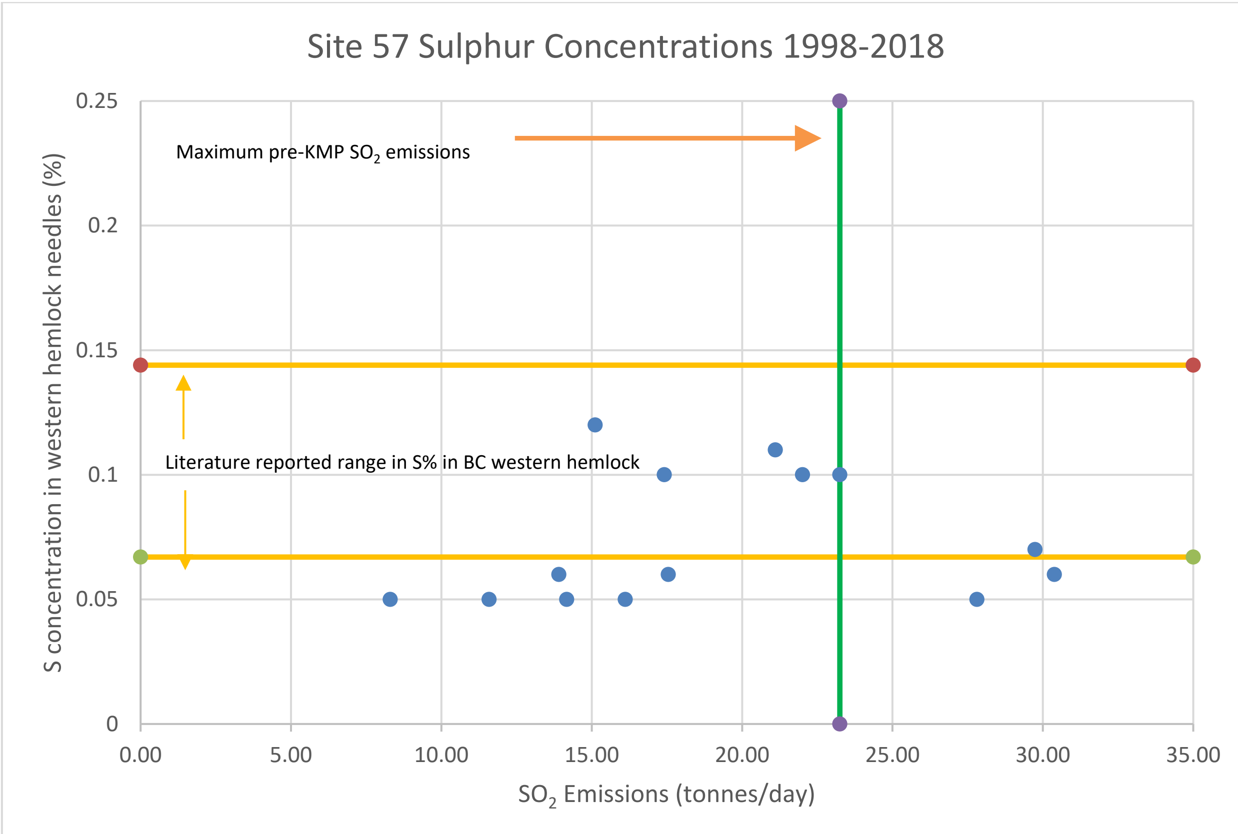

Site 47B Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

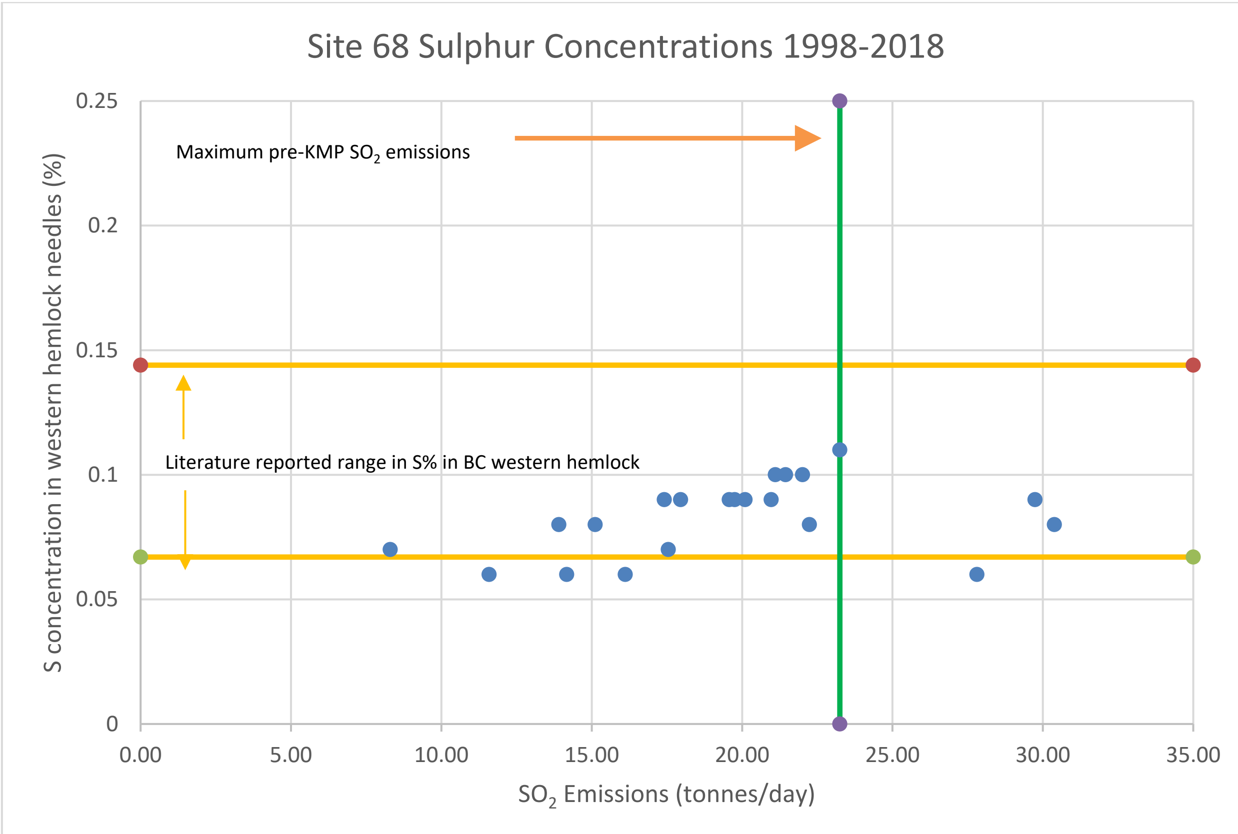

Site 52 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

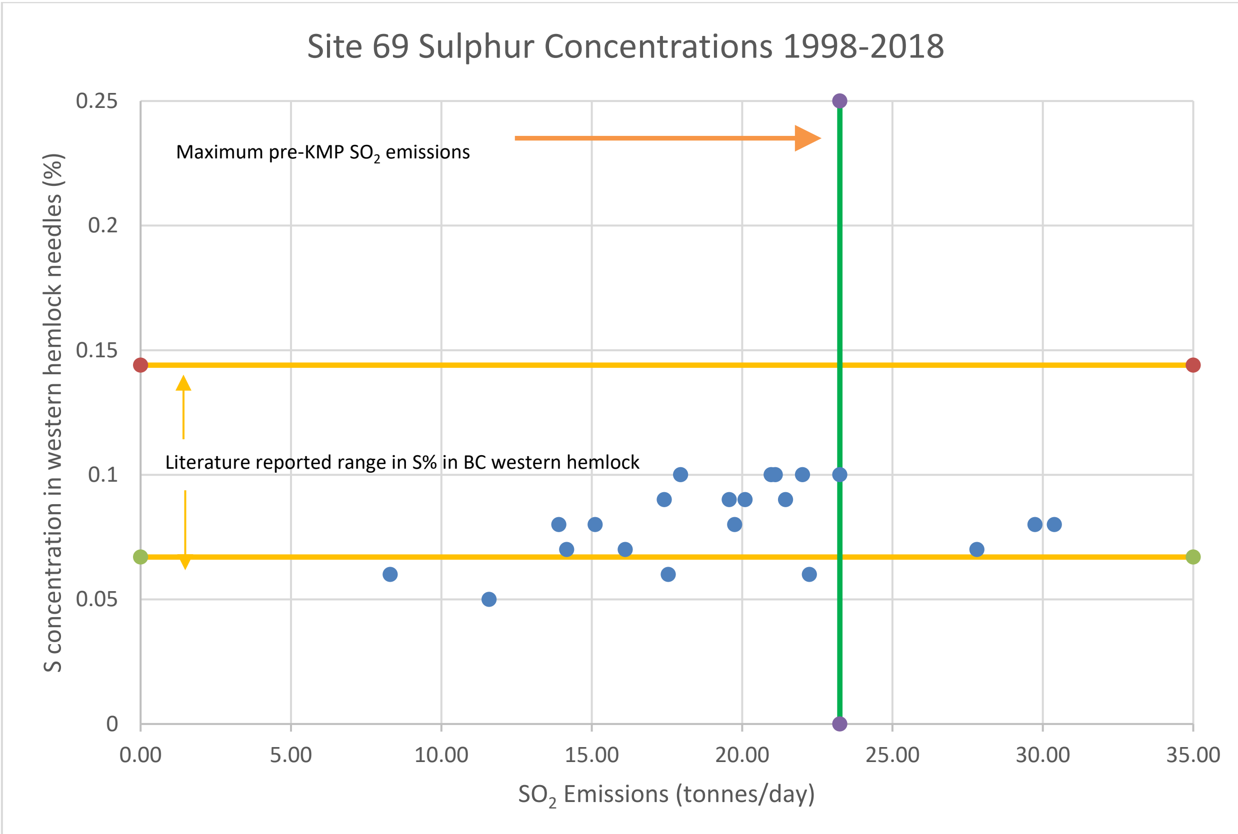

Site 54 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

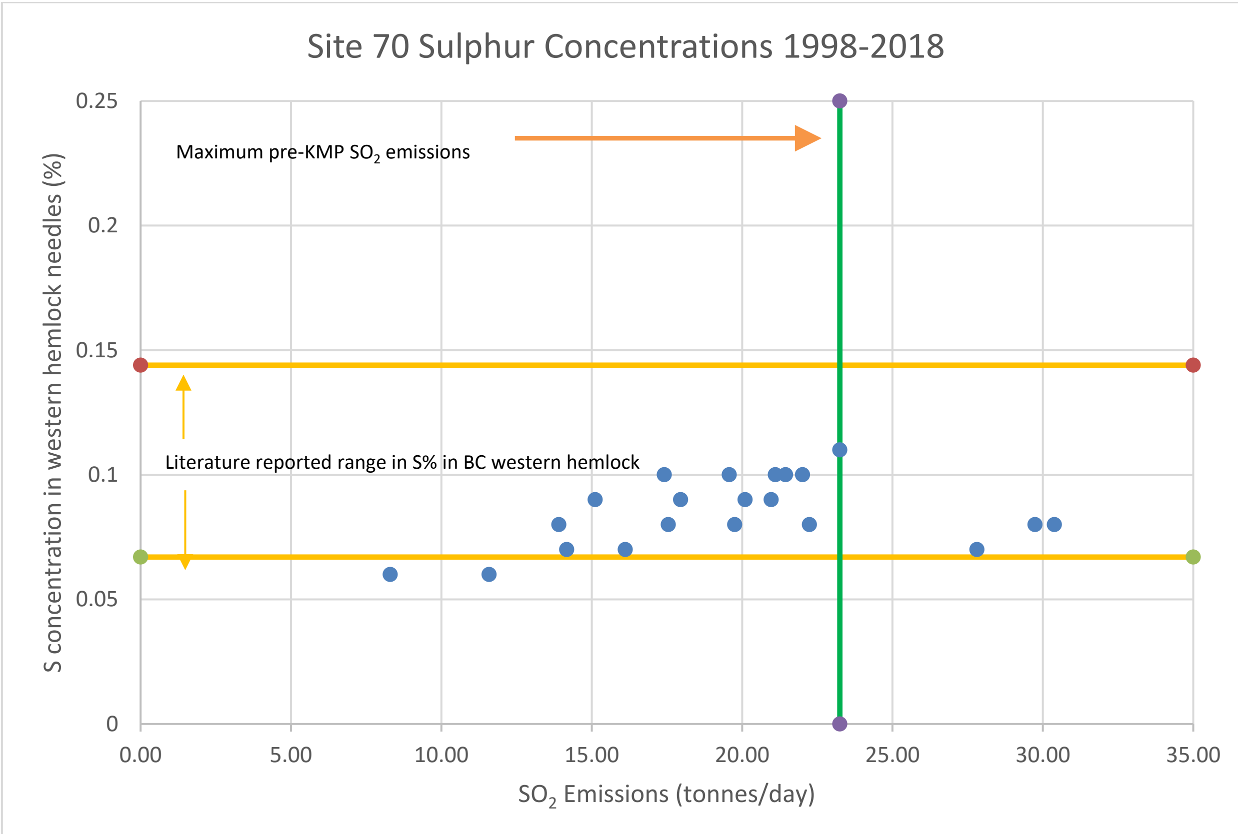

Site 55 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

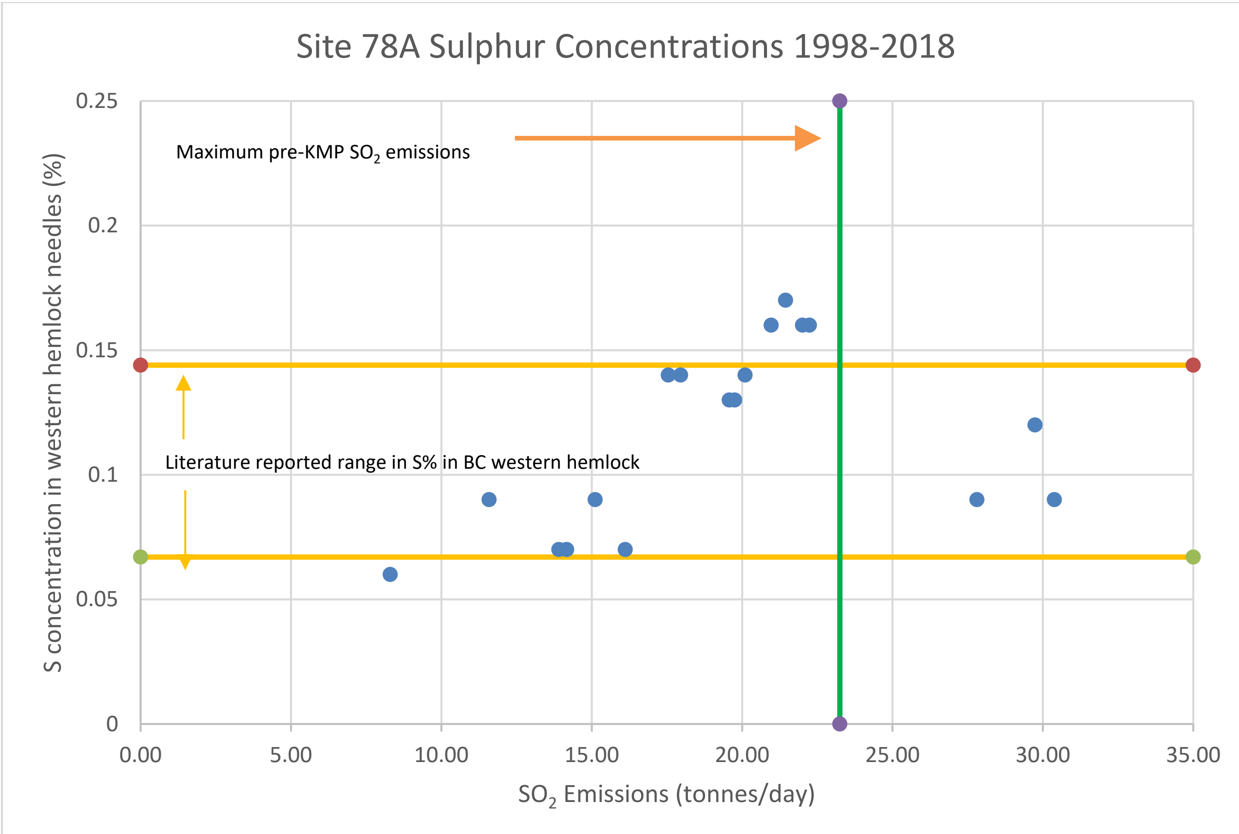

Site 56 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

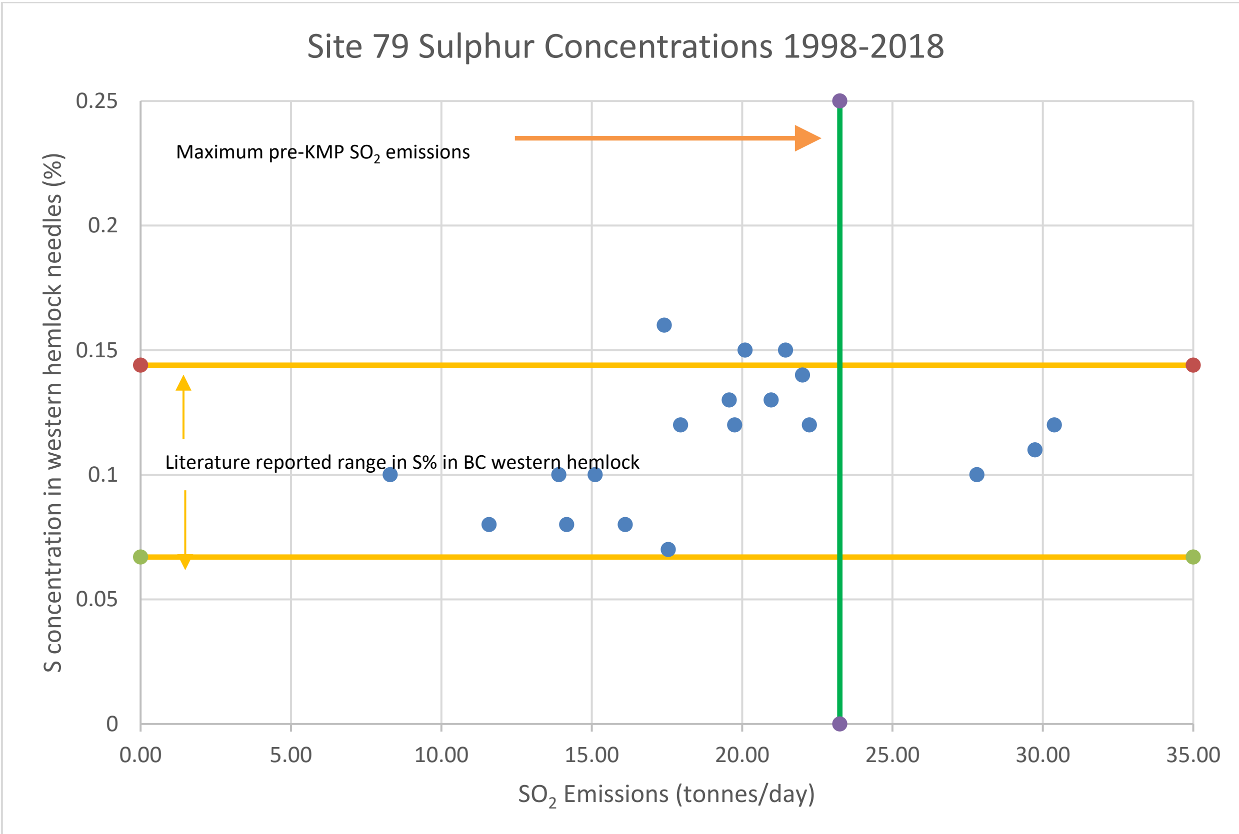

Site 57 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

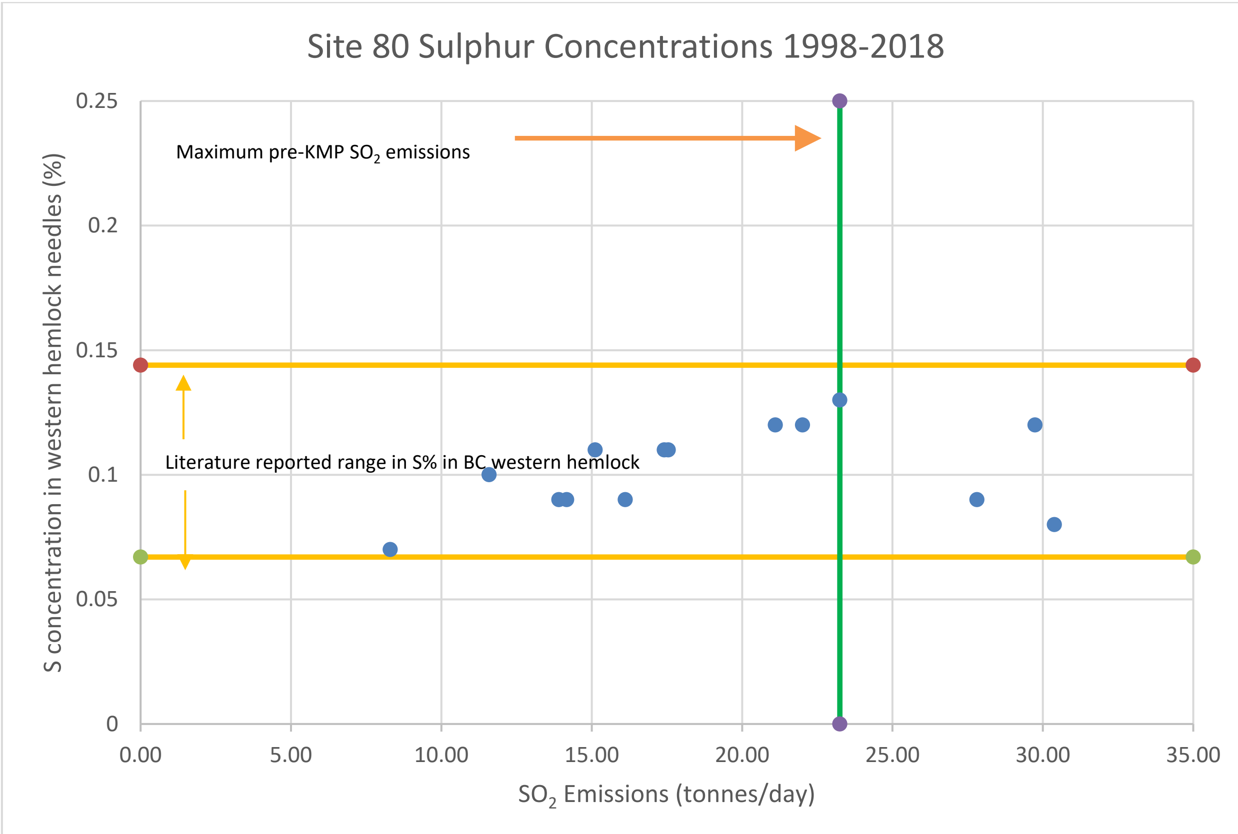

Site 68 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

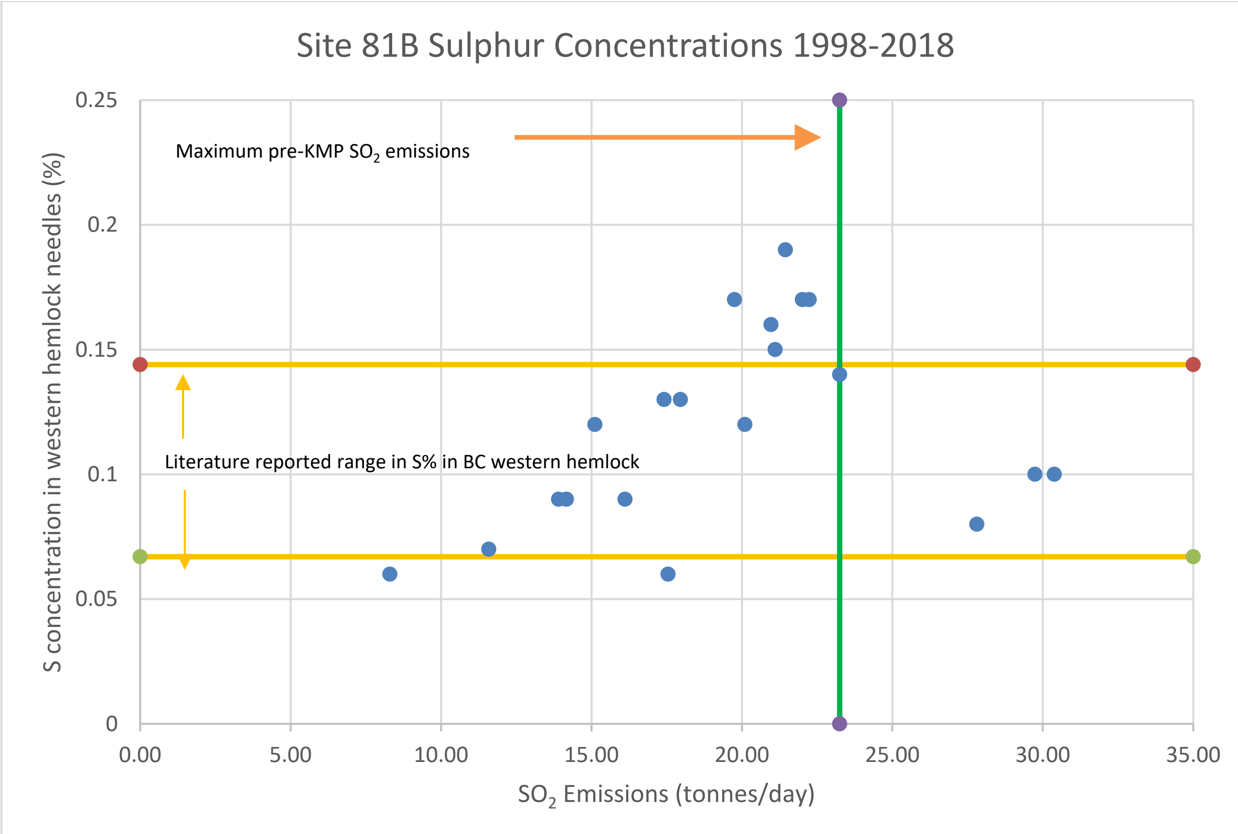

Site 69 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

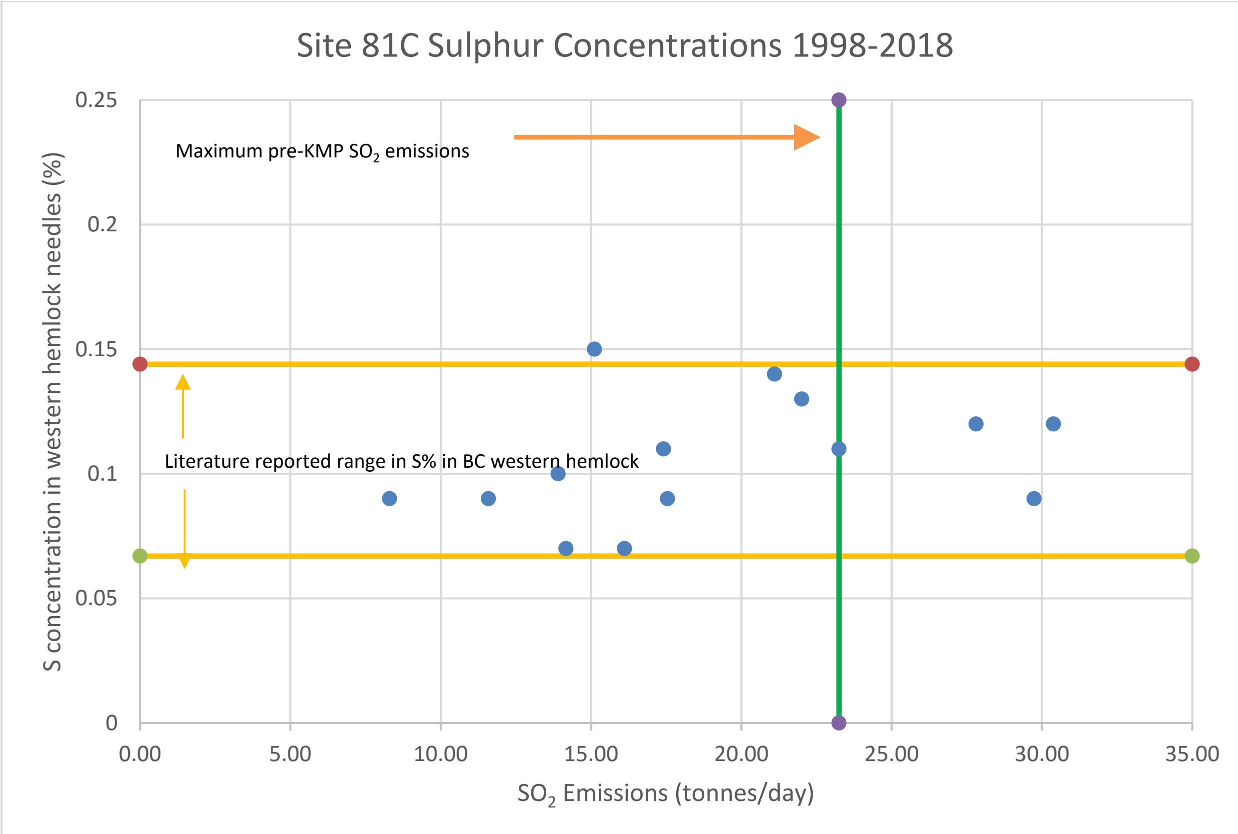

Site 70 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

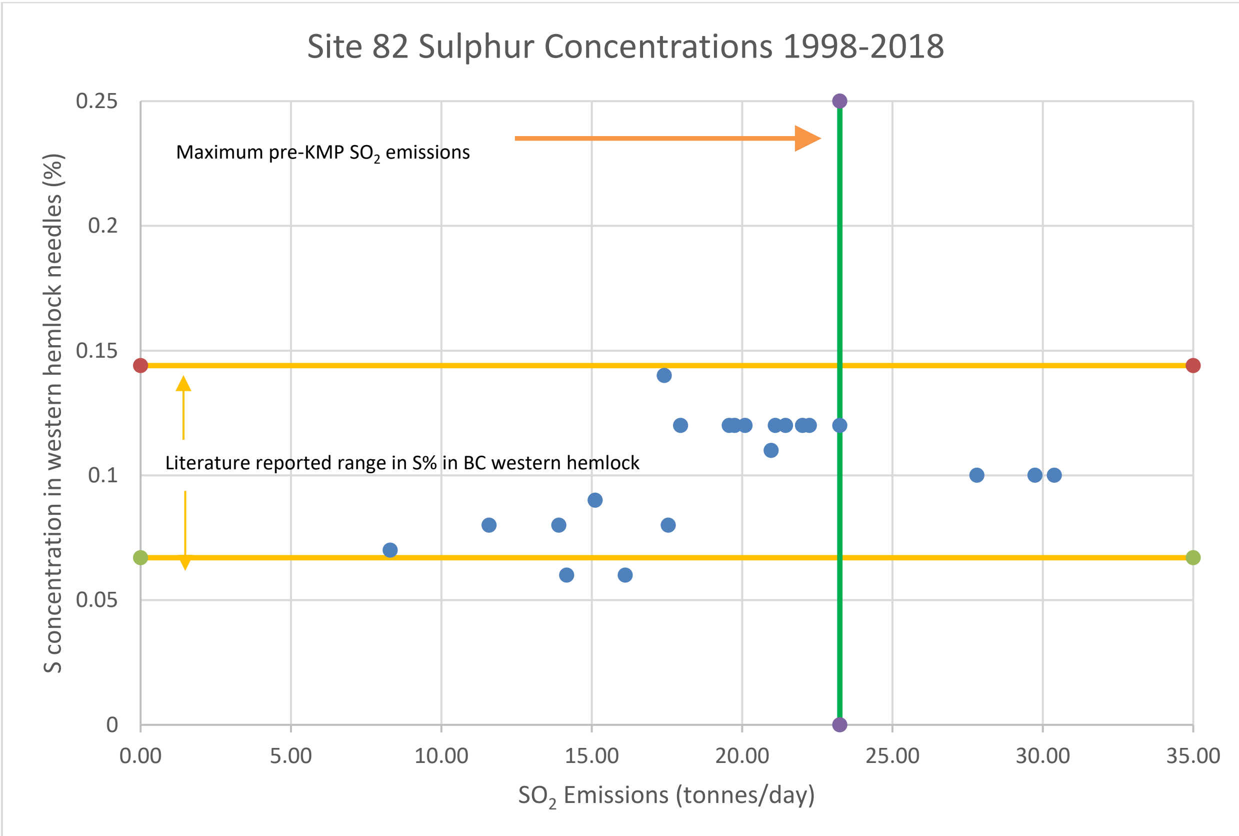

Site 78A Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

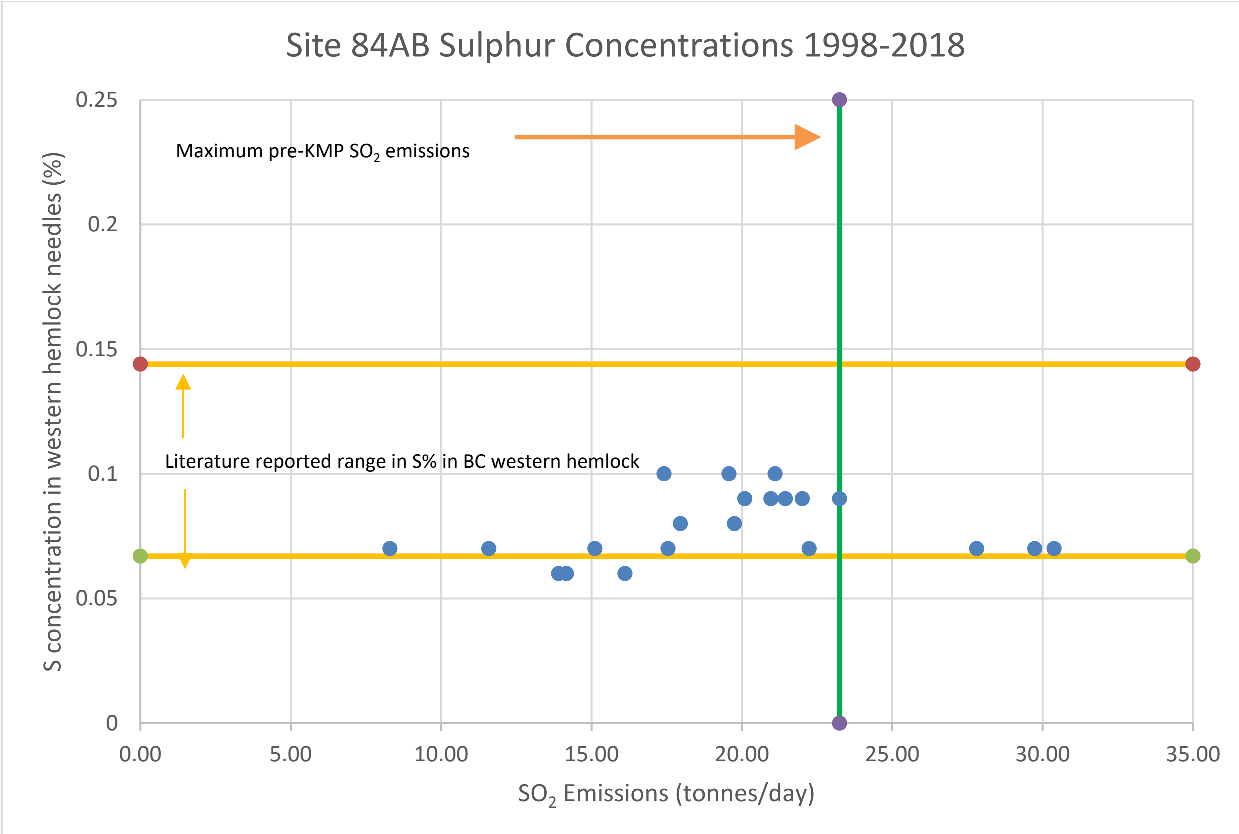

Site 79 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

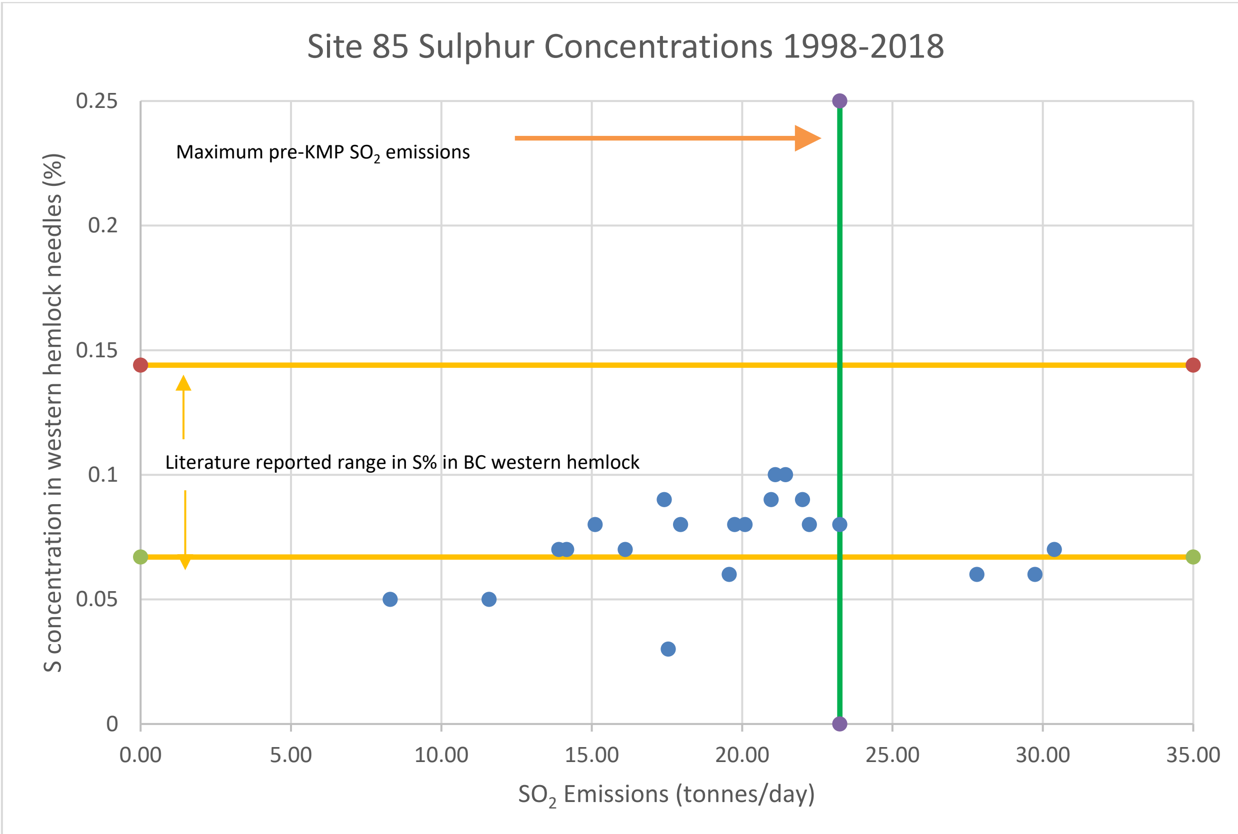

Site 80 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

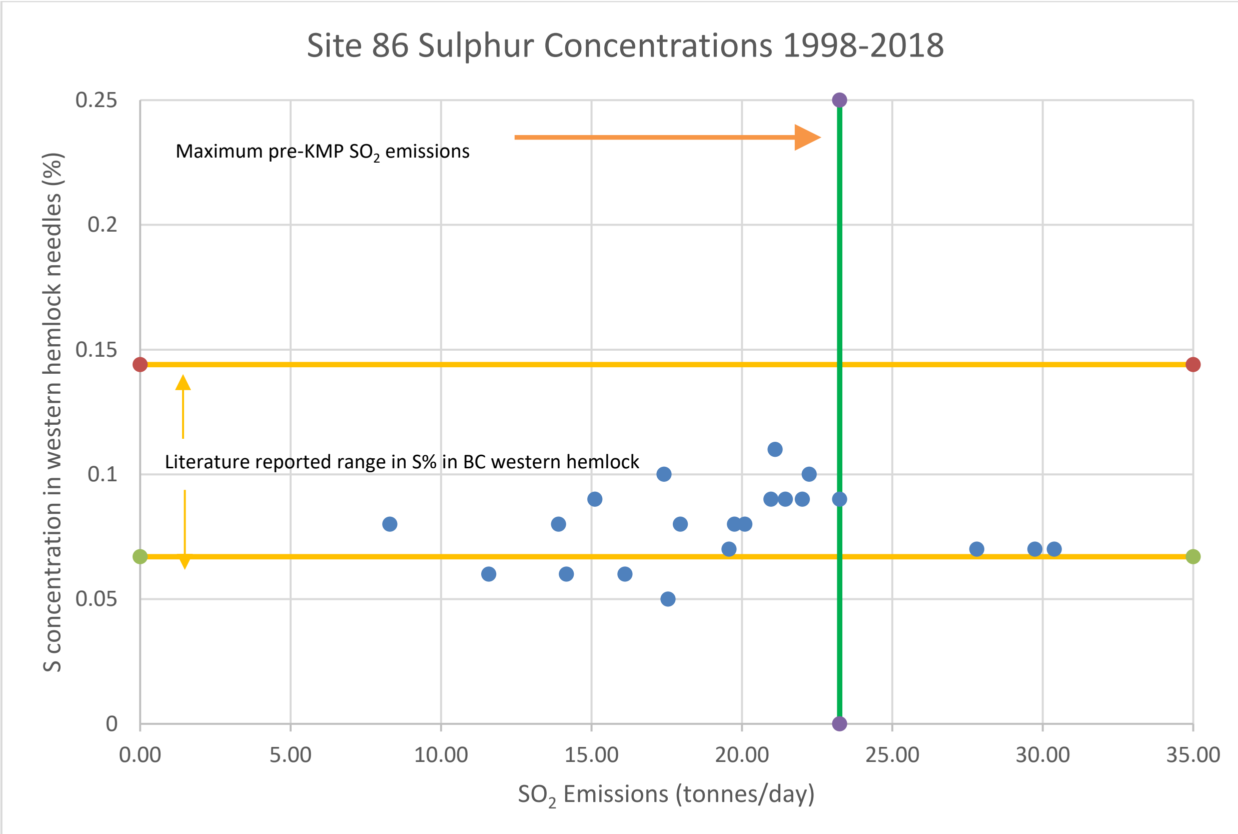

Site 81B Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

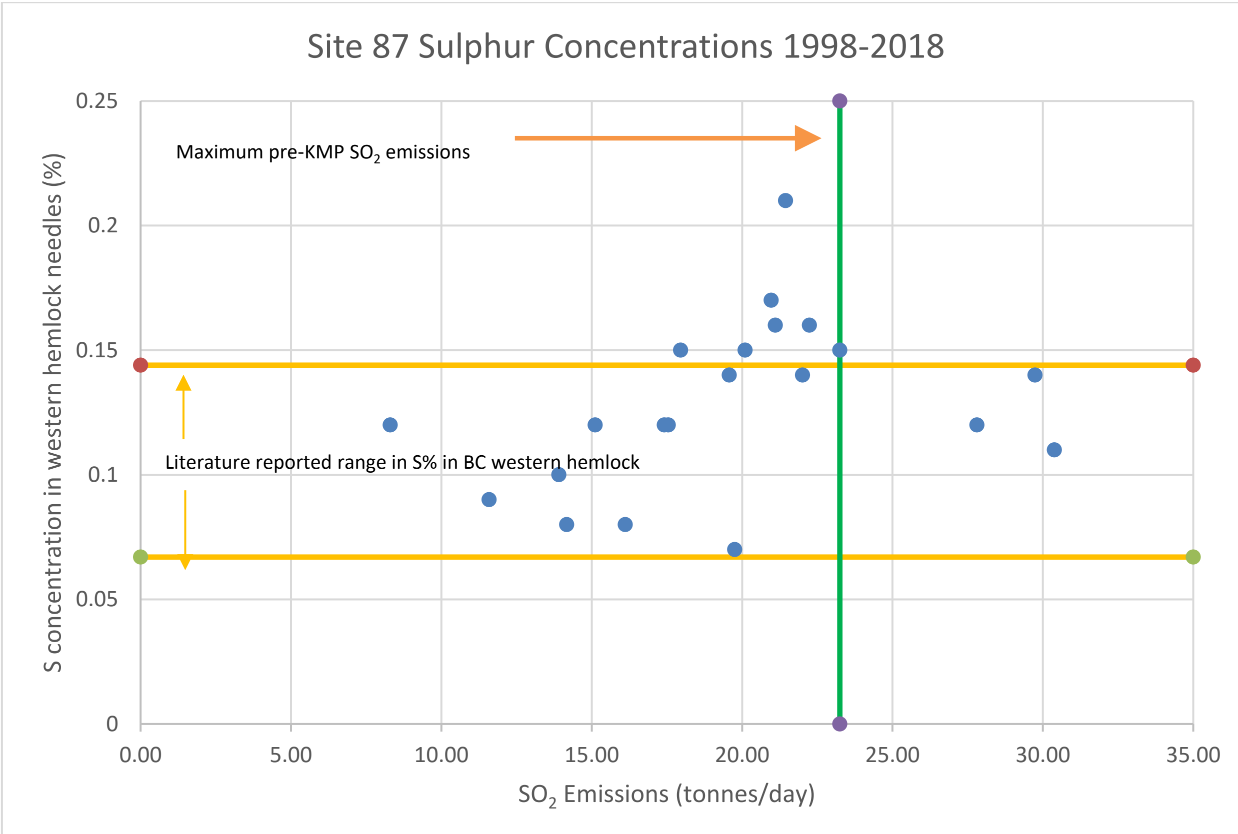

Site 81C Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

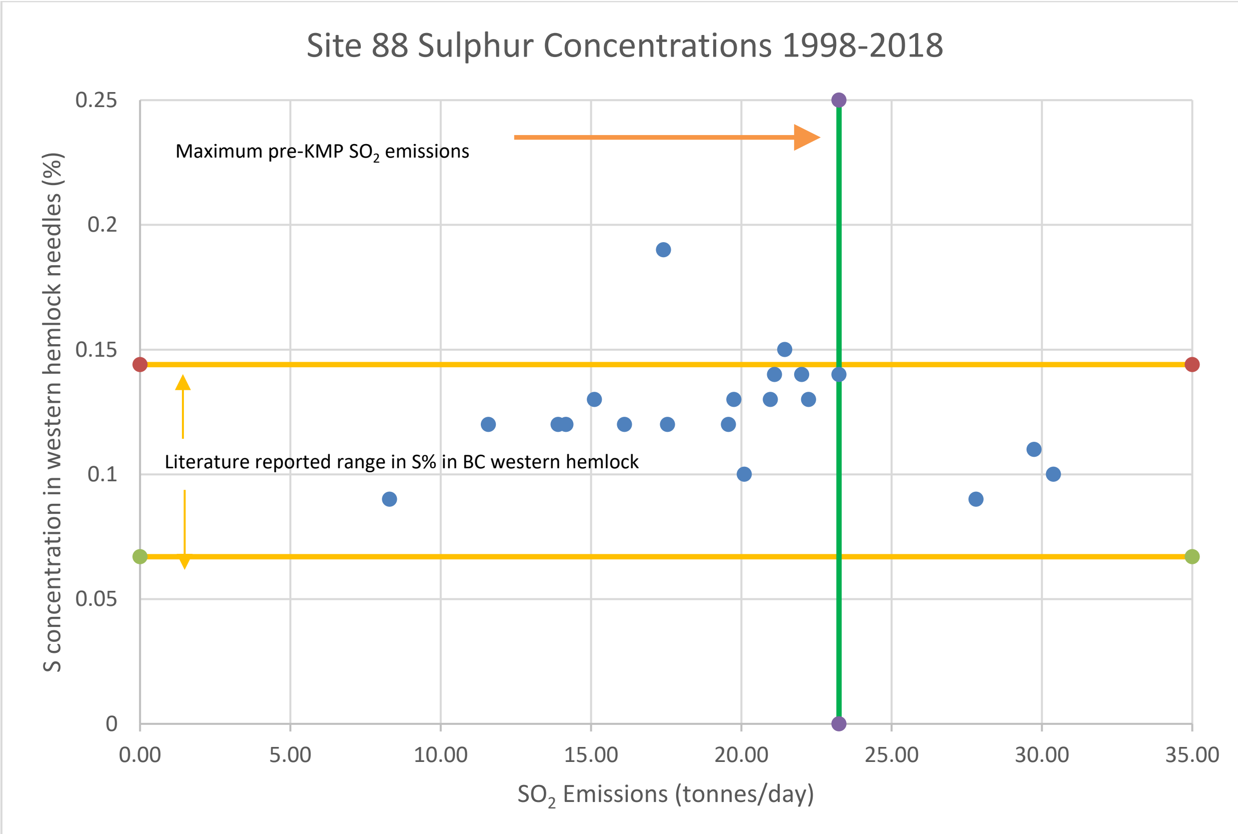

Site 82 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
SO2 Emissions (tonnes/day)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00

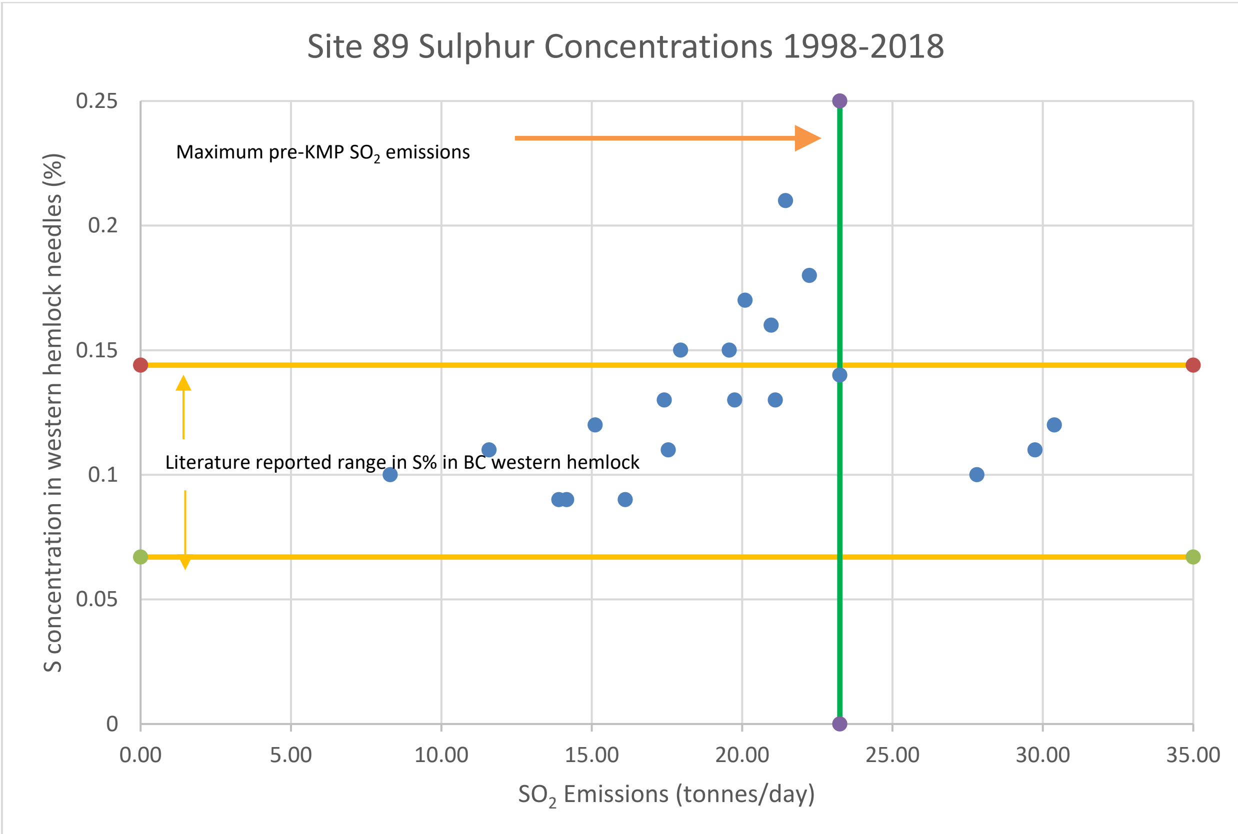

Site 84AB Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

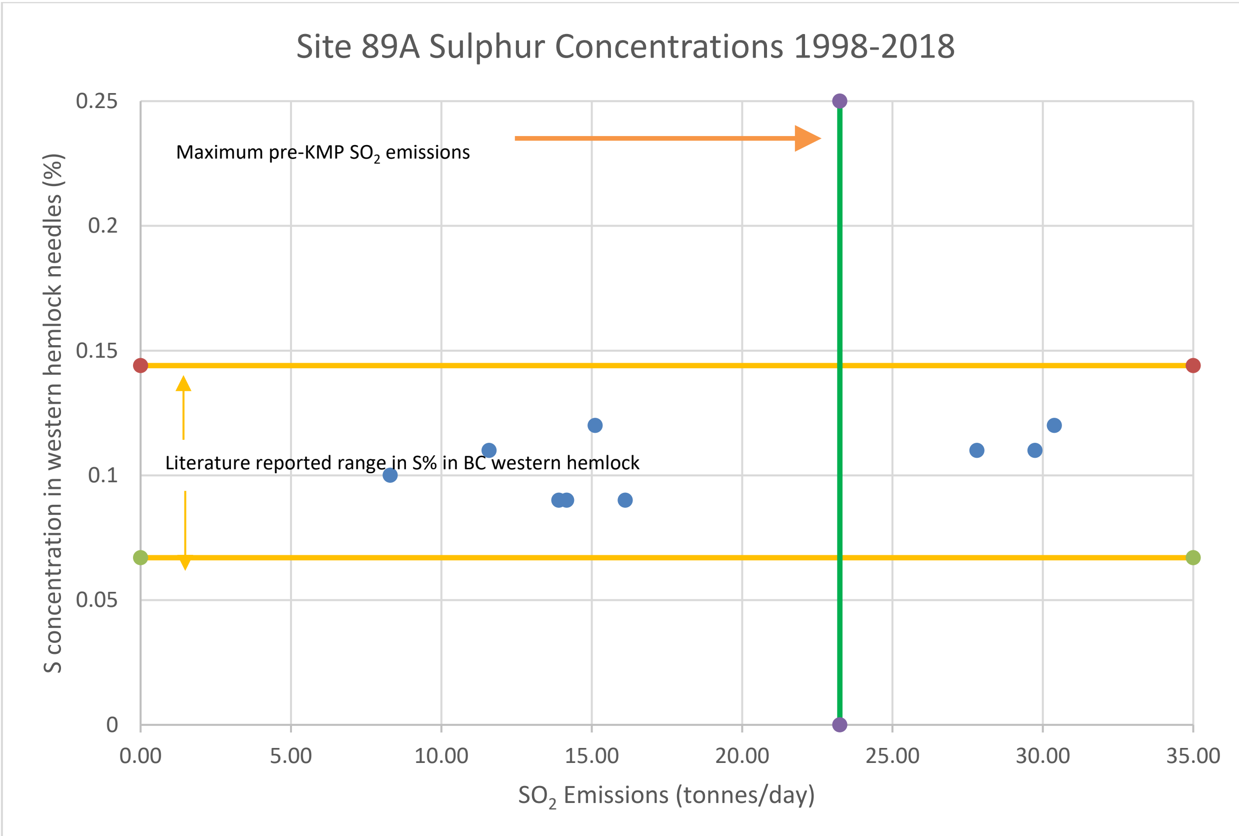

Site 85 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

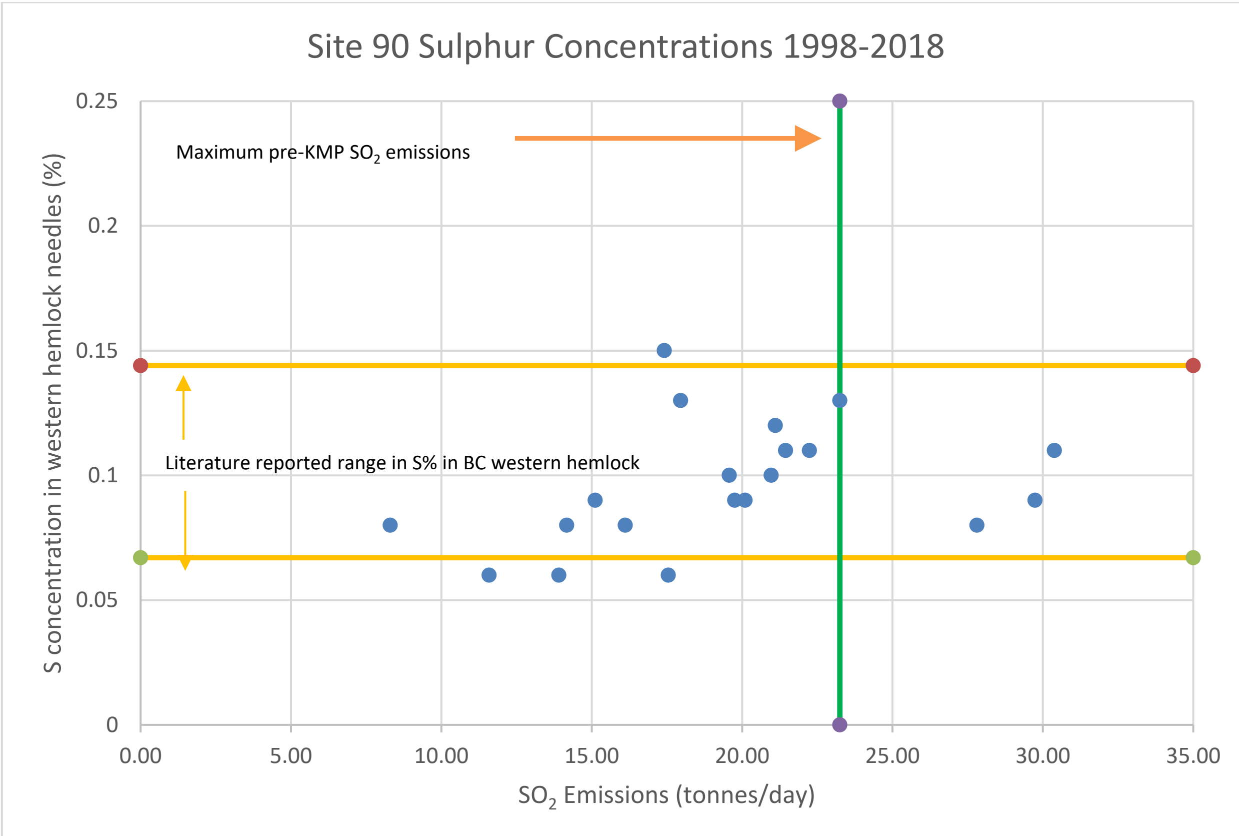

Site 86 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

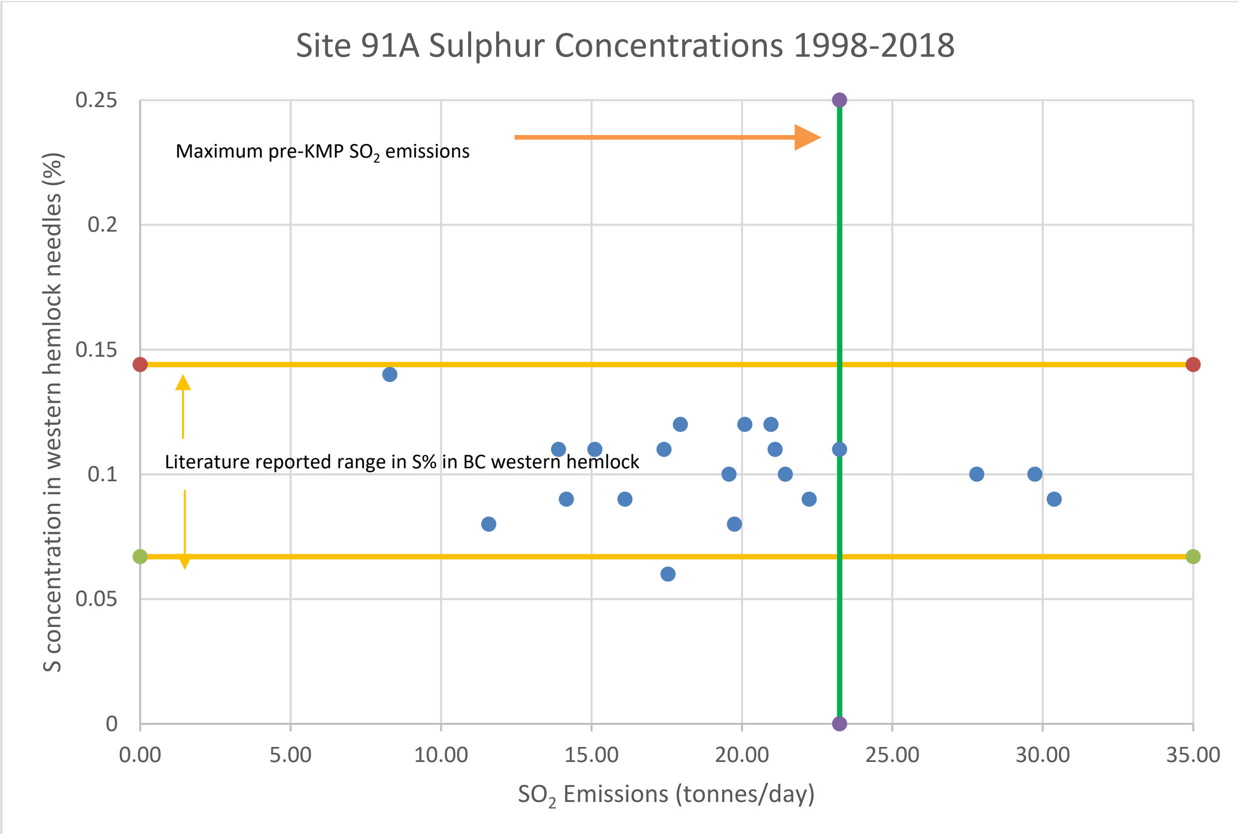

Site 87 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

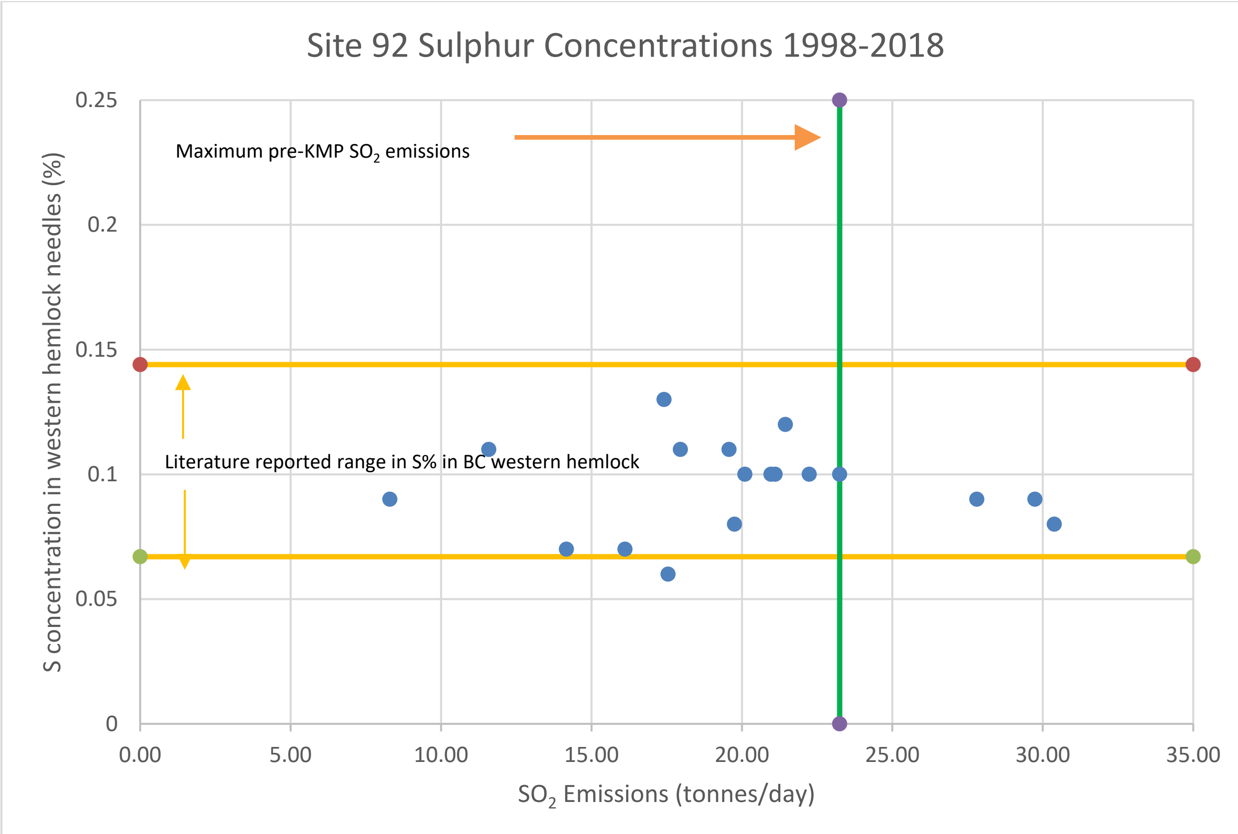

Site 88 Sulphur Concentrations 1998-2018
S concentration in western hemlock needles (%)
SO2 Emissions (tonnes/day)
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00

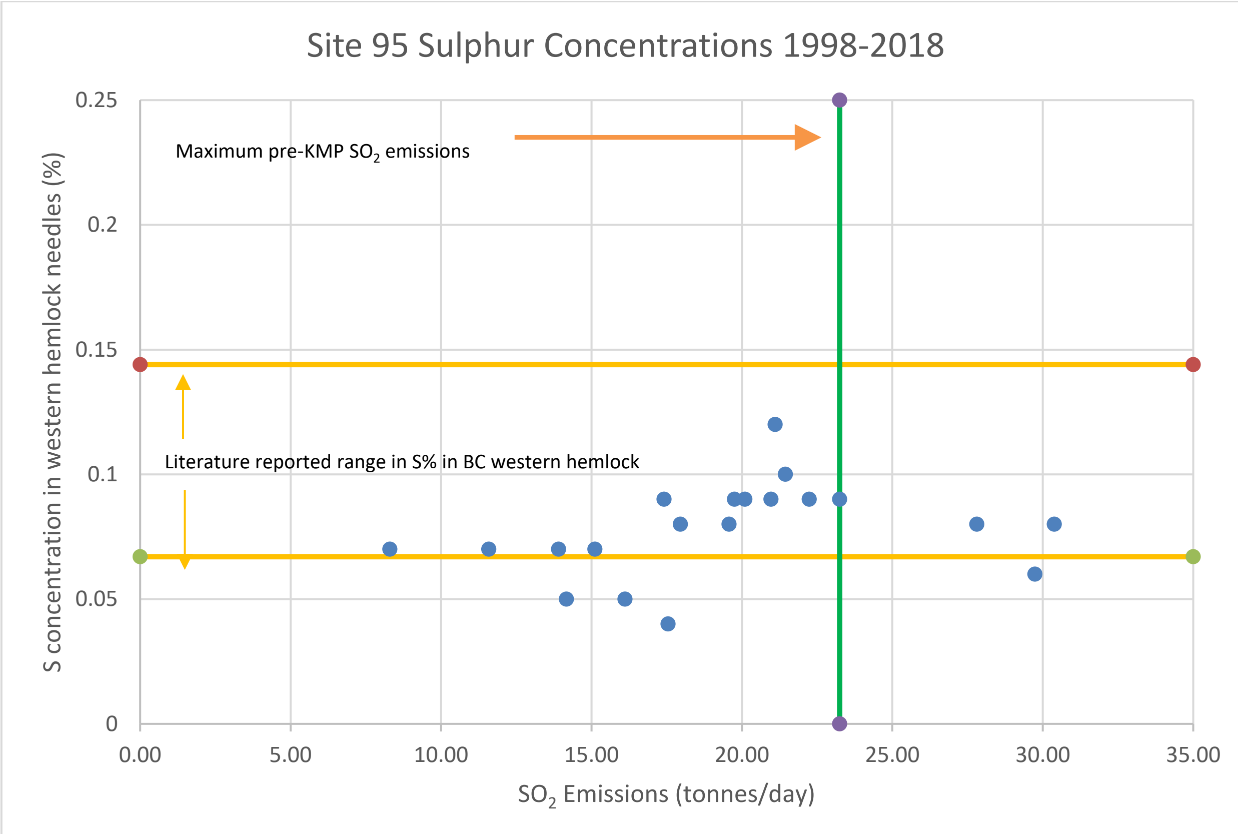

Site 89 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
SO2 Emissions (tonnes/day)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00

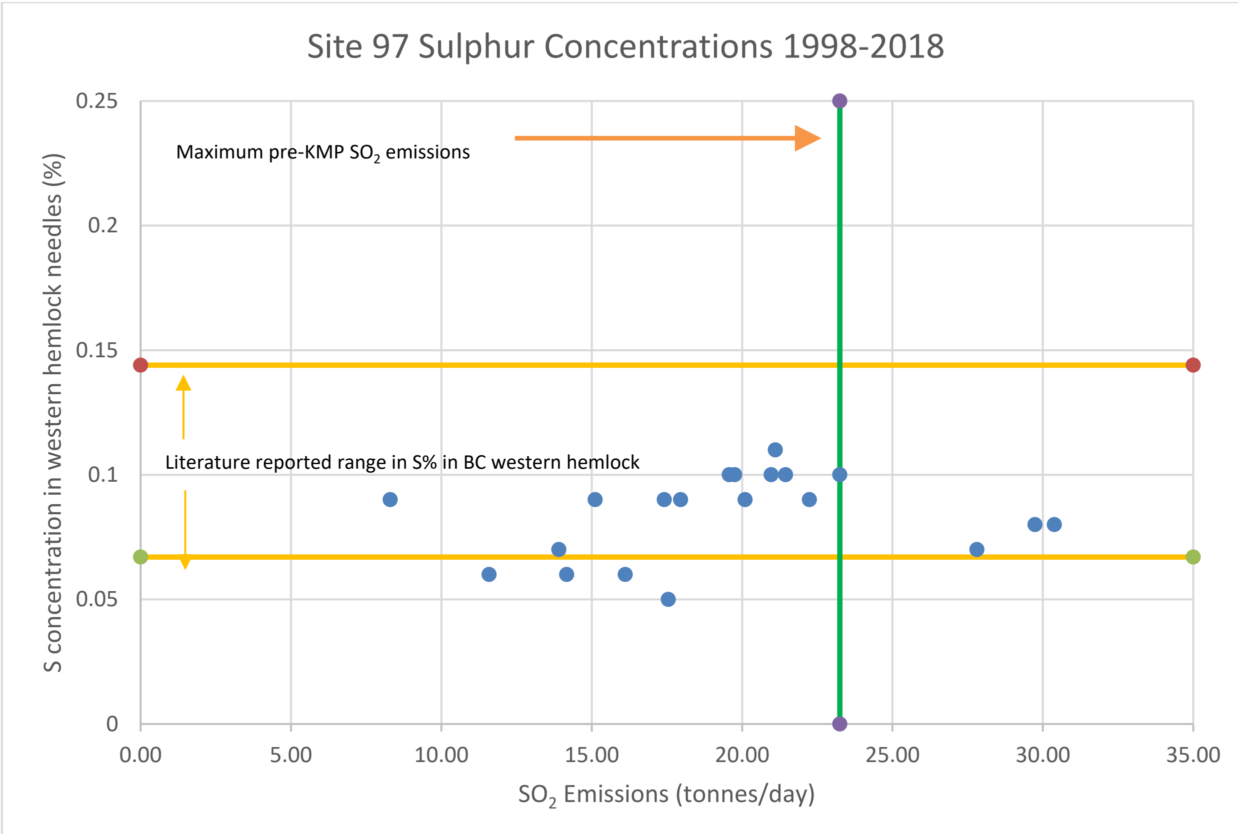

Site 89A Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

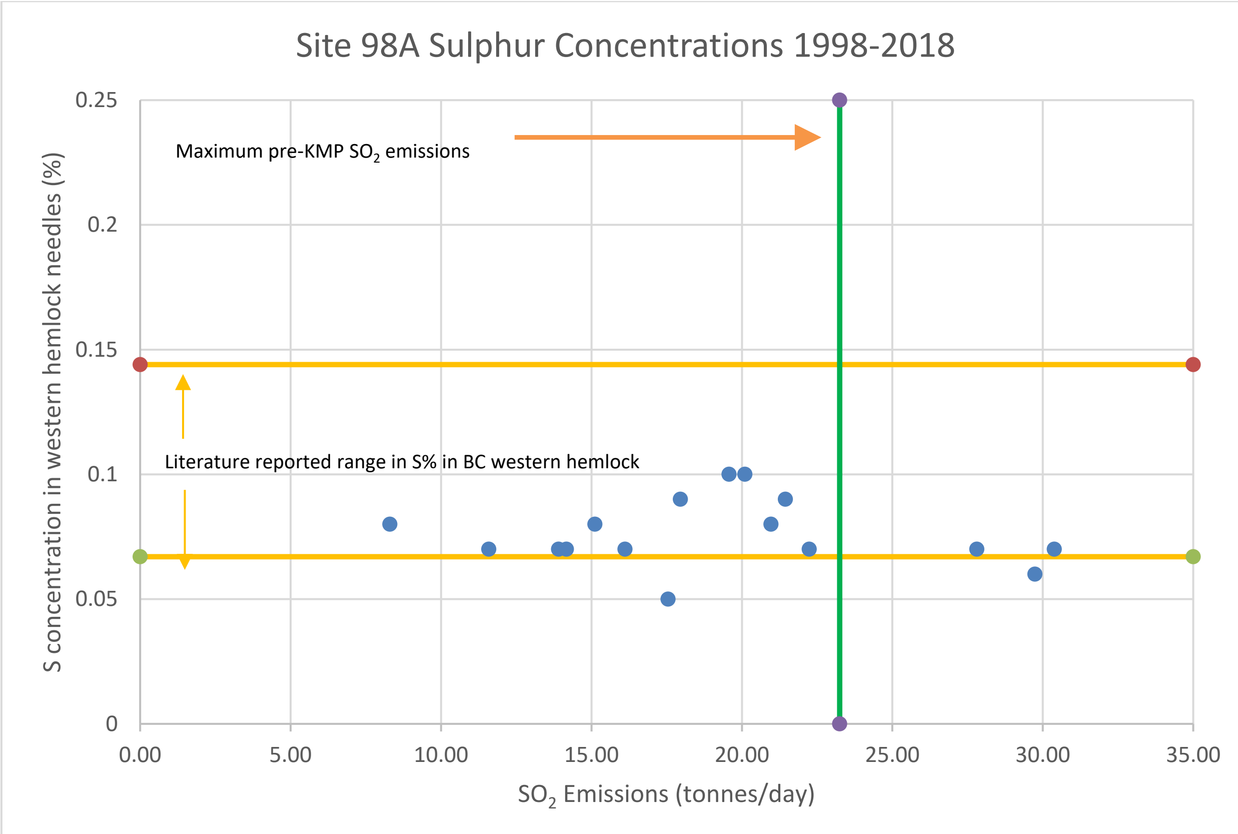

Site 90 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
SO2 Emissions (tonnes/day)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00

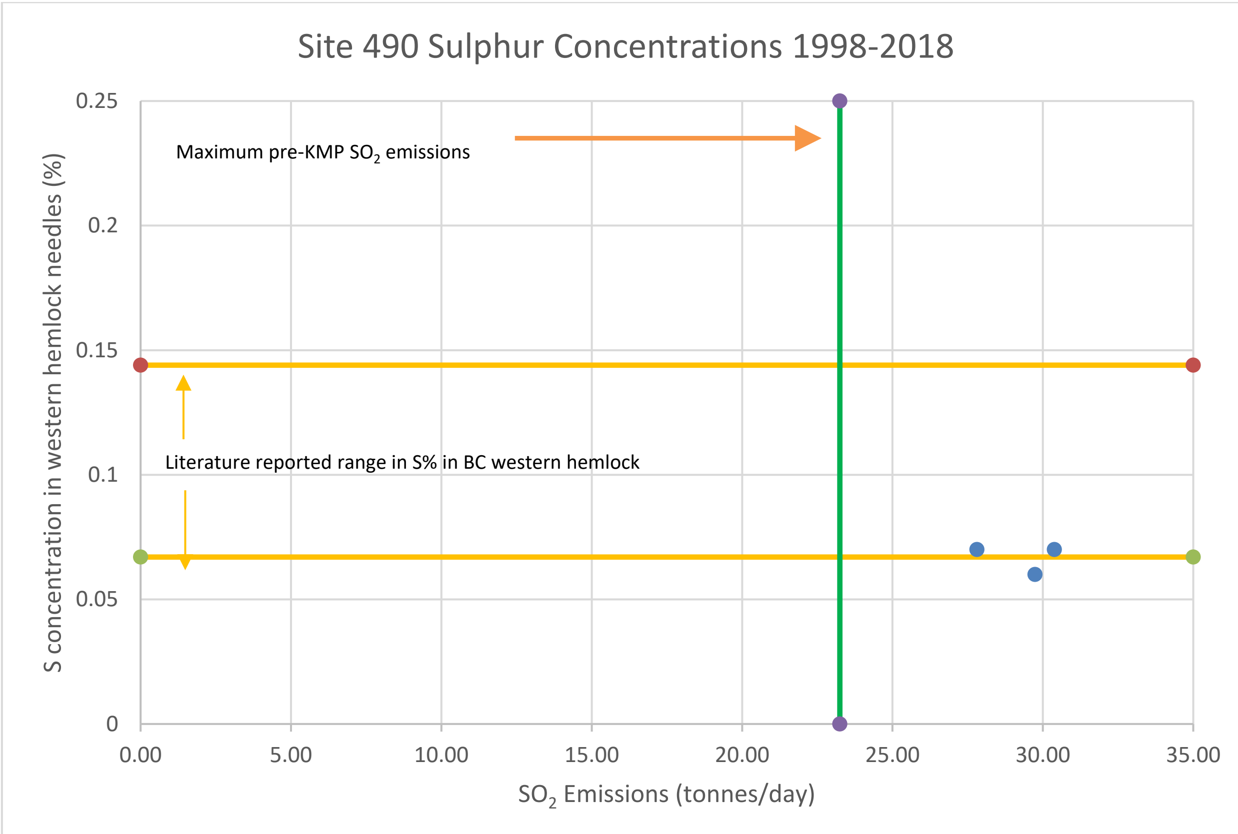

Site 91A Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

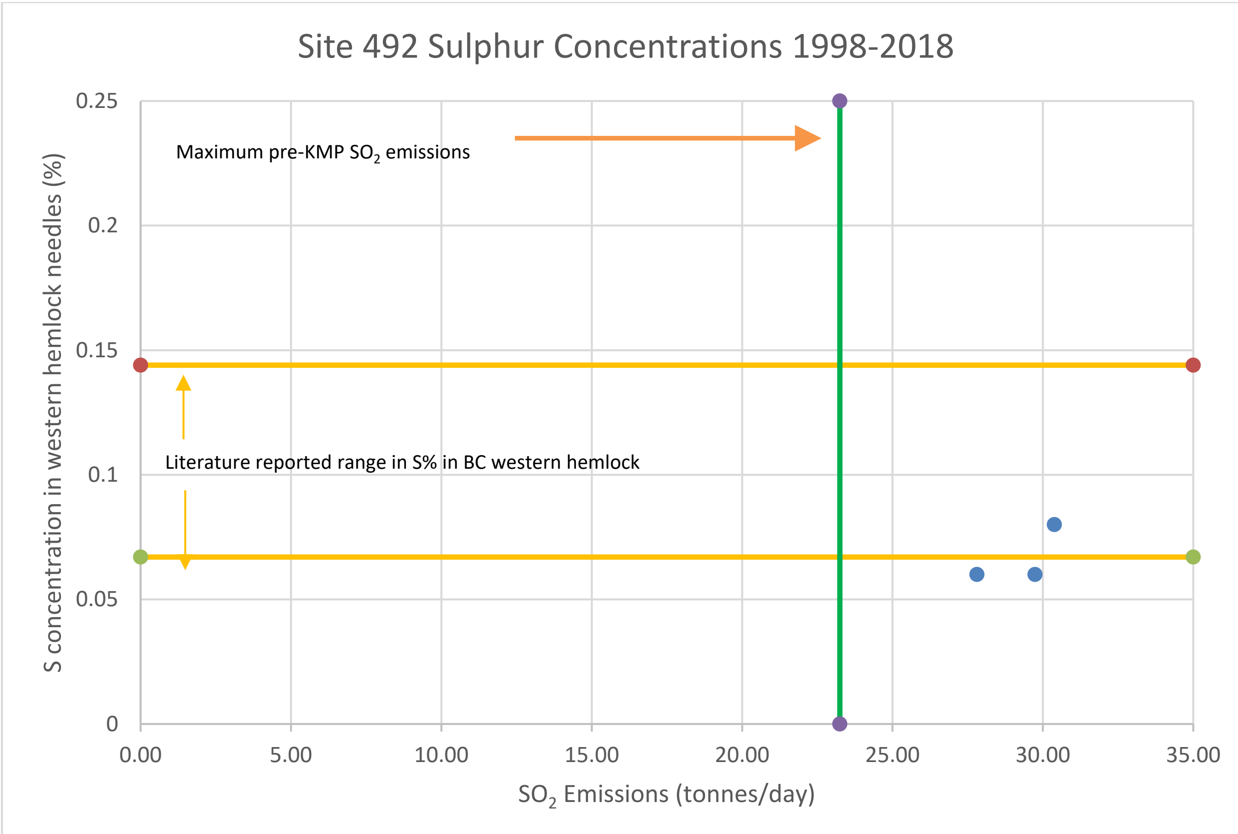

Site 92 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
SO2 Emissions (tonnes/day)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00

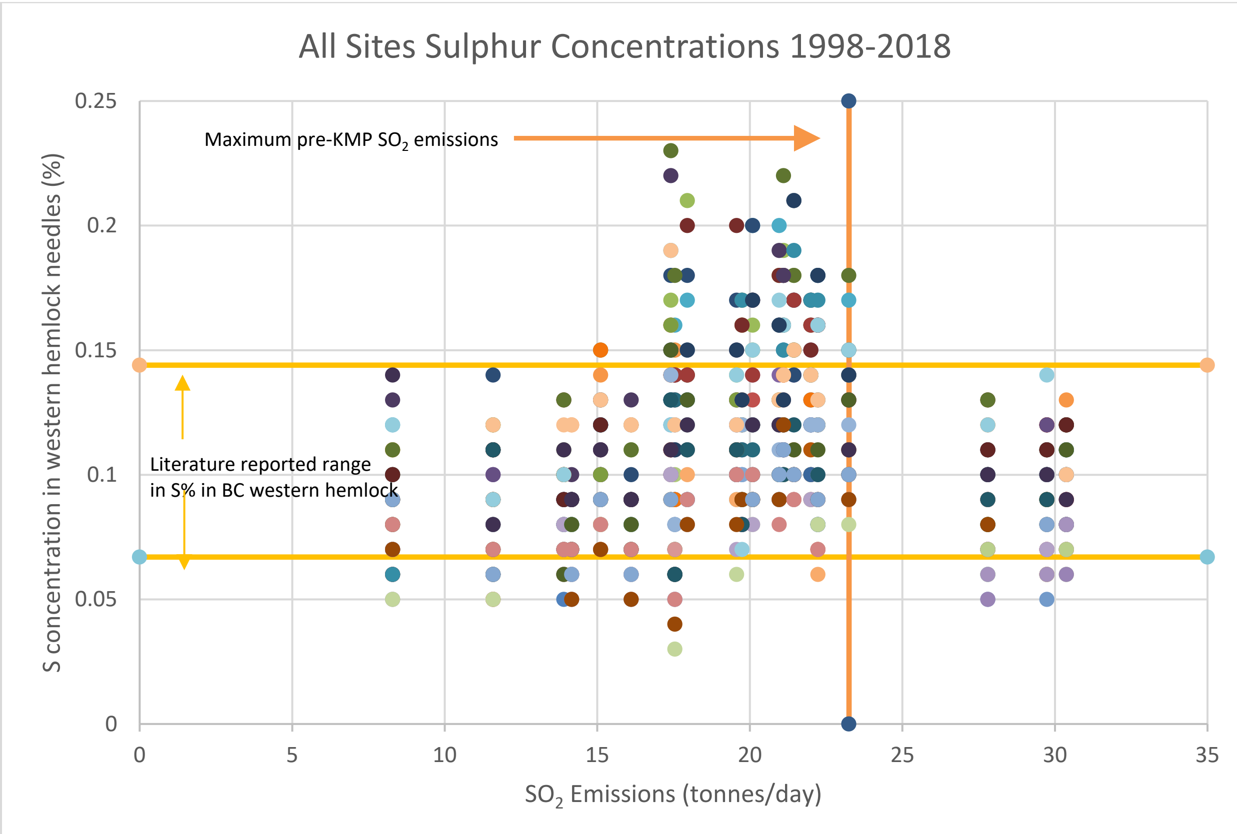

Site 95 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

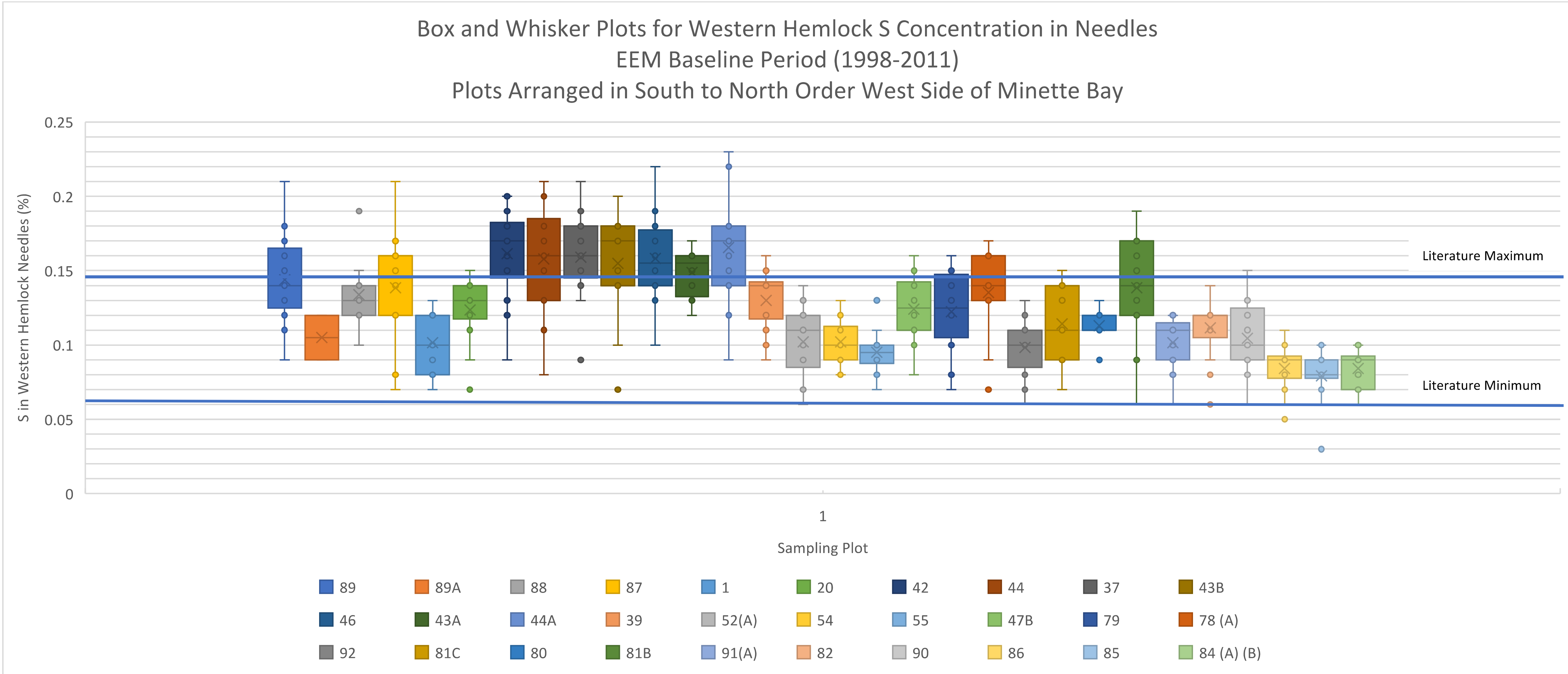

Site 97 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

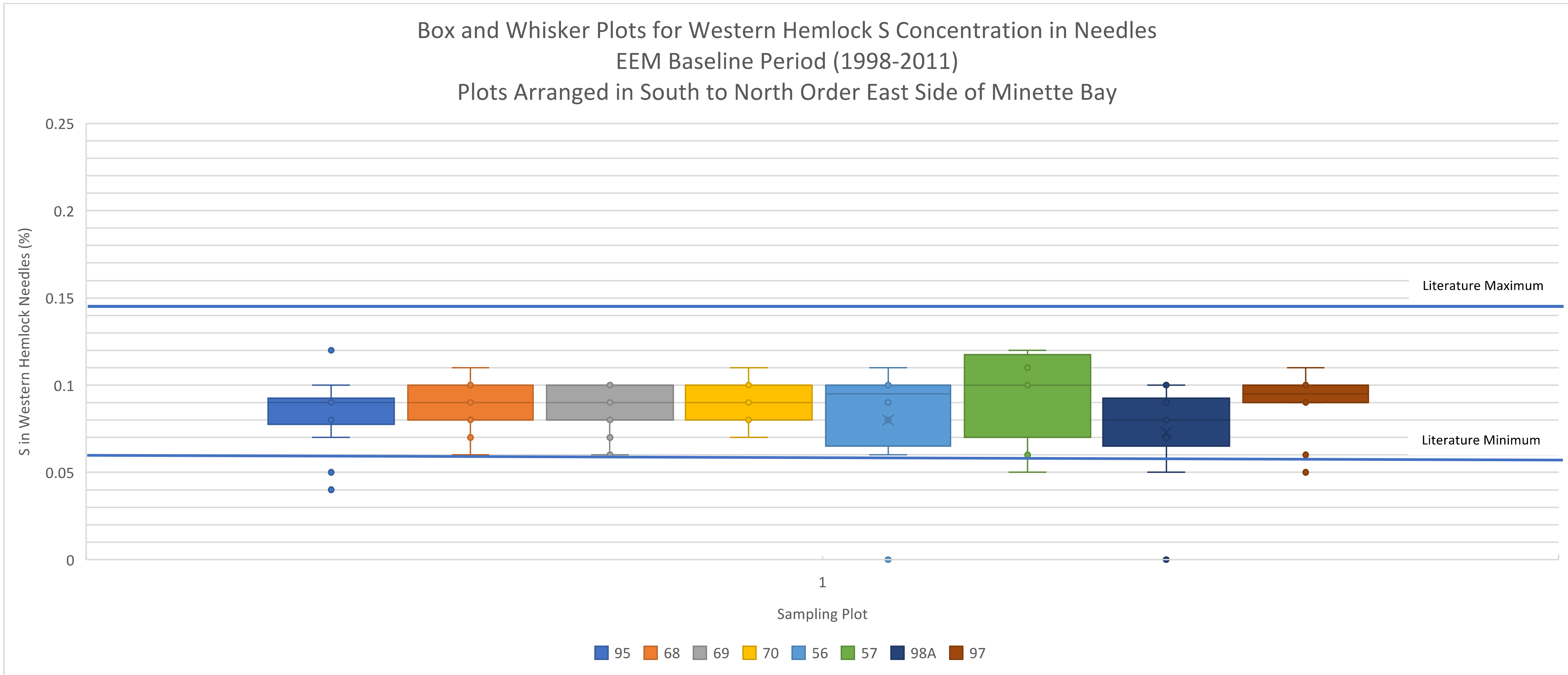

Site 98A Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

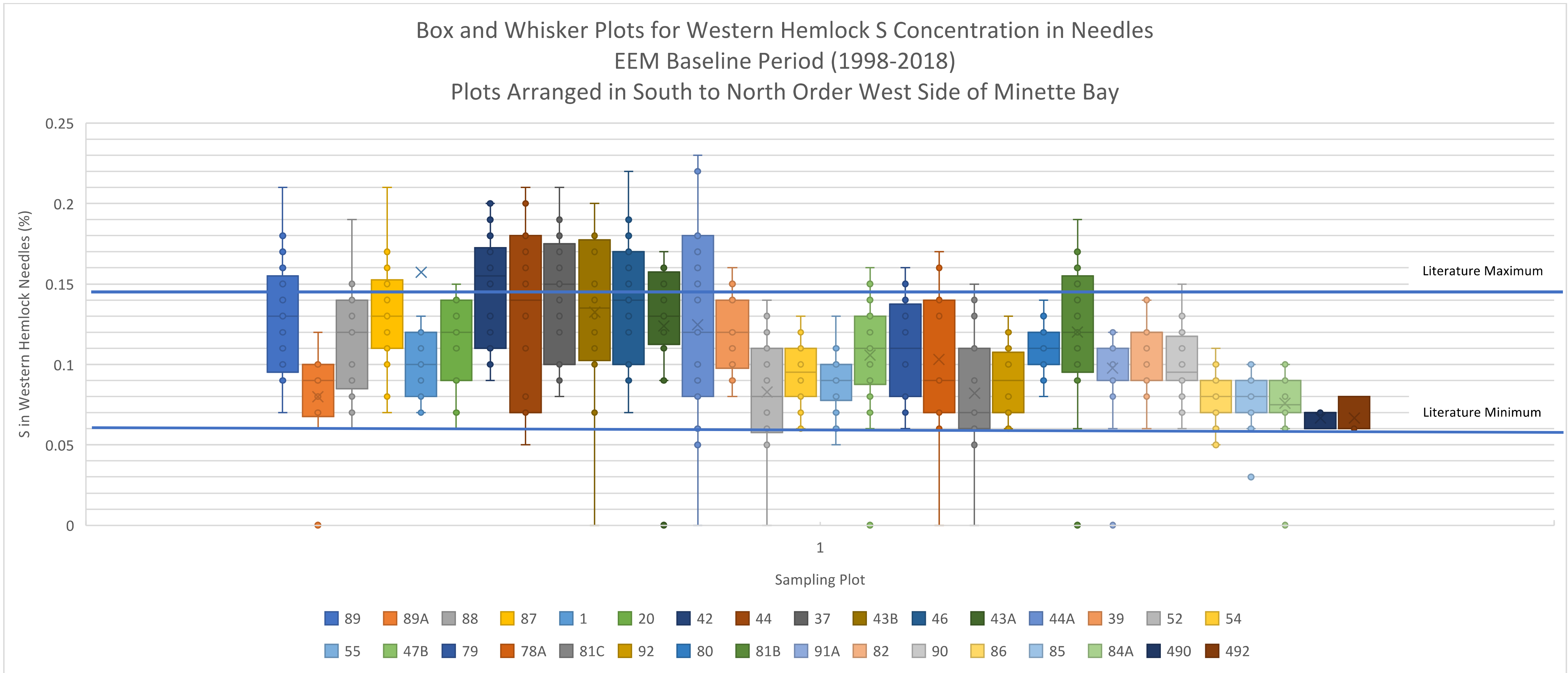

Site 490 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)

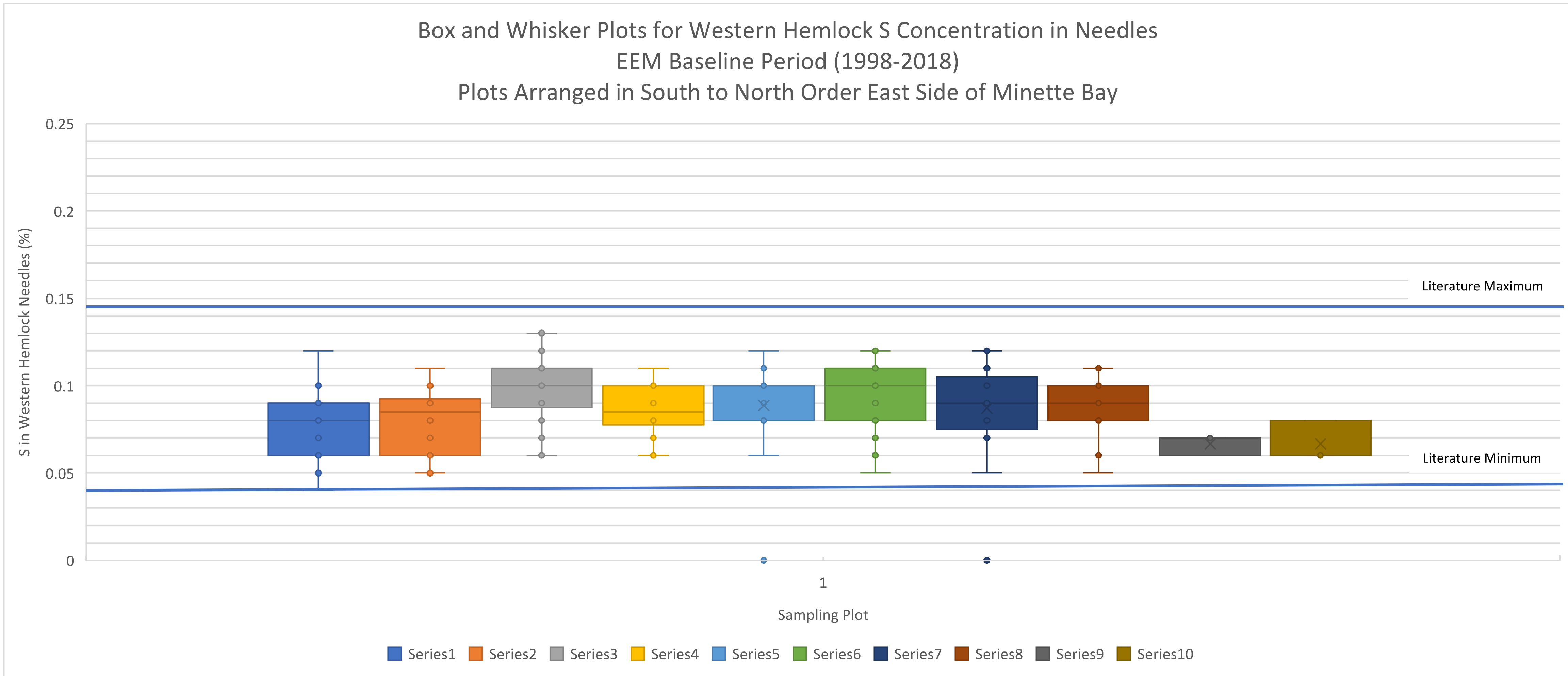

Site 492 Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range in S% in BC western hemlock
S concentration in western hemlock needles (%)
0.25
0.2
0.15
0.1
0.05
0
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
SO2 Emissions (tonnes/day)


All Sites Sulphur Concentrations 1998-2018
Maximum pre-KMP SO2 emissions
Literature reported range
in S% in BC western hemlock
S concentration in western hemlock needles (%)
SO2 Emissions (tonnes/day)
0.25
0.2
0.15
0.1
0.05
0
0
5
10
15
20
25
30
35

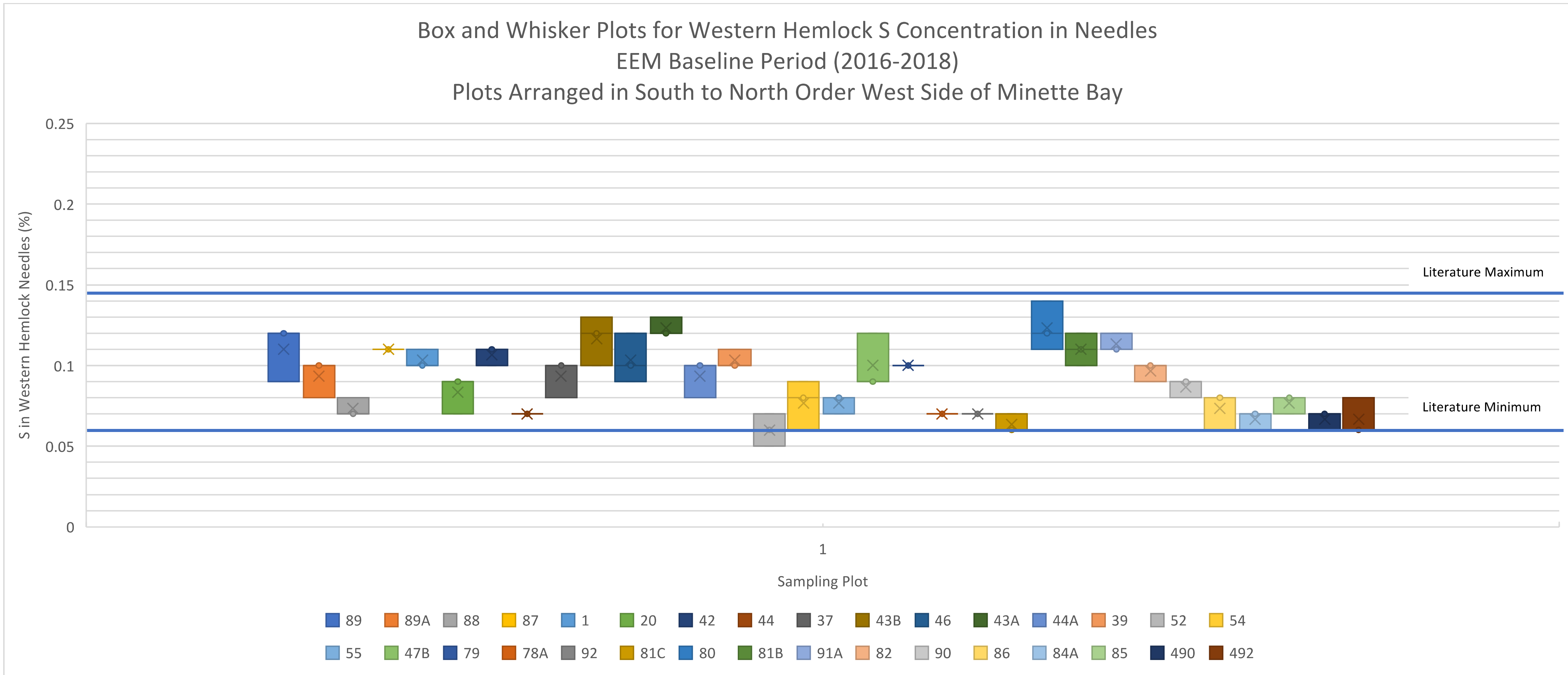

Box and Whisker Plots for Western Hemlock S Concentration in Needles
EEM Baseline Period (1998-2011)
Plots Arranged in South to North Order West Side of Minette Bay
S in Western Hemlock Needles (%)
0.25
0.2
0.15
0.1
0.05
0
Literature Maximum
Literature Minimum
1
Sampling Plot
89
89A
88
87
1
20
42
44
37
43B
46
43A
44A
39
52(A)
54
55
47B
79
78 (A)
92
81C
80
81B
91(A)
82
90
86
85
84 (A) (B)

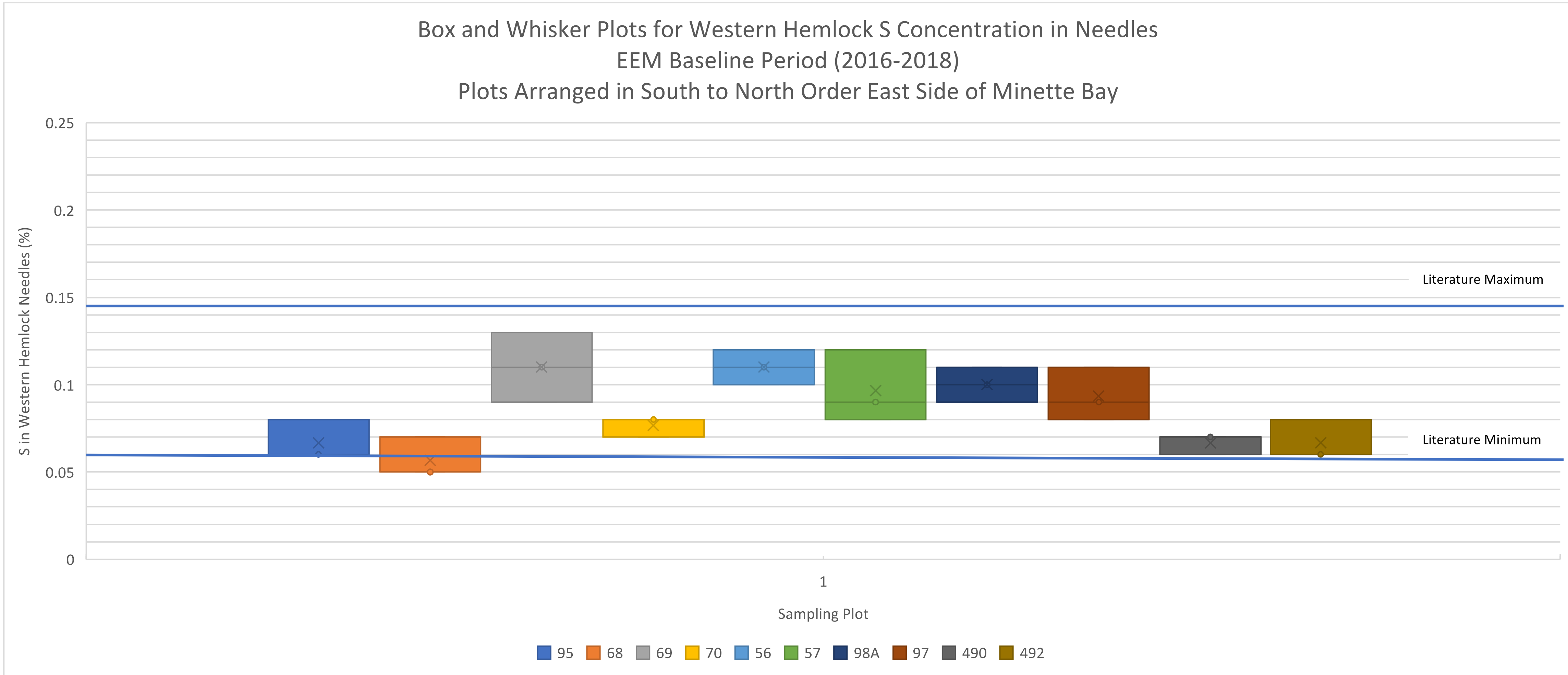

Box and Whisker Plots for Western Hemlock S Concentration in Needles
EEM Baseline Period (1998-2011)
Plots Arranged in South to North Order East Side of Minette Bay
S in Western Hemlock Needles (%)
0.25
0.2
0.15
0.1
0.05
0
Literature Maximum
Literature Minimum
1
Sampling Plot
95
68
69
70
56
57
98A
97


Box and Whisker Plots for Western Hemlock S Concentration in Needles
EEM Baseline Period (1998-2018)
Plots Arranged in South to North Order West Side of Minette Bay
S in Western Hemlock Needles (%)
0.25
0.2
0.15
0.1
0.05
0
Literature Maximum
Literature Minimum
1
Sampling Plot
89
89A
88
87
1
20
42
44
37
43B
46
43A
44A
39
52
54
55
47B
79
78A
81C
92
80
81B
91A
82
90
86
85
84A
490
492



Box and Whisker Plots for Western Hemlock S Concentration in Needles
EEM Baseline Period (1998-2018)
Plots Arranged in South to North Order East Side of Minette Bay
S in Western Hemlock Needles (%)
0.25
0.2
0.15
0.1
0.05
0
Literature Maximum
Literature Minimum
1
Sampling Plot
Series1
Series2
Series3
Series4
Series5
Series6
Series7
Series8
Series9
Series10


Box and Whisker Plots for Western Hemlock S Concentration in Needles
EEM Baseline Period (2016-2018)
Plots Arranged in South to North Order West Side of Minette Bay
S in Western Hemlock Needles (%)
0.25
0.2
0.15
0.1
0.05
0
Literature Maximum
Literature Minimum
1
Sampling Plot
89 89A 88 87 1 20 42 44 37 43B 46 43A 44A 39 52 54
55 47B 79 78A 92 81C 80 81B 91A 82 90 86 84A 85 490 492


Box and Whisker Plots for Western Hemlock S Concentration in Needles
EEM Baseline Period (2016-2018)
Plots Arranged in South to North Order East Side of Minette Bay
S in Western Hemlock Needles (%)
0.25
0.2
0.15
0.1
0.05
0
Literature Maximum
Literature Minimum
1
Sampling Plot
95
68
69
70
56
57
98A
97
490
492

5.6 Information from the BC Conservation Data Centre

The species and ecological communities that potentially occur in the study area are shown in Table 5.20 and Table 5.21.

Table 5.20: Red-listed species and ecological communities that occur or potentially occur in the study area.

Scientific Name(s)	Common Name(s)
Acroscyphus sphaerophoroides	mountain crab-eye
Arctopoa eminens	eminent bluegrass
Leymus mollis ssp. *mollis* - *Lathyrus japonicus*	dune wildrye - beach pea
Picea sitchensis / Rubus spectabilis	Sitka spruce / salmonberry Very Wet Maritime
Picea sitchensis / Rubus spectabilis	Sitka spruce / salmonberry Wet Submaritime 1
Pinus contorta / Arctostaphylos uva-ursi	lodgepole pine / kinnikinnick
Sclerophora peronella	frosted glass-whiskers

Source: BC Species and Ecosystem Explorer (http://a100.gov.bc.ca/pub/eswp/) accessed January 17, 2020.

Table 5.21: Blue-listed species and communities that occur or potentially occur in the study area.

Scientific Name(s)	Common Name(s)
Abies amabilis - Picea sitchensis / Oplopanax horridus	amabilis fir - Sitka spruce / devil's club
Abies amabilis - Thuja plicata / Gymnocarpium dryopteris	amabilis fir - western redcedar / oak fern
Abies amabilis - Thuja plicata / Oplopanax horridus	amabilis fir - western redcedar / devil's club Moist Submaritime
Abies amabilis - Thuja plicata / Rubus spectabilis	amabilis fir - western redcedar / salmonberry Very Wet Maritime
Lobaria retigera	smoker's lung
Nephroma occultum	cryptic paw
Picea sitchensis / Rubus spectabilis	Sitka spruce / salmonberry Wet Submaritime 2
Populus trichocarpa - Alnus rubra / Rubus spectabilis	black cottonwood - red alder / salmonberry
Pseudocyphellaria rainierensis	oldgrowth specklebelly
Thuja plicata - Picea sitchensis / Lysichiton americanus	western redcedar - Sitka spruce / skunk cabbage
Thuja plicata - Picea sitchensis / Polystichum munitum	western redcedar - Sitka spruce / sword fern
Thuja plicata - Tsuga heterophylla / Polystichum munitum	western redcedar - western hemlock / sword fern
Tsuga heterophylla - Abies amabilis / Struthiopteris spicant	western hemlock - amabilis fir / deer fern
Tsuga heterophylla - Pinus contorta / Pleurozium schreberi	western hemlock - lodgepole pine / red-stemmed feathermoss
Tsuga heterophylla - Thuja plicata / Gaultheria shallon	western hemlock - western redcedar / salal Very Wet Maritime

Source: BC Species and Ecosystem Explorer (http://a100.gov.bc.ca/pub/eswp/)

The following report is from the British Columbia Conservation Data Centre with occurrence and approximate locations of Red- and Blue-listed species and ecological communities in the study area. This report has been inserted in its original format as a PDF file on the subsequent pages, and as such has different headers and footers from this main appendix file.

BC Conservation Data Centre: Ecosystem Occurrence Report
Shape ID: 70480

Scientific Name: *Populus trichocarpa - Alnus rubra / Rubus spectabilis*

English Name: black cottonwood - red alder / salmonberry

Identifiers

Occurrence ID: 9663

Shape ID: 70480

Element Group: Ecological Community

Status

Provincial Rank: S3

BC List: Blue

Global Rank: GNR

Locators

Survey Site: SKEENA RIVER, AT ZYMAGOTITZ RIVER

Directions:

Biogeoclimatic Unit: CWH ws 1

Ecosection: NAM

Occurrence Information

First Observation Date: 1994 **Last Observation Date:** 2004

Occurrence Data:

This deciduous riparian forest occurrence is based on Terrestrial Ecosystem Mapping (TEM). It is mapped as young to mature black cottonwood dominated forests on a middle bench floodplain that have mostly regenerated after harvesting. This ecological community occupies approximately 20 ha or 57% of the area shown.

General Description:

This occurrence is on the north bank of the Skeena River at New Remo. It is bisected by Highway 16 and the CN rail line. It is associated with with high bench floodplain ecosystems and gravel bars; and is surrounded by the Skeena River to the south and the Zymagotiz River to the north.

Environmental Summary:

The terrain is a fluvial plain.

Occurrence Rank and Occurrence Rank Factors

Rank*: E : Verified extant (viability not assessed)

Note: in the case of Ecological Communities, "viability" should read as "ecological integrity".

Rank Date:

Rank Comments:

Condition of Occurrence:

Size of Occurrence:

19.5 ha

Landscape Context:

Version

Version Date: 2012-03-23

Version Author: de Groot, A.

Mapping Information

Estimated Representation Accuracy: Medium

Estimated Representation Accuracy Comments: The ecological community occupies 56.78% (19.5 ha) of the mapped occurrence.

Confident that full extent is represented by Occurrence: ?

Confidence extent Definition: Uncertain whether full extent of EO is known

Additional Inventory Needed: Y

Inventory Comments: This element occurrence is based on available ecosystem mapping. Many factors influence the reliability of an ecosystem map. Depending on the scale of aerial images used to capture the ecosystems, very small ecosystems and some types of disturbance may not be visible and will not be mapped. If the air photos are not current, new disturbance may have occurred since the time of mapping and the inventory may not accurately represent the current state of the landscape. Other factors, such as the skill and experience of the mapper within the study area, and the field survey intensity level will also influence the reliability of the map.

Documentation

References:

de Groot, A,, S. Haussler and D. Yole. 2005. Landscape and Stand Scale Structure and Dynamics Mapping, and Conservation Ranking, of the Skeena River Floodplain Forests. 1:20,000 spatial data.

de Groot, A. 2005. Review of the Hydrology, Geomorphology and Ecology of the Skeena River Floodplain Downstream of Terrace. Bulkley Valley Centre for Natural Resource Research and Management, Smithers, B.C.

de Groot, A., S. Haussler and D. Yole. 2005. Landscape and Stand Scale Structure and Dynamics, and Conservation Ranking, of the Skeena River Floodplain Forests. Bulkley Valley Centre for Natural Resource Research and Management, Smithers, B.C.

Please visit the website http://www.env.gov.bc.ca/cdc/gis/eo_data_fields_06.htm for definitions of the data fields used in this occurrence report.

Suggested Citation:

B.C. Conservation Data Centre. 2014. Occurrence Report Summary, Shape ID: 70480, black cottonwood - red alder / salmonberry. B.C. Ministry of Environment. Available: http://maps.gov.bc.ca/ess/hm/cdc, (accessed Jul 29, 2019).

BC Conservation Data Centre: Ecosystem Occurrence Report
Shape ID: 70598

Scientific Name: *Picea sitchensis* / *Rubus spectabilis* Wet Submaritime 1

English Name: Sitka spruce / salmonberry Wet Submaritime 1

Identifiers

Occurrence ID: 9674

Shape ID: 70598

Element Group: Ecological Community

Status

Provincial Rank: S2

BC List: Red

Global Rank: G3

Locators

Survey Site: SKEENA RIVER, DOWNSTREAM OF TERRACE TO SHAMES RIVER

Directions:

Biogeoclimatic Unit: CWH ws 1

Ecosection: NAM

Occurrence Information

First Observation Date: 1993 **Last Observation Date:** 2004-09-02

Occurrence Data:

This coniferous riparian forest occurrence is based on Terrestrial Ecosystem Mapping (TEM) and has been confirmed by several ecosystem plots. It is comprised of pole-sapling, young, mature and old Sitka spruce dominated forests. These forests are either primary stands or secondary stands that have regenerated after clear-cut or partial-cut forest harvesting. Other tree species include black cottonwood, western redcedar and red alder. This ecological community occupies approximately 363 ha or 82% of the area shown.

General Description:

This occurrence is located along the Skeena River downstream of Terrace. It is associated with middle and low bench floodplain ecosystems. There is an urban area just upstream, and some nearby areas of forest harvesting and agriculture.

Environmental Summary:

This occurrence is located on a fluvial plain. Soil materials are silty.

Occurrence Rank and Occurrence Rank Factors

Rank*: E : Verified extant (viability not assessed)

Note: in the case of Ecological Communities, "viability" should read as "ecological integrity".

Rank Date:

Rank Comments:

Condition of Occurrence:

Size of Occurrence:

1200.6 ha

Landscape Context:

Version

Version Date: 2012-03-26

Version Author: de Groot, A.

Mapping Information

Estimated Representation Accuracy: Medium

Estimated Representation Accuracy Comments: The ecological community occupies 76.08% (1200.6 ha) of the mapped occurrence.

Confident that full extent is represented by Occurrence: ?

Confidence extent Definition: Uncertain whether full extent of EO is known

Additional Inventory Needed: Y

Inventory Comments: Project name - Landscape and stand scale structure and dynamics, and conservation ranking of Skeena River floodplain forests

This element occurrence is based on available ecosystem mapping. Many factors influence the reliability of an ecosystem map. Depending on the scale of aerial images used to capture the ecosystems, very small ecosystems and some types of disturbance may not be visible and will not be mapped. If the air photos are not current, new disturbance may have occurred since the time of mapping and the inventory may not accurately represent the current state of the landscape. Other factors, such as the skill and experience of the mapper within the study area, and the field survey intensity level will also influence the reliability of the map.

Documentation

References:

de Groot, A,, S. Haussler and D. Yole. 2005. Landscape and Stand Scale Structure and Dynamics Mapping, and Conservation Ranking, of the Skeena River Floodplain Forests. 1:20,000 spatial data.

de Groot, A. 2005. Review of the Hydrology, Geomorphology and Ecology of the Skeena River Floodplain Downstream of Terrace. Bulkley Valley Centre for Natural Resource Research and Management, Smithers, B.C.

de Groot, A., S. Haussler and D. Yole. 2005. Landscape and Stand Scale Structure and Dynamics, and Conservation Ranking, of the Skeena River Floodplain Forests. Bulkley Valley Centre for Natural Resource Research and Management, Smithers, B.C.

de Groot, A., and C.M. Cadrin. 2012b. Element occurrence and element occurrence rank specifications for coniferous floodplain forests of coastal British Columbia. Unpublished document. Version October, 2012. B.C. Minist. Environ., Conservation Data Centre, Victoria, B.C. 5 pp.

Please visit the website http://www.env.gov.bc.ca/cdc/gis/eo_data_fields_06.htm for definitions of the data fields used in this occurrence report.

Suggested Citation:

B.C. Conservation Data Centre. 2014. Occurrence Report Summary, Shape ID: 70598, Sitka spruce / salmonberry Wet Submaritime 1. B.C. Ministry of Environment. Available: http://maps.gov.bc.ca/ess/hm/cdc, (accessed Jul 29, 2019).

BC Conservation Data Centre: Ecosystem Occurrence Report
Shape ID: 70497

Scientific Name: *Populus trichocarpa - Alnus rubra / Rubus spectabilis*

English Name: black cottonwood - red alder / salmonberry

Identifiers

Occurrence ID: 9665

Shape ID: 70497

Element Group: Ecological Community

Status

Provincial Rank: S3

BC List: Blue

Global Rank: GNR

Locators

Survey Site: SKEENA RIVER, AT TERRACE

Directions:

Biogeoclimatic Unit: CWH ws 1

Ecosection: NAM

Occurrence Information

First Observation Date: 2003 **Last Observation Date:** 2004-08-31

Occurrence Data:

This deciduous riparian forest occurrence is based on Terrestrial Ecosystem Mapping (TEM) and has been confirmed by several ecosystem plots. It is comprised of young to mature black cottonwood dominated forests on a middle bench floodplain that is a mixture of primary stands and stands that have regenerated after harvesting. Red alder, Sitka spruce and western hemlock may be present in the understory. Soils are generally silty. This ecological community occupies approximately 20 ha or 57% of the area shown.

General Description:

This occurrence is located in the Skeena River immediately downstream of Terrace. It is associated with high bench and low bench floodplain ecosystems. Erosion and deposition is ongoing, shifting the ecosystem types. Adjacent areas are partly urban, but other areas have little or no disturbance evident.

Environmental Summary:

The occurrence is located on a fluvial plain with silty soils.

Occurrence Rank and Occurrence Rank Factors

Rank*: E : Verified extant (viability not assessed)

Note: in the case of Ecological Communities, "viability" should read as "ecological integrity".

Rank Date:

Rank Comments:

Condition of Occurrence:

Size of Occurrence:

288.94 ha

Landscape Context:

Version

Version Date: 2012-03-26

Version Author: de Groot, A.

Mapping Information

Estimated Representation Accuracy: Medium

Estimated Representation Accuracy Comments: The ecological community occupies 75.32% (288.94 ha) of the mapped occurrence.

Confident that full extent is represented by Occurrence: ?

Confidence extent Definition: Uncertain whether full extent of EO is known

Additional Inventory Needed: Y

Inventory Comments: Project name - Landscape and stand scale structure and dynamics, and conservation ranking of Skeena River floodplain forests

This element occurrence is based on available ecosystem mapping. Many factors influence the reliability of an ecosystem map. Depending on the scale of aerial images used to capture the ecosystems, very small ecosystems and some types of disturbance may not be visible and will not be mapped. If the air photos are not current, new disturbance may have occurred since the time of mapping and the inventory may not accurately represent the current state of the landscape. Other factors, such as the skill and experience of the mapper within the study area, and the field survey intensity level will also influence the reliability of the map.

Documentation

References:

de Groot, A,, S. Haussler and D. Yole. 2005. Landscape and Stand Scale Structure and Dynamics Mapping, and Conservation Ranking, of the Skeena River Floodplain Forests. 1:20,000 spatial data.

de Groot, A. 2005. Review of the Hydrology, Geomorphology and Ecology of the Skeena River Floodplain Downstream of Terrace. Bulkley Valley Centre for Natural Resource Research and Management, Smithers, B.C.

de Groot, A., S. Haussler and D. Yole. 2005. Landscape and Stand Scale Structure and Dynamics, and Conservation Ranking, of the Skeena River Floodplain Forests. Bulkley Valley Centre for Natural Resource Research and Management, Smithers, B.C.

Please visit the website http://www.env.gov.bc.ca/cdc/gis/eo_data_fields_06.htm for definitions of the data fields used in this occurrence report.

Suggested Citation:

B.C. Conservation Data Centre. 2014. Occurrence Report Summary, Shape ID: 70497, black cottonwood - red alder / salmonberry. B.C. Ministry of Environment. Available: http://maps.gov.bc.ca/ess/hm/cdc, (accessed Jul 29, 2019).

BC Conservation Data Centre: Ecosystem Occurrence Report
Shape ID: 70597

Scientific Name: *Populus trichocarpa - Alnus rubra / Rubus spectabilis*

English Name: black cottonwood - red alder / salmonberry

Identifiers

Occurrence ID: 9673

Shape ID: 70597

Element Group: Ecological Community

Status

Provincial Rank: S3

BC List: Blue

Global Rank: GNR

Locators

Survey Site: SKEENA RIVER, DOWNSTREAM OF TERRACE

Directions:

Biogeoclimatic Unit: CWH vm 1;CWH ws 1

Ecosection: KIR;NAM

Occurrence Information

First Observation Date: 1994 **Last Observation Date:** 2004-09-01

Occurrence Data:

This deciduous riparian forest occurrence is based on Terrestrial Ecosystem Mapping (TEM) and has been confirmed by numerous ecosystem plots. It is comprised of young to mature black cottonwood dominated forests on a middle bench floodplain, which are a mixture of primary stands and secondary stands that have regenerated after harvesting. Red alder, Sitka spruce and western redcedar may be present in the understory. Soils maybe sandy loam or silty. This ecological community occupies approximately 3,276 ha or 68% of the area shown.

General Description:

This occurrence is located on the floodplain of the Skeena River downstream of Terrace, from Zymagotitz River to Kwinitsa Creek. It is approximately 60 km long. It is associated with and surrounded by high and low bench floodplain ecosystems. These ecosystems are subject to erosional and depositional processes, and are shifting over time.

Environmental Summary:

The occurrence is mapped on a fluvial plain, with silty to sandy soils.

Occurrence Rank and Occurrence Rank Factors

Rank*: E : Verified extant (viability not assessed)

Note: in the case of Ecological Communities, "viability" should read as "ecological integrity".

Rank Date:

Rank Comments:

Condition of Occurrence:

Size of Occurrence:

3,275.8 ha

Landscape Context:

Version

Version Date: 2012-03-26

Version Author: de Groot, A.

Mapping Information

Estimated Representation Accuracy: Medium

Estimated Representation Accuracy Comments: The ecological community occupies 67.9% (3275.8 ha) of the mapped occurrence.

Confident that full extent is represented by Occurrence: ?

Confidence extent Definition: Uncertain whether full extent of EO is known

Additional Inventory Needed: Y

Inventory Comments: Project name - Landscape and stand scale structure and dynamics, and conservation ranking of Skeena River floodplain forests

This element occurrence is based on available ecosystem mapping. Many factors influence the reliability of an ecosystem map. Depending on the scale of aerial images used to capture the ecosystems, very small ecosystems and some types of disturbance may not be visible and will not be mapped. If the air photos are not current, new disturbance may have occurred since the time of mapping and the inventory may not accurately represent the current state of the landscape. Other factors, such as the skill and experience of the mapper within the study area, and the field survey intensity level will also influence the reliability of the map.

Documentation

References:

de Groot, A,, S. Haussler and D. Yole. 2005. Landscape and Stand Scale Structure and Dynamics Mapping, and Conservation Ranking, of the Skeena River Floodplain Forests. 1:20,000 spatial data.

de Groot, A. 2005. Review of the Hydrology, Geomorphology and Ecology of the Skeena River Floodplain Downstream of Terrace. Bulkley Valley Centre for Natural Resource Research and Management, Smithers, B.C.

de Groot, A., S. Haussler and D. Yole. 2005. Landscape and Stand Scale Structure and Dynamics, and Conservation Ranking, of the Skeena River Floodplain Forests. Bulkley Valley Centre for Natural Resource Research and Management, Smithers, B.C.

Please visit the website http://www.env.gov.bc.ca/cdc/gis/eo_data_fields_06.htm for definitions of the data fields used in this occurrence report.

Suggested Citation:

B.C. Conservation Data Centre. 2014. Occurrence Report Summary, Shape ID: 70597, black cottonwood - red alder / salmonberry. B.C. Ministry of Environment. Available: http://maps.gov.bc.ca/ess/hm/cdc, (accessed Jul 29, 2019).

BC Conservation Data Centre: Ecosystem Occurrence Report
Shape ID: 70489

Scientific Name: *Picea sitchensis / Rubus spectabilis* Wet Submaritime 1

English Name: Sitka spruce / salmonberry Wet Submaritime 1

Identifiers

Occurrence ID: 9664

Shape ID: 70489

Element Group: Ecological Community

Status

Provincial Rank: S2

BC List: Red

Global Rank: G3

Locators

Survey Site: SKEENA RIVER, AT REMO

Directions:

Biogeoclimatic Unit: CWH ws 1

Ecosection: NAM

Occurrence Information

First Observation Date: 1994 **Last Observation Date:** 2004

Occurrence Data:

This coniferous riparian forest occurrence is based on Terrestrial Ecosystem Mapping (TEM). It is comprised of pole-sapling, mature and old forests. This ecological community occupies approximately 18 ha or 42% of the area shown.

General Description:

This occurrrence is located on the north bank of the Skeena River at Remo. It is associated with middle bench floodplain and backchannels of the Skeena River. It is surrounded by residential development, railway and fields.

Environmental Summary:

This occurrence is located on a fluvial plain.

Occurrence Rank and Occurrence Rank Factors

Rank*: E : Verified extant (viability not assessed)

Note: in the case of Ecological Communities, "viability" should read as "ecological integrity".

Rank Date:

Rank Comments:

Condition of Occurrence:

Size of Occurrence:

17.79 ha

Landscape Context:

Version

Version Date: 2012-03-26

Version Author: de Groot, A.

Mapping Information

Estimated Representation Accuracy:	Medium
Estimated Representation Accuracy Comments:	The ecological community occupies 41.53% (17.79 ha) of the mapped occurrence.
Confident that full extent is represented by Occurrence:	?
Confidence extent Definition:	Uncertain whether full extent of EO is known
Additional Inventory Needed:	Y
Inventory Comments:	This element occurrence is based on available ecosystem mapping. Many factors influence the reliability of an ecosystem map. Depending on the scale of aerial images used to capture the ecosystems, very small ecosystems and some types of disturbance may not be visible and will not be mapped. If the air photos are not current, new disturbance may have occurred since the time of mapping and the inventory may not accurately represent the current state of the landscape. Other factors, such as the skill and experience of the mapper within the study area, and the field survey intensity level will also influence the reliability of the map.

Documentation

References:

de Groot, A,, S. Haussler and D. Yole. 2005. Landscape and Stand Scale Structure and Dynamics Mapping, and Conservation Ranking, of the Skeena River Floodplain Forests. 1:20,000 spatial data.

de Groot, A. 2005. Review of the Hydrology, Geomorphology and Ecology of the Skeena River Floodplain Downstream of Terrace. Bulkley Valley Centre for Natural Resource Research and Management, Smithers, B.C.

de Groot, A., S. Haussler and D. Yole. 2005. Landscape and Stand Scale Structure and Dynamics, and Conservation Ranking, of the Skeena River Floodplain Forests. Bulkley Valley Centre for Natural Resource Research and Management, Smithers, B.C.

Please visit the website http://www.env.gov.bc.ca/cdc/gis/eo_data_fields_06.htm for definitions of the data fields used in this occurrence report.

Suggested Citation:

B.C. Conservation Data Centre. 2014. Occurrence Report Summary, Shape ID: 70489, Sitka spruce / salmonberry Wet Submaritime 1. B.C. Ministry of Environment. Available: http://maps.gov.bc.ca/ess/hm/cdc, (accessed Jul 29, 2019).

BC Conservation Data Centre: Species Occurrence Report
Shape ID: 3716

Scientific Name: *Arctopoa eminens*
English Name: eminent bluegrass

Identifiers

Occurrence ID: 4150
Shape ID: 3716
Taxonomic Class: monocots
Element Group: Vascular Plant

Status

Provincial Rank: S1S2
BC List: Red
Global Rank: G5
COSEWIC:
SARA Schedule:

Locators

Survey Site: BISH CREEK, MOUTH OF
Directions:
Biogeoclimatic Zone:
Ecosection: NCF;KIR

Area Description

General Description:

Vegetation Zone: Lowland

Min. Elevation (m): **Max. Elevation (m):**

Habitat: ESTUARINE; TIDAL FLAT

Occurrence Information

First Observation Date: 1977-06-12 **Last Observation Date:** 1977-06-12

Occurrence Data:

Tide water predominant.

Occurrence Rank and Occurrence Rank Factors

Rank: H : Historical

Rank Date: 1977-06-12

Rank Comments:

There is insufficient data to assign a viability rank.

Condition of Occurrence:

Size of Occurrence:

Landscape Context:

Version

Version Date: 1994-12-17

Version Author: DOUGLAS, G.D.

Mapping Information

Estimated Representation Accuracy:

Estimated Representation Accuracy Comments:

Confident that full extent is represented by Occurrence:

Confidence Extent Definition:

Additional Inventory Needed: N

Inventory Comments:

Documentation

References:

Royal British Columbia Museum. 675 Belleville Street, Victoria, BC. V8V 1X4.

Specimen: Mendel, G.

Suggested Citation:

B.C. Conservation Data Centre. 2014. Occurrence Report Summary, Shape ID: 3716, eminent bluegrass. B.C. Ministry of Environment. Available: http://maps.gov.bc.ca/ess/hm/cdc, (accessed Jul 29, 2019).

BC Conservation Data Centre: Species Occurrence Report
Shape ID: 33798

Scientific Name: *Nephroma occultum*

English Name: cryptic paw

Identifiers

Occurrence ID: 7233

Shape ID: 33798

Taxonomic Class:

Element Group: Fungus

Status

Provincial Rank: S3

BC List: Blue

Global Rank: G4

COSEWIC: T (MAY 2019)

SARA Schedule: 1

Locators

Survey Site: KITIMAT VILLAGE

Directions: South of Terrace, at the head of Kitimat Arm.

Biogeoclimatic Zone:

Ecosection: NCF;KIR

Area Description

General Description:

Epiphytic in humid, old growth forests (COSEWIC 2006g).

Vegetation Zone: Lowland

Min. Elevation (m): 0 **Max. Elevation (m):** 10

Habitat: TERRESTRIAL: Epiphytic; Old Forest

Occurrence Information

First Observation Date: 1991-08-28 **Last Observation Date:** 1991-08-28

Occurrence Data:

1991-08-28: Collected (University of British Columbia herbarium)

Occurrence Rank and Occurrence Rank Factors

Rank: B? : Possibly good estimated viability

Rank Date: 1991-08-28

Rank Comments:

Appears to be successfully regenerating, but is not abundant and is potentially threatened by forest harvest.

Condition of Occurrence:

Seems to show good vigour with many young thalli having been noted (Goward 1995).

Size of Occurrence:

Not abundant (Goward 1995).

Landscape Context:

The continued logging of oldgrowth forests in B.C. is leading to a steady decline of this species throughout most of its range (Goward 1995).

Version

Version Date: 2007-03-08

Version Author: Varrin, G.

Mapping Information

Estimated Representation Accuracy: Low

Estimated Representation Accuracy Comments:

Confident that full extent is represented by Occurrence: ?

Confidence Extent Definition: Uncertain whether full extent of EO is known

Additional Inventory Needed: Y

Inventory Comments: To determine full extent and viability of population.

Documentation

References:

COSEWIC. 2006g. COSEWIC assessment and update status report on the cryptic paw Nephroma occultum in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 28 pp.

Goward, T. 1995. Status report on the Cryptic Paw Lichen, Nephroma occultum Wetm. in Canada. Rep. submitted to the Comm. on the Status of Endangered Wildl. in Can. (COSEWIC). Ottawa. 32pp.

University of British Columbia. Dep. Bot., Dep. Zool., Biol. Sci. Bldg., 6270 Univ. Blvd., Vancouver, BC.

Specimen: Goward, T. (91-1240). 1991. UBC.

Suggested Citation:

B.C. Conservation Data Centre. 2014. Occurrence Report Summary, Shape ID: 33798, cryptic paw. B.C. Ministry of Environment. Available: http://maps.gov.bc.ca/ess/hm/cdc, (accessed Jul 29, 2019).

BC Conservation Data Centre: Species Occurrence Report
Shape ID: 74212

Scientific Name: *Arctopoa eminens*
English Name: eminent bluegrass

Identifiers

Occurrence ID: 10155
Shape ID: 74212
Taxonomic Class: monocots
Element Group: Vascular Plant

Status

Provincial Rank: S1S2
BC List: Red
Global Rank: G5
COSEWIC:
SARA Schedule:

Locators

Survey Site: DALA-KILDALA ESTUARY PARK
Directions: Kildala River estuary; near Kitimat.
Biogeoclimatic Zone:
Ecosection: NCF;KIR

Area Description

General Description:

Vegetation Zone: Lowland

Min. Elevation (m): **Max. Elevation (m):**

Habitat: ESTUARINE: Tidal Flat

Occurrence Information

First Observation Date: 1985-07-31 **Last Observation Date:** 1985-07-31

Occurrence Data:

1985-07-31: Collected (Royal British Columbia Museum).

Occurrence Rank and Occurrence Rank Factors

Rank: E : Verified extant (viability not assessed)

Rank Date: 1985-07-31

Rank Comments:

There is not enough information to rank this occurrence.

Condition of Occurrence:

[No data provided.]

Size of Occurrence:

[No data provided.]

Landscape Context:

[No data provided.]

Version

Version Date: 2012-10-30

Version Author: Sinclair, L.

Mapping Information

Estimated Representation Accuracy: Low

Estimated Representation Accuracy Comments:

Confident that full extent is represented by Occurrence: ?

Confidence Extent Definition: Uncertain whether full extent of EO is known

Additional Inventory Needed: Y

Inventory Comments:

Documentation

References:

Royal British Columbia Museum. 675 Belleville Street, Victoria, BC. V8V 1X4.

Specimen: Cambell, A. (A). 1985. V133566A. V. ; Cambell. A. (B). 1985. V133566B. V. ; Cambell, A. (C). 1985. V133566C. V.

Suggested Citation:

B.C. Conservation Data Centre. 2014. Occurrence Report Summary, Shape ID: 74212, eminent bluegrass. B.C. Ministry of Environment. Available: http://maps.gov.bc.ca/ess/hm/cdc, (accessed Jul 29, 2019).

BC Conservation Data Centre: Species Occurrence Report
Shape ID: 96973

Scientific Name: *Pseudocyphellaria rainierensis*

English Name: oldgrowth specklebelly

Identifiers

Occurrence ID: 12220

Shape ID: 96973

Taxonomic Class:

Element Group: Fungus

Status

Provincial Rank: S2S3

BC List: Blue

Global Rank: G4

COSEWIC: SC (APR 2010)

SARA Schedule: 1

Locators

Survey Site: MINETTE BAY CREEK, KITIMAT

Directions: On trail to Robinson Lake above Kitamat Village, at north end of boardwalk on yellow cedar at edge of wetland.

Biogeoclimatic Zone:

Ecosection: KIR

Area Description

General Description:

Vegetation Zone: Lowland

Min. Elevation (m): 367 **Max. Elevation (m):**

Habitat: TERRESTRIAL: Forest Needleleaf

Occurrence Information

First Observation Date: 2013-06-25 **Last Observation Date:** 2013-06-25

Occurrence Data:

2013-06-25: On 5 or 6 small stunted yellow cedar trees growing in association with Lobaria oregana (University of British Columbia Herbarium).

Occurrence Rank and Occurrence Rank Factors

Rank: E : Verified extant (viability not assessed)

Rank Date: 2013-06-25

Rank Comments:

Condition of Occurrence:

[No data provided.]

Size of Occurrence:

2013: On 5 or 6 small stunted yellow cedar trees (University of British Columbia Herbarium).

Landscape Context:

[No data provided.]

Version

Version Date: 2014-10-24

Version Author: Chytyk, P.

Mapping Information

Estimated Representation Accuracy: High

Estimated Representation Accuracy Comments:

Confident that full extent is represented by Occurrence: ?

Confidence Extent Definition: Uncertain whether full extent of EO is known

Additional Inventory Needed: Y

Inventory Comments: To determine full extent and viability of population.

Documentation

References:

University of British Columbia. Dep. Bot., Dep. Zool., Biol. Sci. Bldg., 6270 Univ. Blvd., Vancouver, BC.

Specimen: Williston, P. (8621). 2013. UBC.

Suggested Citation:

B.C. Conservation Data Centre. 2014. Occurrence Report Summary, Shape ID: 96973, oldgrowth specklebelly. B.C. Ministry of Environment. Available: http://maps.gov.bc.ca/ess/hm/cdc, (accessed Jul 29, 2019).

BC Conservation Data Centre: Species Occurrence Report
Shape ID: 97189

Scientific Name: *Lobaria retigera*

English Name: smoker's lung

Identifiers

Occurrence ID: 12250

Shape ID: 97189

Taxonomic Class:

Element Group: Fungus

Status

Provincial Rank: S3

BC List: Blue

Global Rank: GNR

COSEWIC: T (MAY 2018)

SARA Schedule:

Locators

Survey Site: FURLONG BAY, LAKELSE LAKE

Directions: Terrace area: 18 km south of Terrace at Lakelse Provincial Park (Furlong Bay).

Biogeoclimatic Zone:

Ecosection: NAM

Area Description

General Description:

Located in open, old growth coniferous dominant stand.

Vegetation Zone: Lowland

Min. Elevation (m): 61 **Max. Elevation (m):** 90

Habitat: TERRESTRIAL: Forest Needleleaf, Old Forest, Epiphytic

Occurrence Information

First Observation Date: 1970-07-24 **Last Observation Date:** 2015-10-08

Occurrence Data:

2015-10-08: One, old thallus over 1 square m (1 m x 1 m) on an Acer twig in oldgrowth (or selectively logged) Thuja-dominated rain forest. Associates include: Porella navicularis and Lobaria oregana. On a level slope position with a slope of 0%. Filtered crown closure and very moist moisture regime (Bjork 2016a,b,c). 1991-08-27: Branch of Tsuga sp. in open old growth Picea-Tsuga forest (University of British Columbia Herbarium). 1970-07-24: Forest primarily of cedars and firs (University of British Columbia Herbarium).

Occurrence Rank and Occurrence Rank Factors

Rank: D : Poor estimated viability

Rank Date: 2015-10-08

Rank Comments:

Small population within provincial park, with no evidence of successful reproduction.

Condition of Occurrence:

2015: Old thallus, no juveniles present. Overall quality of the occurrence is poor (Bjork 2016a,b,c).

Size of Occurrence:

2015: One thallus over 1 square m (1 m x 1 m) (Bjork 2016a,b,c).

Landscape Context:

2015: Air pollution may be a threat or may become a threat (Bjork 2016a,b,c).

Version

Version Date: 2017-09-12

Version Author: Chytyk, P.

Mapping Information

Estimated Representation Accuracy: High

Estimated Representation Accuracy Comments:

Confident that full extent is represented by Occurrence: N

Confidence Extent Definition: Confident full extent of EO is NOT known

Additional Inventory Needed: Y

Inventory Comments: To determine precise location, full extent and viability of population.

Documentation

References:

Bjork, C. 2016. Report on surveys for Lobaria retigera in the Skeen-Nass-Kispiox Basins, British Columbia. Unpubl. Rep. prepared for the B.C. CDC by Enlichened Consulting Ltd., Clearwater, B.C. 6 pp.

Bjork, C. 2016b. ‘Appendix A’ for: Report on surveys for Lobaria retigera in the Skeen-Nass-Kispiox Basins, British Columbia. Unpubl. Rep. prepared for the B.C. CDC by Enlichened Consulting Ltd., Clearwater, B.C. 32 pp.

Bjork, C. 2016c. EXCEL spreadsheet of Lobaria retigera and other rare lichens for the Skeen-Nass-Kispiox Basins, British Columbia.

Canadian Museum of Nature. P.O. Box 3443, Stn. "D", Ottawa. K1P 6P4.

Michigan State University Herbarium. Plant Biology Laboratories, Michigan State University, 612 Wilson Road, Room 166, East Lansing, Michigan 48824.

University of British Columbia. Dep. Bot., Dep. Zool., Biol. Sci. Bldg., 6270 Univ. Blvd., Vancouver, BC.

Specimen: Goward, T. and H. Knight. (91-1182). 1991. #L25315. UBC.; Ohlsson, K.E. (2579). 1991. #L32053. CAN.; Ohlsson, K.E. (2579). 1991. #L5090. UBC.; Ohlsson, K.E. (2579). 1991. #59927.

Suggested Citation:

B.C. Conservation Data Centre. 2014. Occurrence Report Summary, Shape ID: 97189, smoker's lung. B.C. Ministry of Environment. Available: http://maps.gov.bc.ca/ess/hm/cdc, (accessed Jul 29, 2019).

BC Conservation Data Centre: Species Occurrence Report
Shape ID: 43828

Scientific Name: *Pseudocyphellaria rainierensis*

English Name: oldgrowth specklebelly

Identifiers

Occurrence ID: 7851

Shape ID: 43828

Taxonomic Class:

Element Group: Fungus

Status

Provincial Rank: S2S3

BC List: Blue

Global Rank: G4

COSEWIC: SC (APR 2010)

SARA Schedule: 1

Locators

Survey Site: KITIMAT, EAST OF

Directions: On the trail to Robinson Lake, leading from the road between Kitimat and Kitimat Mission. Robinson Lake trail, near Volunteer Creek.

Biogeoclimatic Zone:

Ecosection: KIR

Area Description

General Description:

Vegetation Zone: Lowland

Min. Elevation (m): 183 **Max. Elevation (m):**

Habitat: PALUSTRINE: Herbaceous Wetland

5.7 Species Presence Recorded During Vegetation Sampling and Inspection

This table shows the presence of selected species at vegetation sampling sites during inspections in 2014, 2015, 2016, and 2018. Absence of a species means that it was not observed, not that it didn't exist in a defined area during the inspection. Sampling and inspection methodology did not use a pre-determined defined area that was revisited, but rather an inspection of the general area near the sampled western hemlock.

Table 5.22: Presence of species reported to be sensitive to SO_2 in scientific or anecdotal literature at vegetation inspection and collection sites in 2018. Presence is indicated by an x. Absence does not mean that the species is not present in the area of the site, only that it was not observed during the survey. NV=not visited.

Year	Species\Site	1	20A	37	39	42	43A	43B	44	44A	46	47B	52	54	55	56	57	68	69	70	78A	79	80	81B	81C	82	84A	85	86	87	88	89A	90	91A	92	95	97	98A	490	492
	Shrubs and small stature plants																																							
2014	*Amelanchier alnifolia*			X						N/A			X		X						N/A			N/A	N/A											X				
2015				X											X																							X		
2016			X							N/A					X																							X		
2018				X								X						X	X																					
2014	*Aralia nudicaulis*									N/A											N/A			N/A	N/A															
2015																																								
2016										N/A																														
2018																																								
2014	*Cornus stolonifera*				X					N/A		X	X		X	X	X	X		X	N/A			N/A	N/A				X							X	X	X		
2015			X		X								X	X	X	X		X	X	X							X		X				X	X		X		X		
2016			X		X	X			X	N/A		X		X	X			X				X					X		X							X		X		
2018		X	X		X	X		X	X			X	X	X				X		X							X		X					X		X	X	X		X
2014	*Disporum hookeri*									N/A											N/A			N/A	N/A				X											
2015																																								
2016										N/A																														
2018																																								
2014	*Dryopteris epansa*									N/A											N/A			N/A	N/A															
2015																																								
2016										N/A																														
2018											X																					X								
2014	*Epilobium angustifolium*									N/A											N/A			N/A	N/A															
2015			X	X	X	X		X	X			X		X				X	X	X							X	X	X	X	X	X	X		X		X	X		

Year	Species\Site	1	20A	37	39	42	43A	43B	44	44A	46	47B	52	54	55	56	57	68	69	70	78A	79	80	81B	81C	82	84A	85	86	87	88	89A	90	91A	92	95	97	98A	490	492
2016		X	X	X	X	X			X	N/A	X	X		X		X	X	X	X								X		X		X	X	X		X	X		X	X	X
2018		X	X	X	X	X			X			X	X	X				X	X	X							X		X			X	X	X	X	X	X	X	X	X
2014	*Lycopodium clavatum*									N/A											N/A			N/A	N/A															
2015							X																			X														
2016										N/A																X						X								
2018																																								
2014	*Menziesia ferruginea*						X			N/A											N/A			N/A	N/A		X													
2015																									X	X	X			X		X		X	X					
2016										N/A									X						X	X	X	X		X		X							X	
2018											X						X						X		X	X	X	X		X		X	X		X		X		X	
2014	*Pteridium aquilinum*						X		X	N/A	X									X	N/A	X	X	N/A	N/A		X	X					X	X	X					
2015							X	X	X		X			X						X	X	X	X	X	X		X	X			X	X	X	X	X		X			
2016						X	X			N/A	X			X							X	X	X				X	X		X		X	X	X	X		X	X		X
2018																			X		X	X	X				X					X		X	X		X			
2014	*Rosa acicularis*									N/A											N/A			N/A	N/A															
2015																X																								
2016										N/A																			X											
2018																																								
2014	*Rubus parviflorus*	X	X	X	X	X	X	X	X	N/A		X	X	X	X	X		X	X	X	N/A	X	X	N/A	N/A	X	X		X				X	X	X	X	X	X		
2015		X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X		X	X				X	X	X	X	X		X	X	X	X	X	X		
2016		X	X	X	X	X	X		X	N/A	X	X	X	X		X	X	X	X	X		X	X				X	X	X	X	X		X	X		X	X	X	X	X
2018		X	X		X	X	X	X	X		X	X	X	X		X	X	X	X	X				X			X		X	X	X		X	X	X	X	X	X		X
2014	*Rubus spectabilis*	X	X		X	X	X	X	X	N/A	X		X		X	X			X	X	N/A	X	X	N/A	N/A	X			X				X	X	X	X	X	X		
2015		X	X		X	X	X	X	X		X			X	X	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X		X	X		
2016		X	X		X	X	X	X	X	N/A	X		X	X	X	X	X	X	X	X		X	X		X	X	X		X	X	X	X	X	X	X	X	X	X	X	X
2018		X	X		X	X	X	X			X		X			X		X	X	X		X	X	X	X	X				X	X	X	X	X	X	X	X	X		X
2014	*Senecio triangularis*									N/A											N/A			N/A	N/A															
2015																																								
2016										N/A																														
2018																																								

Year	Species\Site	1	20A	37	39	42	43A	43B	44	44A	46	47B	52	54	55	56	57	68	69	70	78A	79	80	81B	81C	82	84A	85	86	87	88	89A	90	91A	92	95	97	98A	490	492
2014	*Symphoricarpos albus*									N/A											N/A			N/A	N/A															
2015																																								
2016										N/A																														
2018																																								
2014	*Vaccinium alaskaense*									N/A											N/A			N/A	N/A		X	X												
2015																											X					X								
2016							X			N/A					X	X	X				X	X		X	X	X	X	X				X					X			
2018																	X							X	X	X		X				X								
2014	*Vaccinium membranaceum*									N/A											N/A	X		N/A	N/A	X														
2015																						X																		
2016							X			N/A					X	X	X				X	X		X	X	X	X	X				X					X			
2018																	X							X	X			X												
2014	*Vaccinium ovalifolium*				X		X	X		N/A	X						X				N/A			N/A	N/A										X			X		
2015					X		X	X			X					X	X				X			X	X	X		X												
2016										N/A																														
2018							X								X	X	X				X	X		X	X	X	X	X				X					X			
2014	*Vicia americana*									N/A											N/A			N/A	N/A															
2015																			X										X											
2016										N/A																														
2018																													X											

Trees

Year	Species\Site	1	20A	37	39	42	43A	43B	44	44A	46	47B	52	54	55	56	57	68	69	70	78A	79	80	81B	81C	82	84A	85	86	87	88	89A	90	91A	92	95	97	98A	490	492
2014	*Abies amabilis*									N/A							X				N/A		X	N/A	N/A															
2015																								X	X															
2016										N/A																						X							X	
2018																																X								X
2014	*Abies lasiocarpa*									N/A											N/A			N/A	N/A															
2015																																								
2016										N/A																														
2018																																								

Year	Species\Site	1	20A	37	39	42	43A	43B	44	44A	46	47B	52	54	55	56	57	68	69	70	78A	79	80	81B	81C	82	84A	85	86	87	88	89A	90	91A	92	95	97	98A	490	492
2014	*Acer glabrum*									N/A											N/A		X	N/A	N/A		X													
2015														X													X													
2016										N/A			X	X																									X	
2018													X	X																									X	
2014	*Alnus crispa*	X						X		N/A	X		X		X		X				N/A			N/A	N/A		X	X	X				X	X			X	X		
2015		X	X	X	X	X	X	X	X		X	X	X	X		X	X	X	X	X		X		X	X	X	X	X	X	X	X	X		X		X	X	X		
2016				X		X	X		X	N/A	X		X					X	X	X		X		X	X	X	X	X		X	X	X	X		X	X	X		X	X
2018		X	X		X	X														X		X		X	X			X		X	X	X	X		X			X	X	X
2014	*Alnus tenuifolia*	X	X	X	X	X	X	X	X	N/A	X	X	X	X		X	X		X	X	N/A	X		N/A	N/A	X	X	X	X				X	X	X	X	X			
2015		X	X			X	X	X			X	X	X		X			X	X	X	X	X	X	X		X	X	X	X	X		X	X	X	X	X	X	X		
2016										N/A																														
2018																																								
2014	*Betula papyrifera*									N/A							X		X		N/A			N/A	N/A															
2015																	X		X																					
2016										N/A							X		X		X						X	X									X			
2018																X			X																					
2014	*Crataegus douglasii*									N/A											N/A			N/A	N/A															
2015																					X																			
2016										N/A																														
2018																																								
2014	*Pinus contorta*								X	N/A							X	X			N/A			N/A	N/A	X		X	X											
2015									X								X	X	X		X					X		X				X						X		
2016									X	N/A							X	X	X		X					X		X				X								
2018									X						X		X		X		X					X		X												X
2014	*Populus tremuloides*									N/A						X	X				N/A			N/A	N/A			X	X											
2015																X	X	X	X									X	X											
2016				X						N/A						X												X	X											X
2018																X		X	X									X	X											X
2014	*Populus trichocarpa*	X		X	X				X	N/A		X		X				X	X		N/A			N/A	N/A		X						X			X		X		
2015		X		X				X	X			X	X						X	X				X		X			X		X		X							

Year	Species\Site	1	20A	37	39	42	43A	43B	44	44A	46	47B	52	54	55	56	57	68	69	70	78A	79	80	81B	81C	82	84A	85	86	87	88	89A	90	91A	92	95	97	98A	490	492
2016		X	X	X	X			X	X	N/A			X						X	X				X			X		X		X		X			X			X	X
2018		X	X	X	X			X	X			X	X	X						X		X		X					X		X		X			X			X	
2014	*Prunus pennsylvanica*									N/A											N/A			N/A	N/A															
2015																																								
2016										N/A																														
2018									X																															
2014	*Prunus virginiana*				X					N/A											N/A			N/A	N/A															
2015															X																									
2016																																								
2018									X	N/A																														
2014	*Sorbus scopulina*	X	X	X		X	X	X	X	N/A											N/A			N/A	N/A			X							X		X	X		
2015		X	X	X		X	X	X	X		X				X	X	X					X			X									X	X			X		
2016										N/A															X															
2018																																								
																					N/A			N/A	N/A															
2014	*Sorbus sitchensis*							X		N/A						X	X																							
2015							X	X			X																													
2016		X	X	X		X		X	X	N/A	X	X			X	X	X					X					X									X		X		
2018		X	X	X	X	X	X	X	X		X	X			X	X	X		X			X			X		X					X			X	X		X		
2014	*Tsuga heterophylla*	X	X	X	X	X	X	X	X	N/A	X	X	X	X	X	X	X	X	X	X	N/A	X		N/A	N/A	X	X	X	X				X	X	X	X	X	X		
2015		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
2016		X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2018		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

5.8 Supplementary Versions of Vegetation Maps

This section includes supplementary versions of maps used in Section 5 of the main report. These additional figures provide larger versions of the maps used in multi-panel figures in the main report for improved legibility, and include site labels for vegetation monitoring sites on all the maps.

For the full-page versions of individual map panels from the multi-panel figures, the original multi-panel figures are also included for figures that have more than two map panels in the main report, to help orient readers.

The maps are presented in the same order as they appear in Section 5 of the main report. Each map caption includes a reference to the relevant figure number in the main report (e.g., **main report Figure 5-2**).

Note: **Main report Figure 5-16** is the same map as the left panel of **main report Figure 5-7.** Therefore a large version of only main report Figure 5-7 is provided in this appendix.

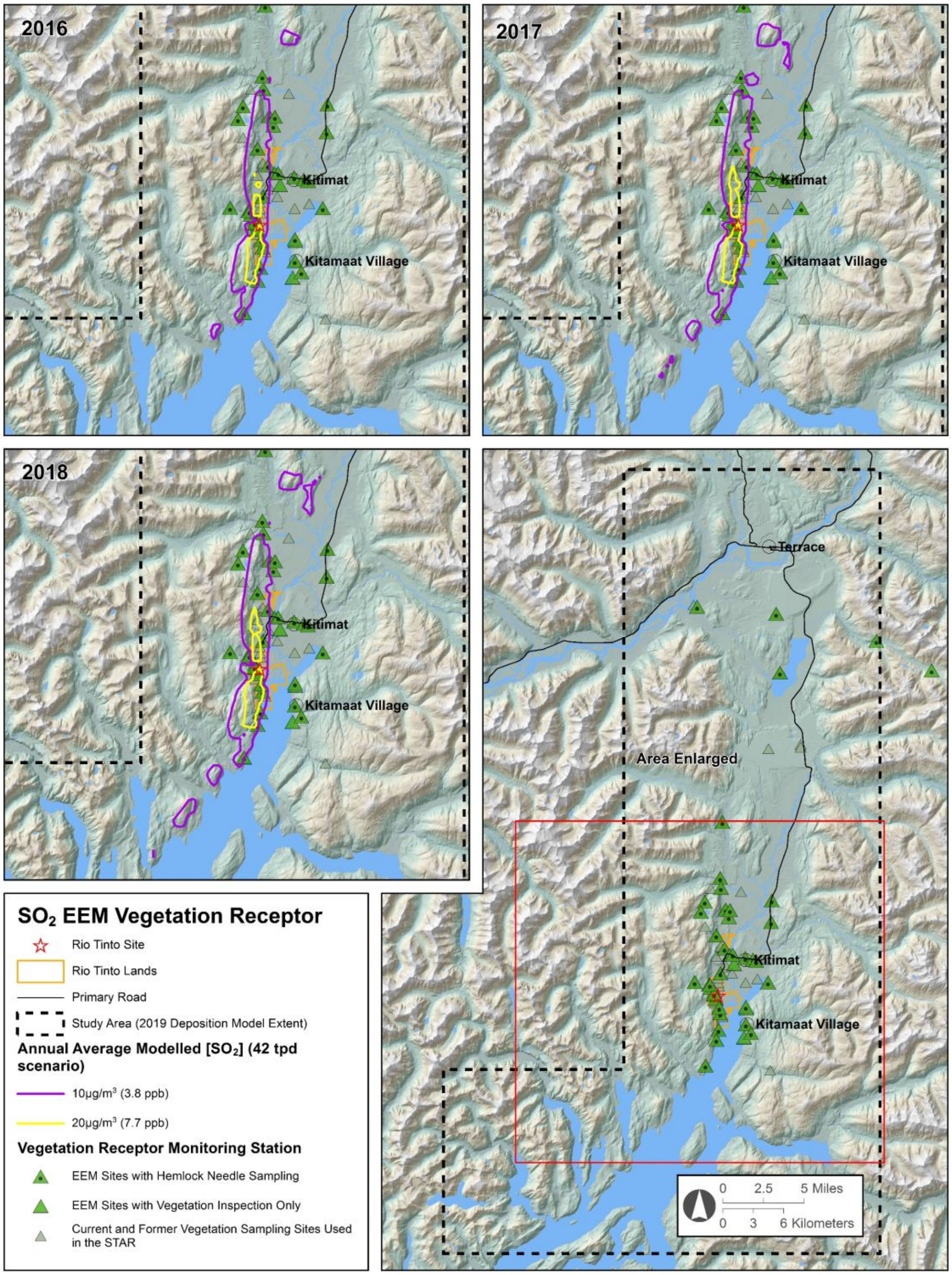


Figure 5.2: Main report Figure 5-2. Location of sampling and inspection sites with respect to the CALPUFF-modelled annual average air concentration isopleths of 10 and 20 μg/m³ (3.8 and 7.6 ppb), the threshold values used in Europe to protect sensitive lichens and natural ecosystems. The 10 μg/m³ isopleth corresponds approximately to the 2025 CAAQS. The modelling scenario is 42 tpd (the maximum permitted level). The isopleths include background SO_2 concentrations of 0.47 ppb.

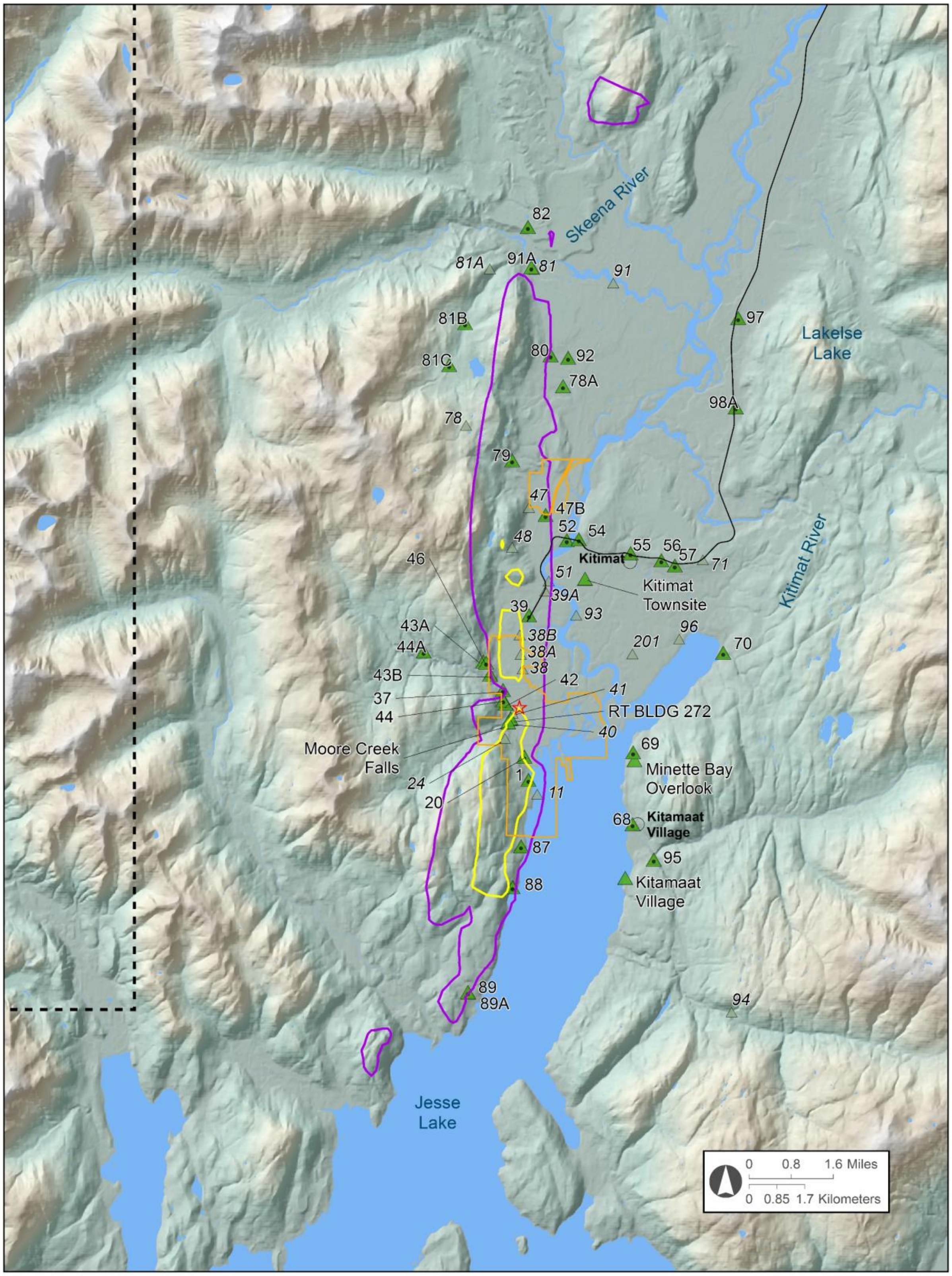


Figure 5.3: Upper left panel of main report Figure 5-2 – 2016 results.

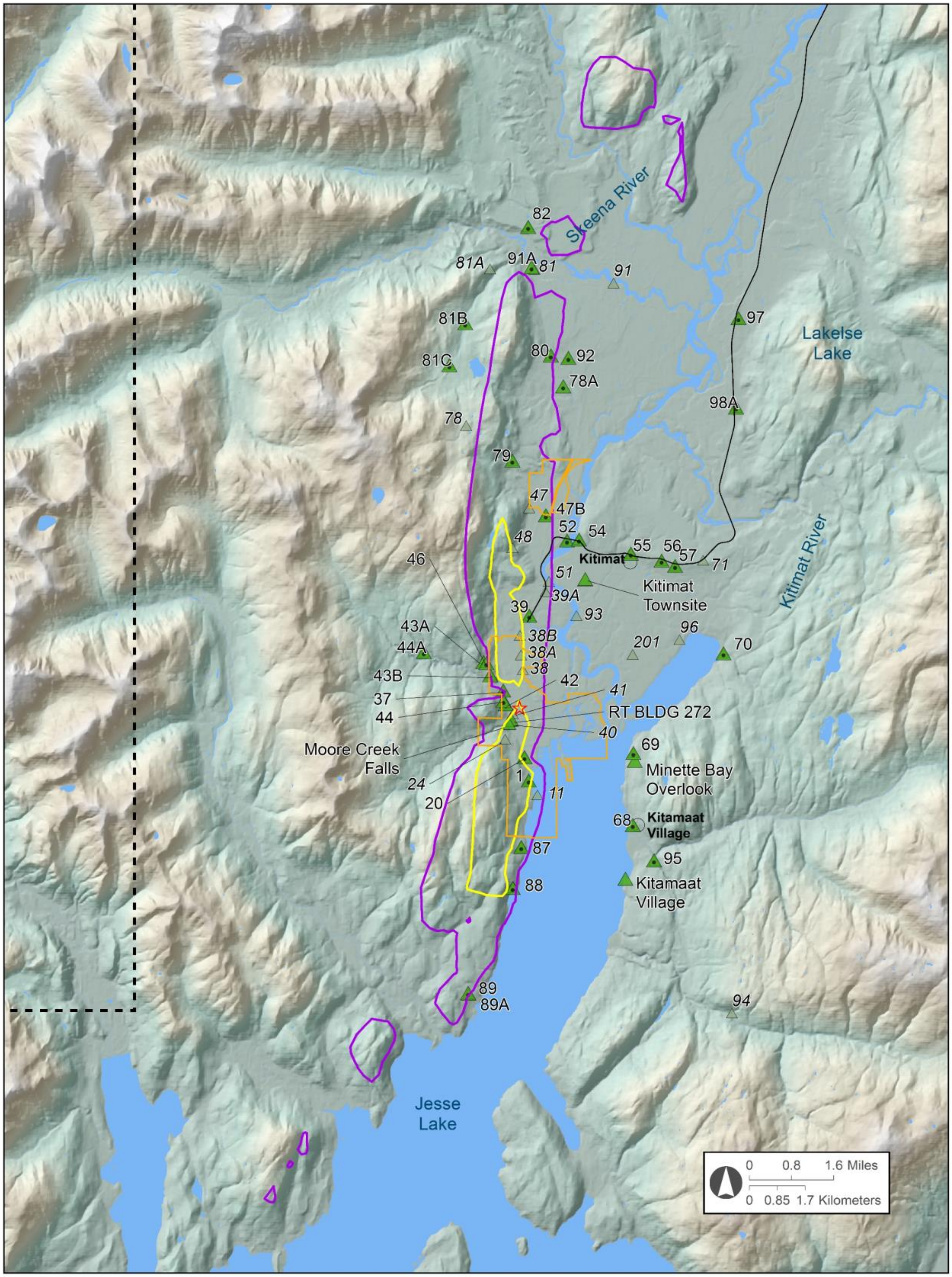


Figure 5.4: Upper right panel of main report Figure 5-2 – 2017 results.

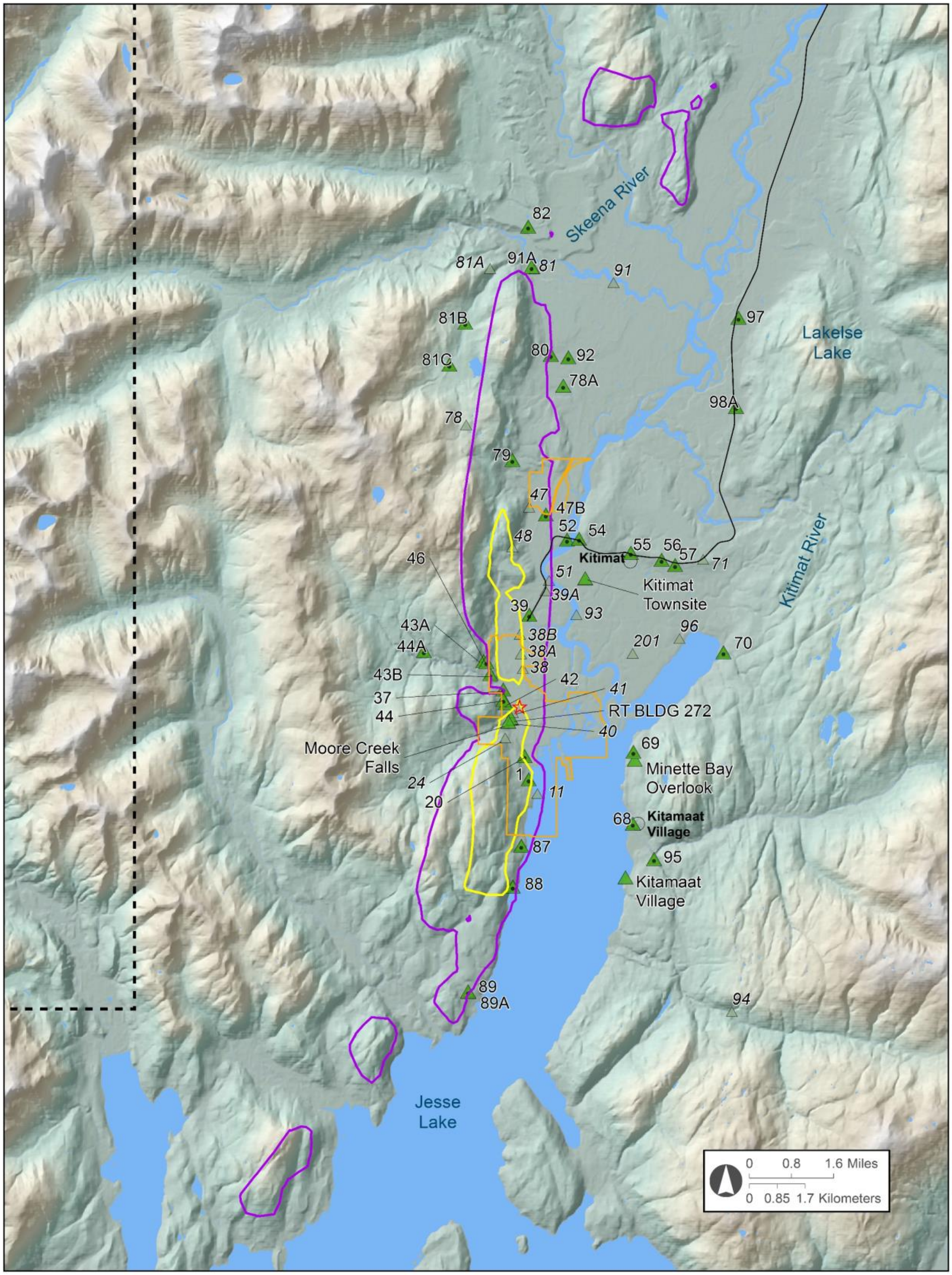


Figure 5.5: Middle left panel of main report Figure 5-2 – 2018 results.

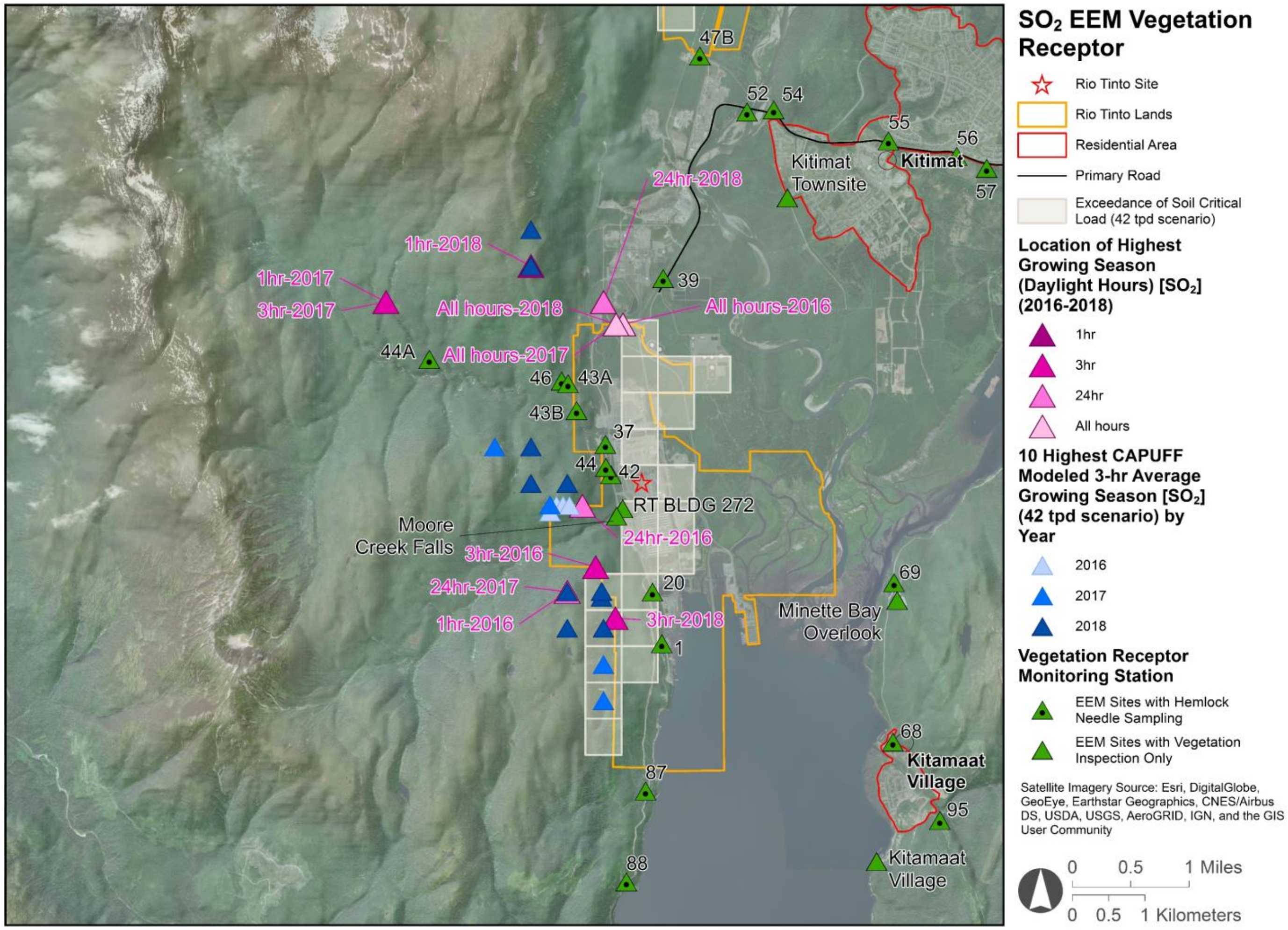


Figure 5.6: Main report Figure 5-4. Location of the 10 highest CAPUFF modelled 3-hour average Growing Season SO_2 concentrations under the 42 tpd scenario (maximum permitted level case) for 2016-2018 (blue symbols) and the highest locations for growing season daylight hours 1-hour, 3-hour, 24-hour, and annual averages for each year (pink symbols). Background SO_2 concentrations of 5.53, 2.80, 1.74, and 0.47 ppb for 1-hour, 3-hour, 24-hour, and annual (and growing season) average, respectively, are not included but do not affect the locations.

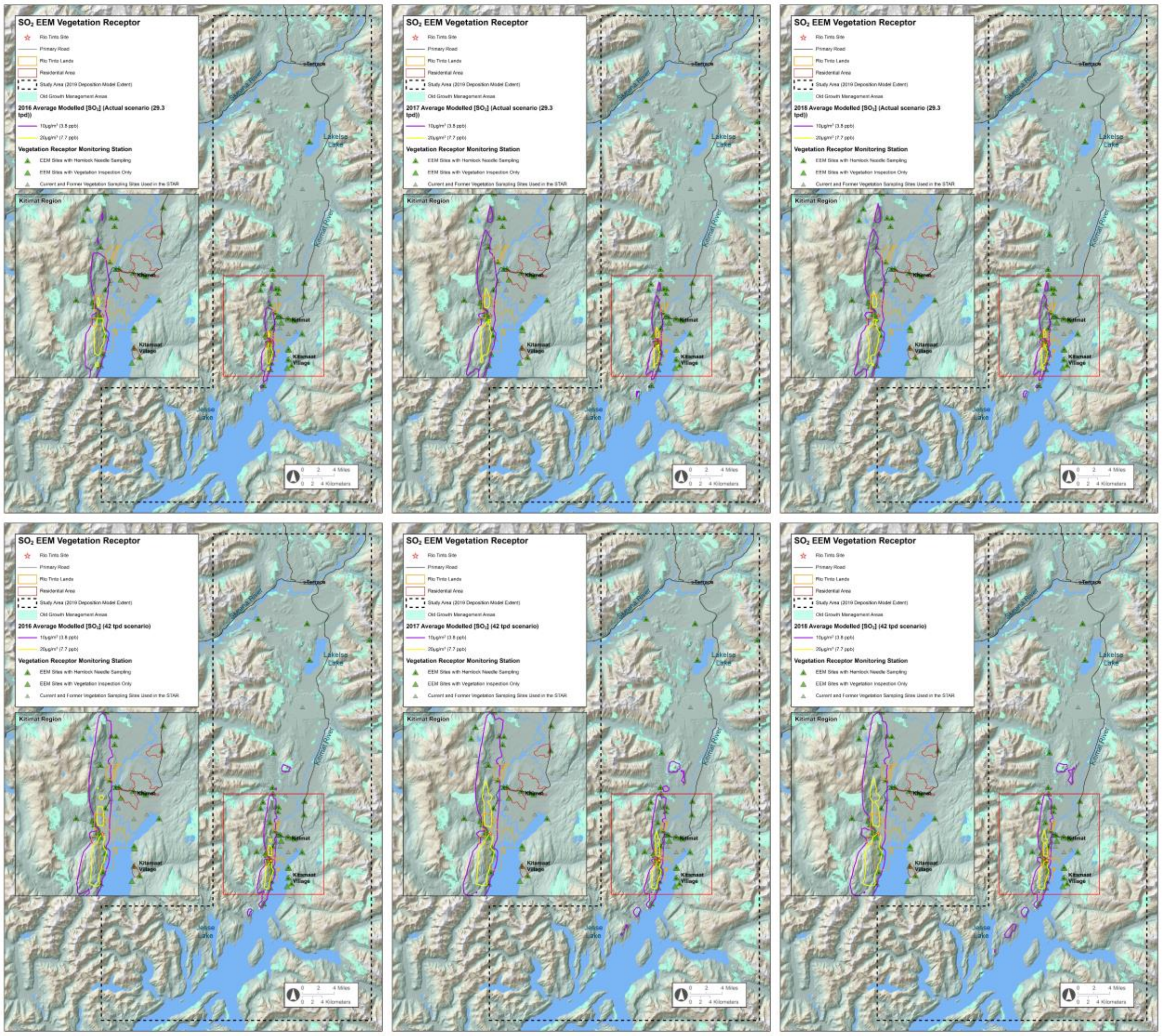


Figure 5.7: Main report Figure 5-5. CALPUFF-modelled annual average SO2 concentration isopleths (yellow=20 µg/m³ (7.6 ppb) and purple=10µg/m3 (3.8 ppb) for 2016-2018 under the actual emission scenario (top) and the 42 tpd scenario (bottom). Teal-coloured areas are Old Growth Management Areas. Background SO2 concentrations are included to allow comparison to European thresholds of 10 and 20 µg/m³.

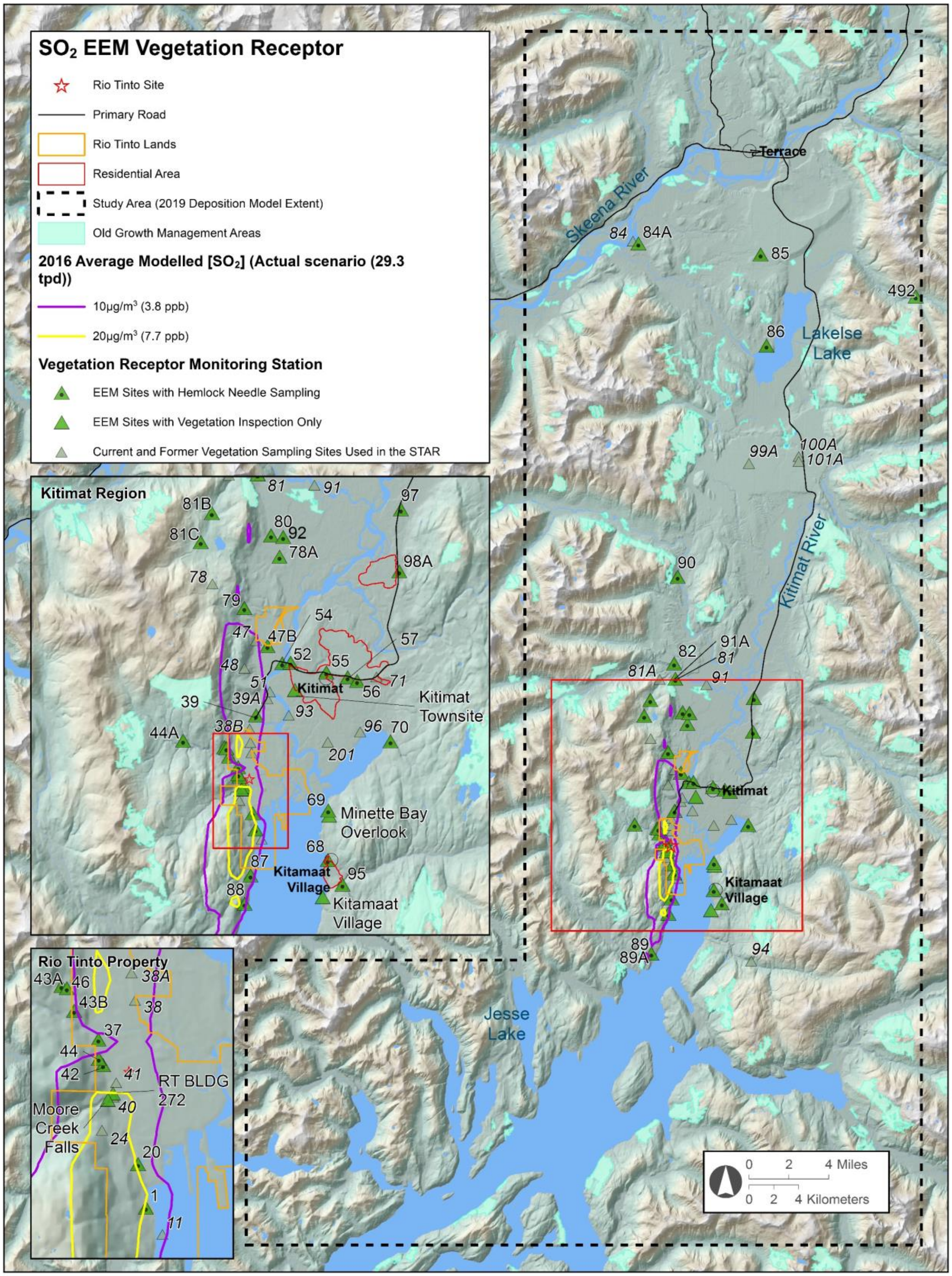


Figure 5.8: Upper left panel of Main report Figure 5-5 – Actual scenario; 2016 results.

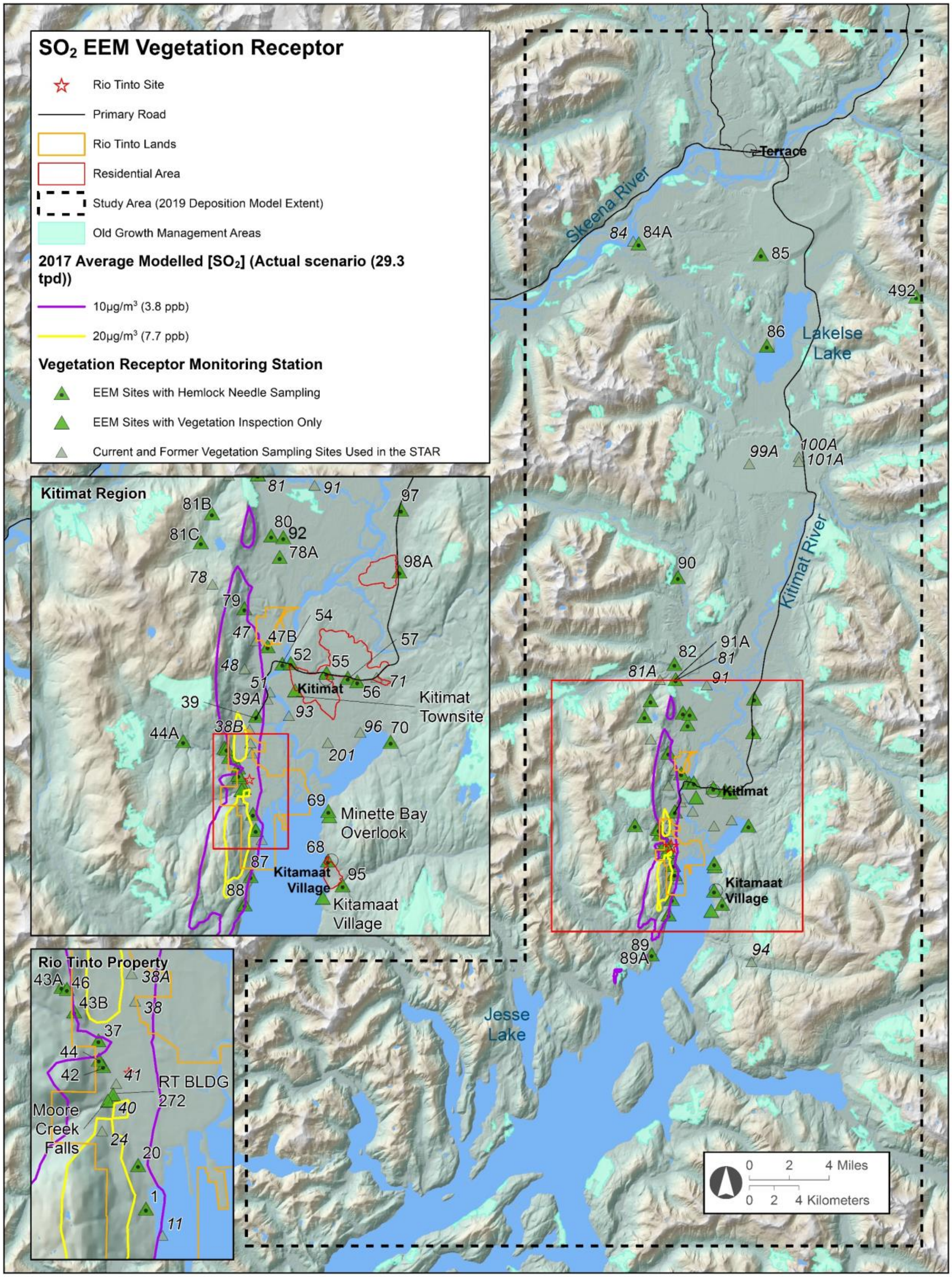


Figure 5.9: Upper middle panel of main report Figure 5-5 – Actual scenario; 2017 results.

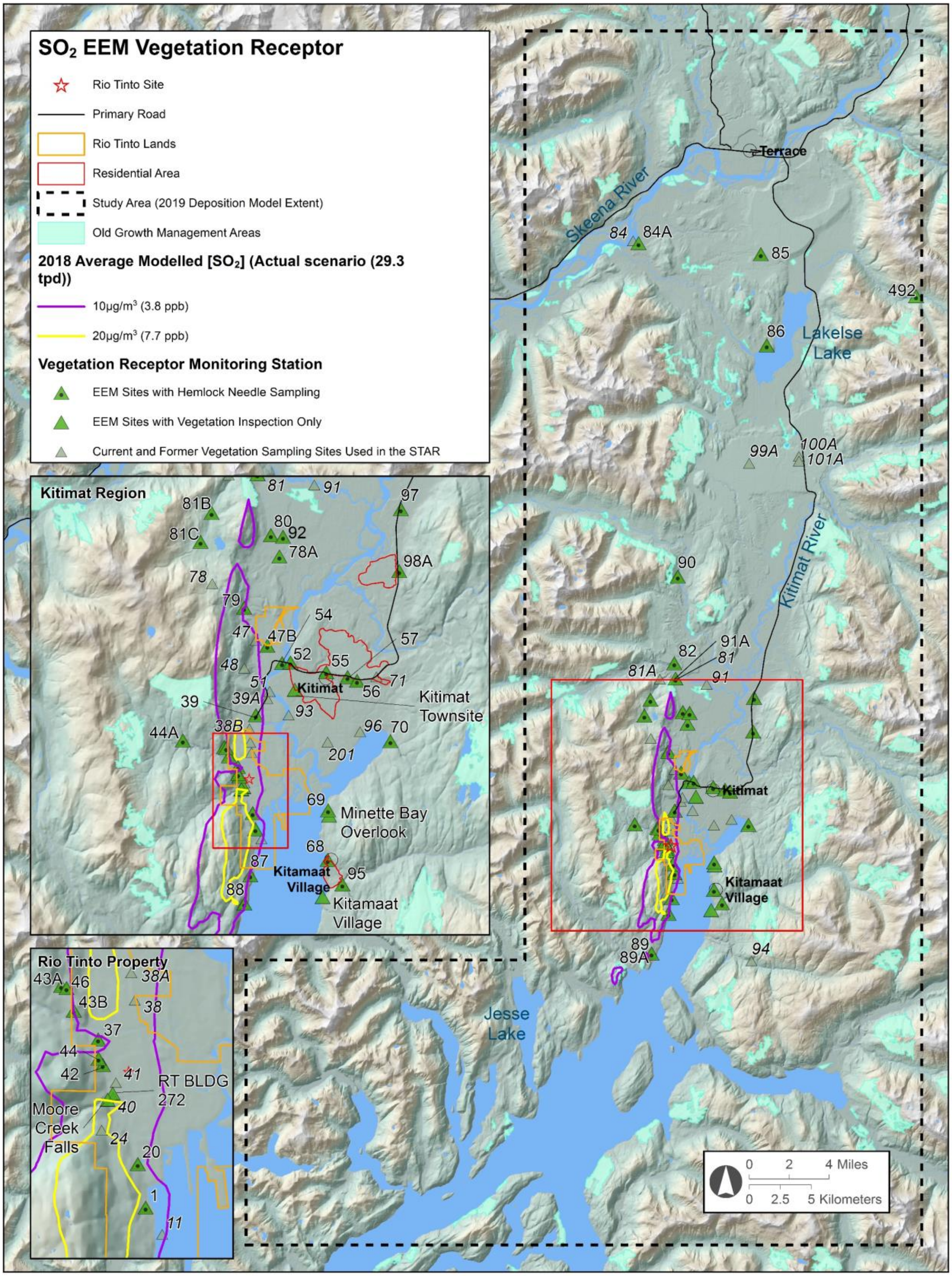


Figure 5.10: Upper right panel of main report Figure 5-5 – Actual scenario; 2018 results.

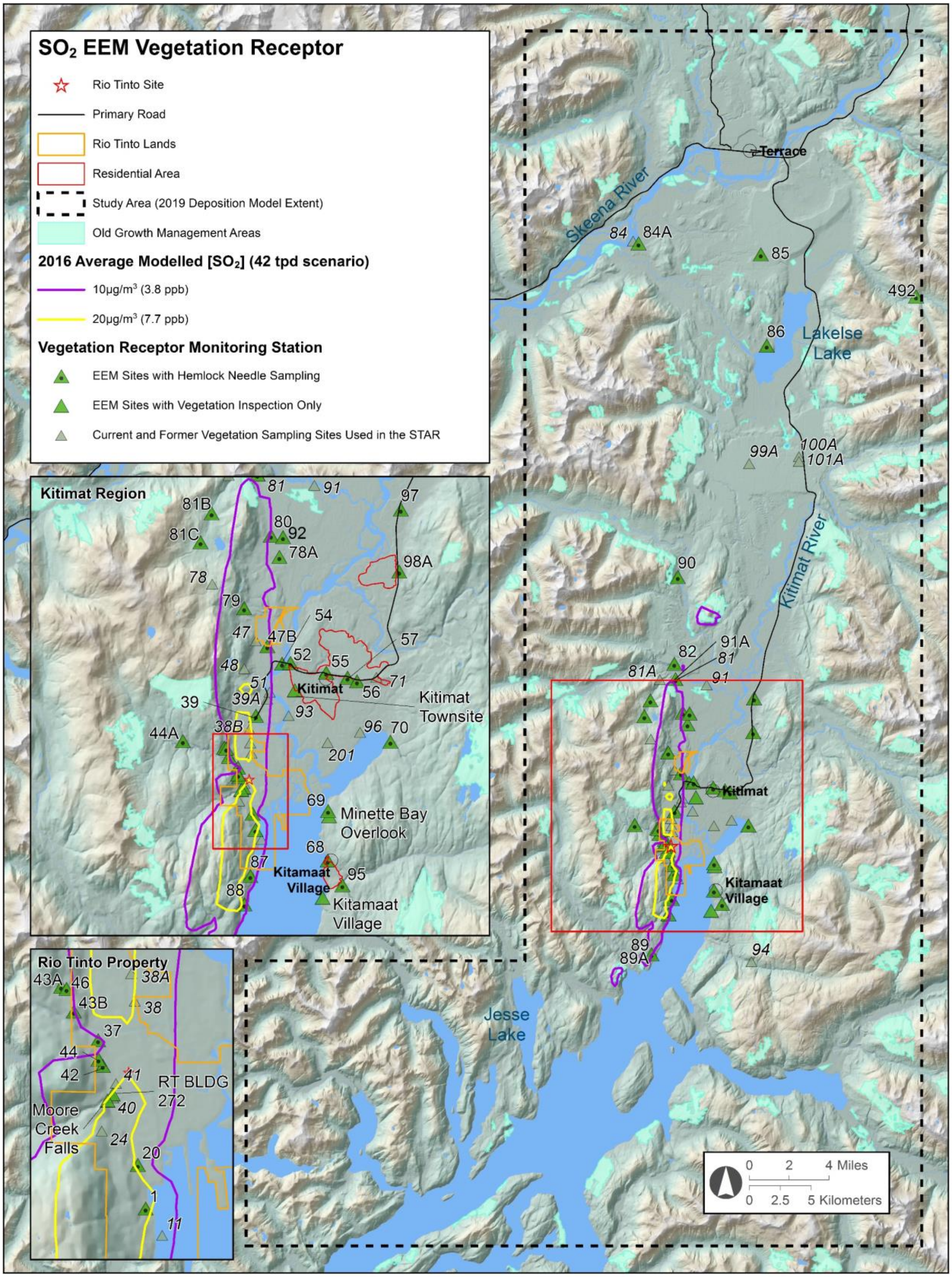


Figure 5.11: Lower left panel of main report Figure 5-5 – 42 tpd scenario; 2016 results.

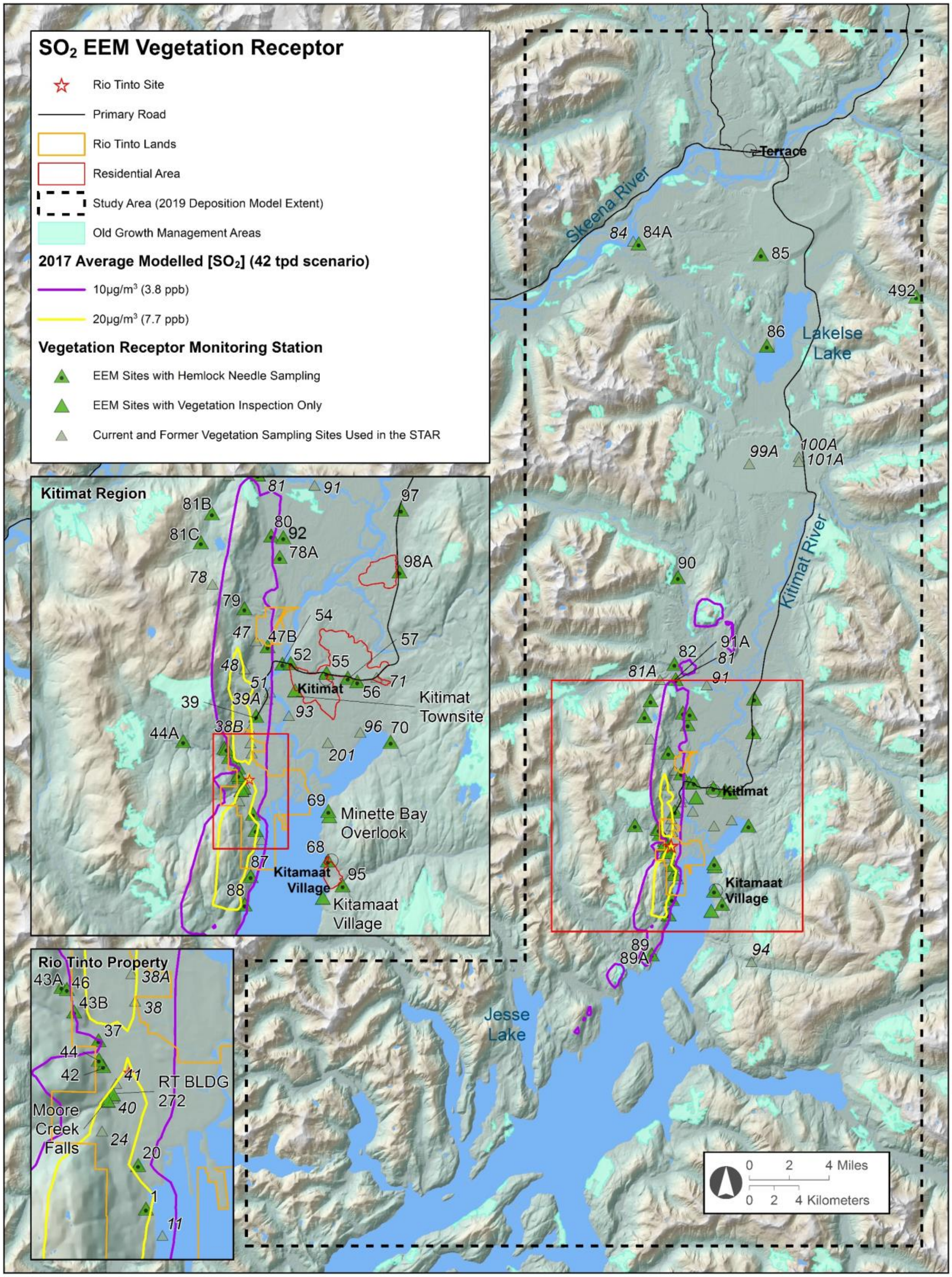


Figure 5.12: Lower middle panel of main report Figure 5-5 – 42 tpd scenario; 2017 results.

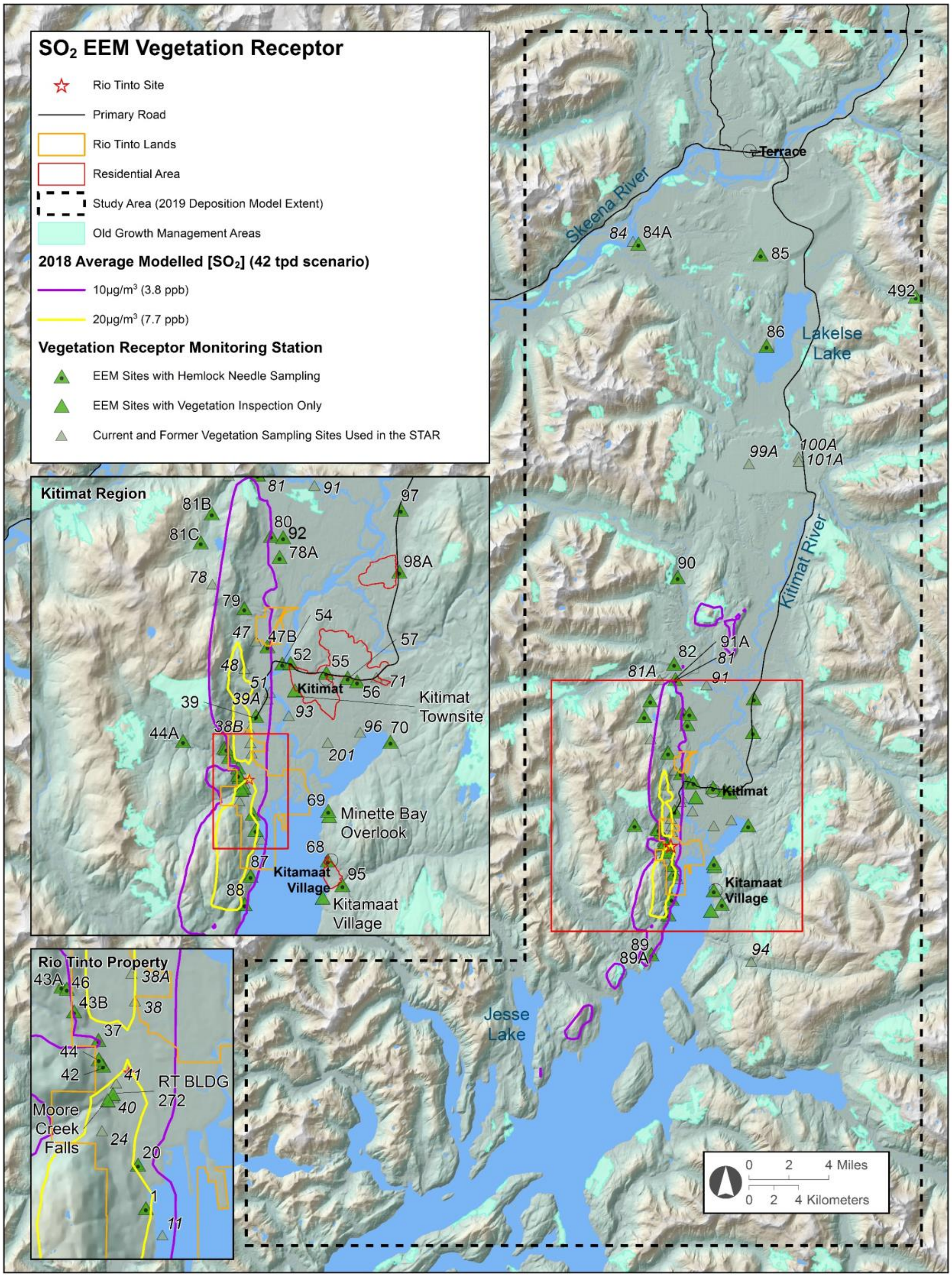


Figure 5.13: Lower right panel of main report Figure 5-5 – 42 tpd scenario; 2018 results.

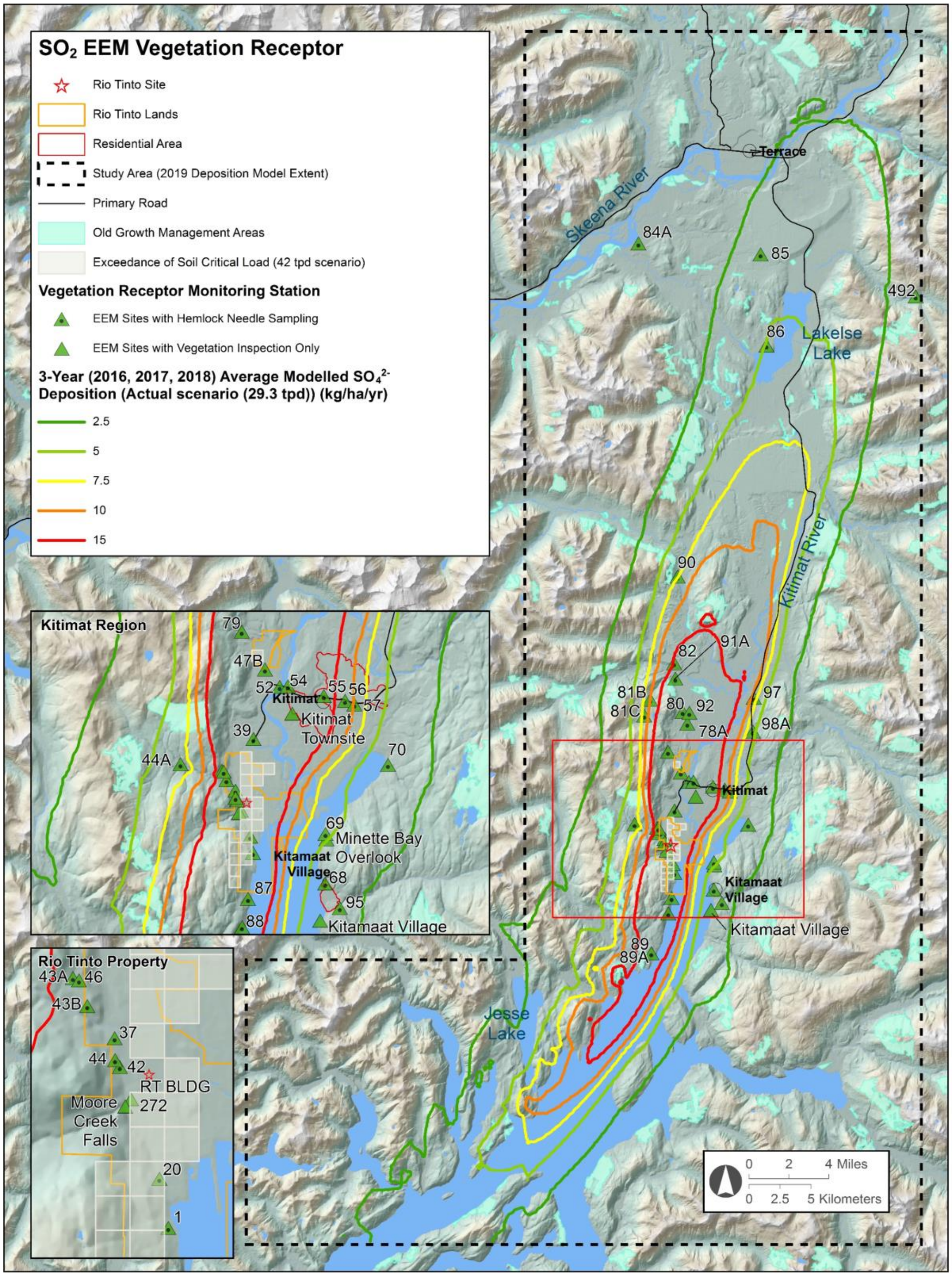


Figure 5.14: Left panel of main report Figure 5-7. Three-year average deposition of SO_4^{2-} as modelled by CALPUFF under the actual deposition scenario. Background deposition of 3.6 kg SO_4^{2-}/ha/yr is not included in the isopleths.

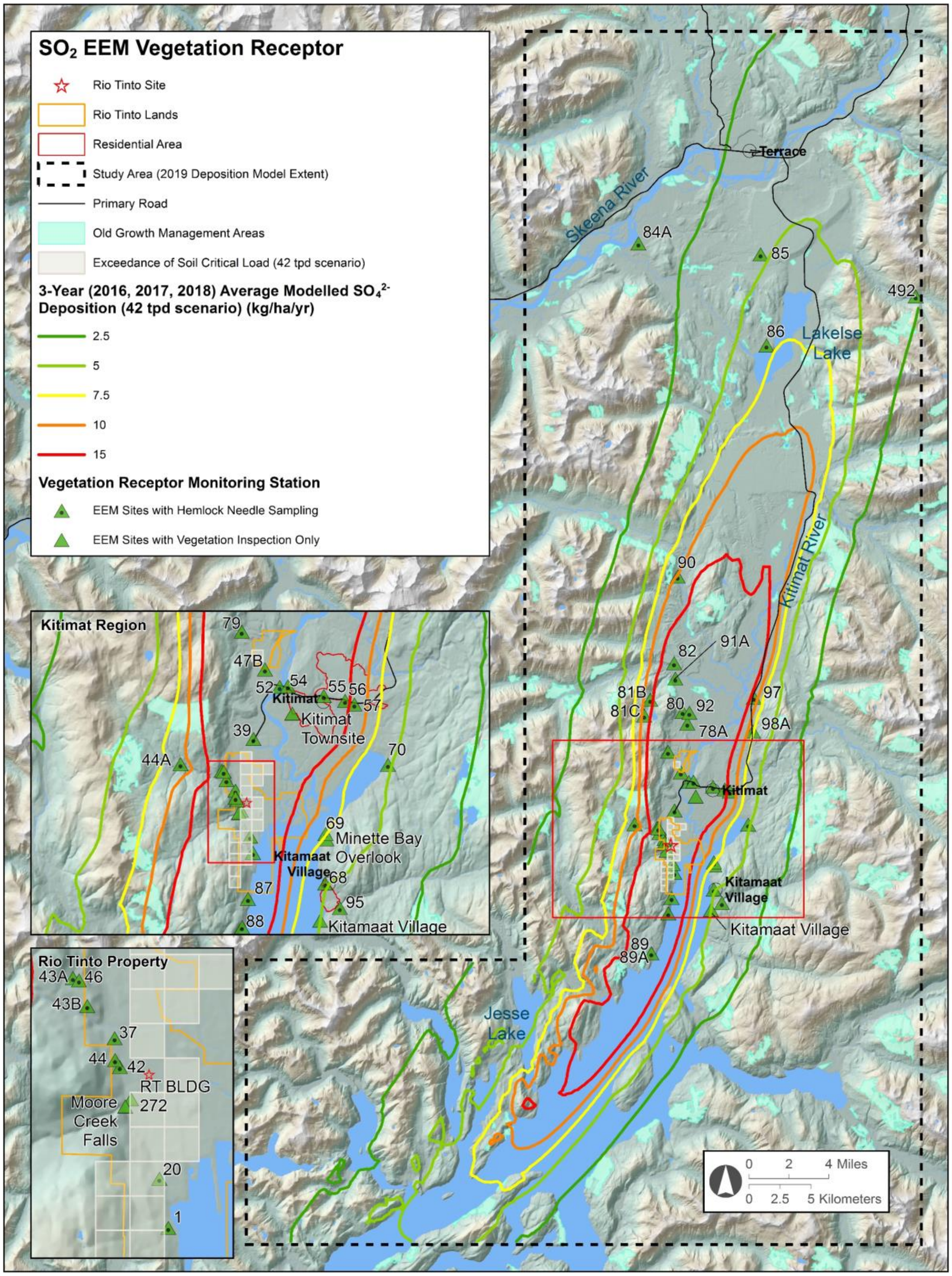


Figure 5.15: Right panel of main report Figure 5-7. Three-year average deposition of SO_4^{2-} as modelled by CALPUFF under the 42 tpd scenario. Background deposition of 3.6 kg SO_4^{2-}/ha/yr is not included in the isopleths.

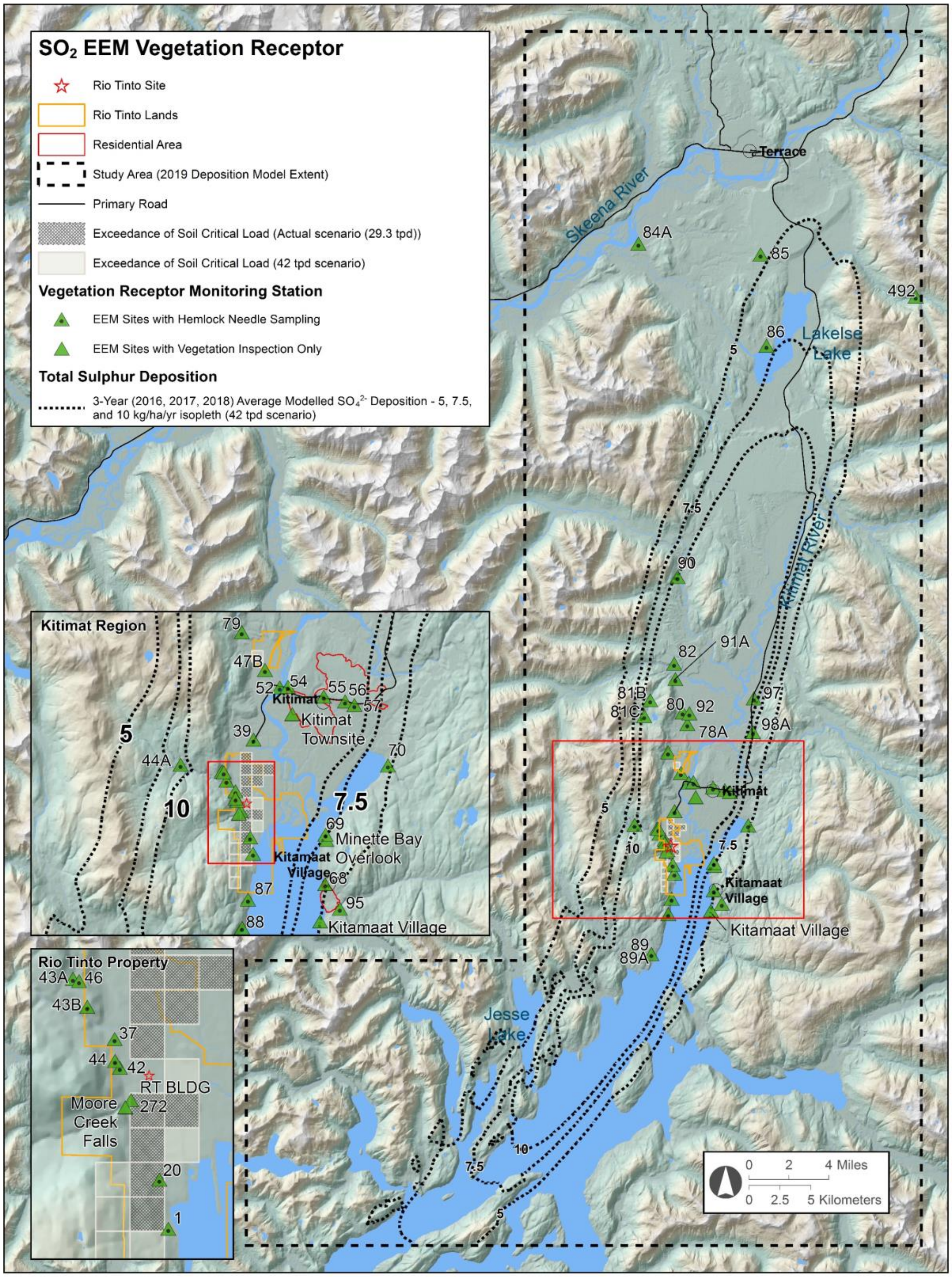


Figure 5.16: Main report Figure 5-8. Location of vegetation sampling and inspection sites, as well as isopleths of SO_4^{2-} deposition. Background deposition of 3.6 kg SO_4^{2-}/yr is not included in the isopleths.

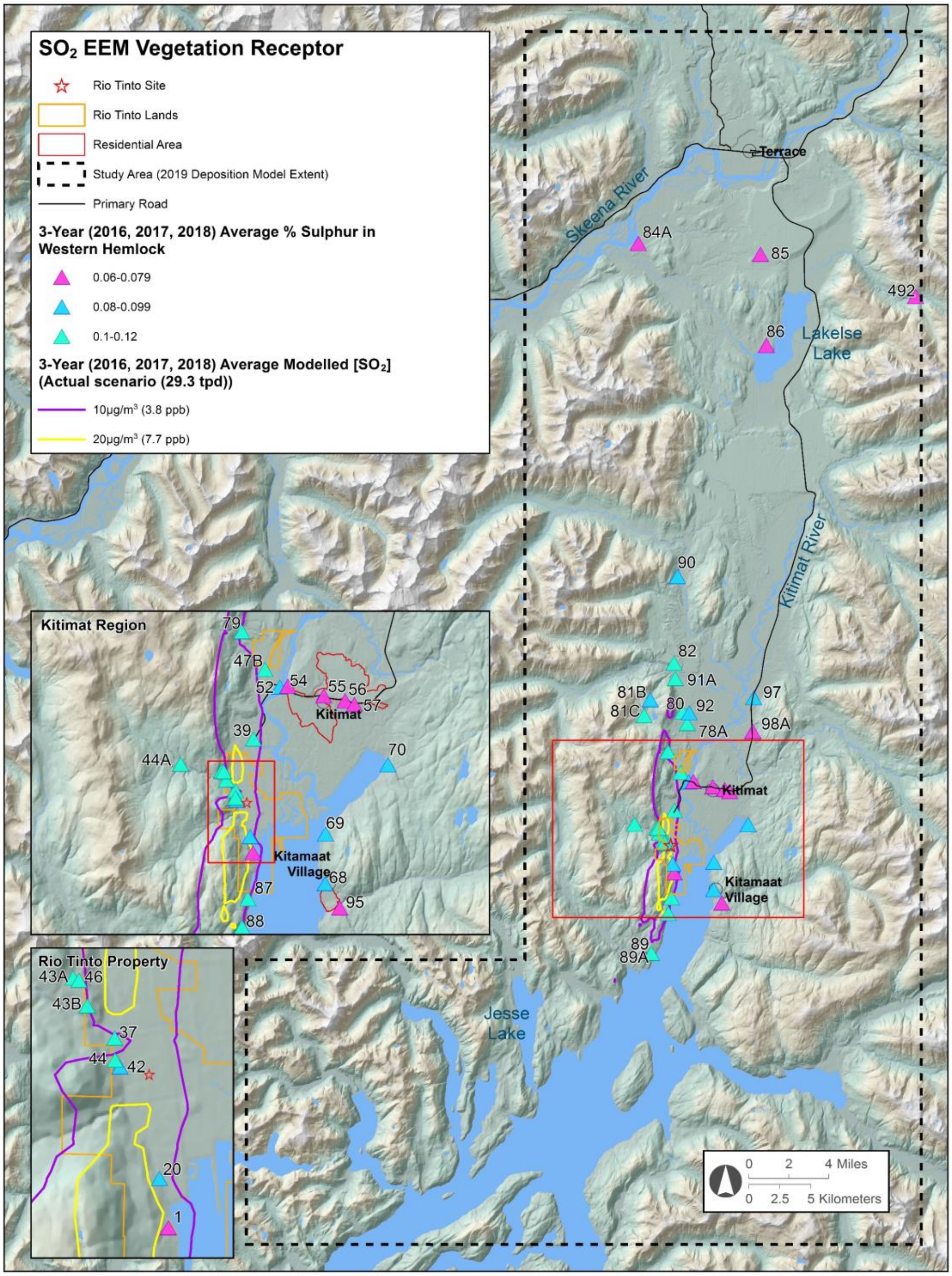


Figure 5.17: Main report Figure 5-10. The spatial distribution of %S in western hemlock needles in relation to SO_2 concentrations as modelled by CALPUFF. Purple symbols are at sites that have a post-KMP average %S between 0.06 and 0.08; blue symbols %S between 0.08 and 0.10; cyan symbols %S between 0.10 and 0.12. Isopleths represent growing season means of 10 and 20 µg/m³, threshold concentrations established in Europe for the protection of sensitive lichens and natural forest ecosystems respectively. Background air concentrations of SO_2 have been added.

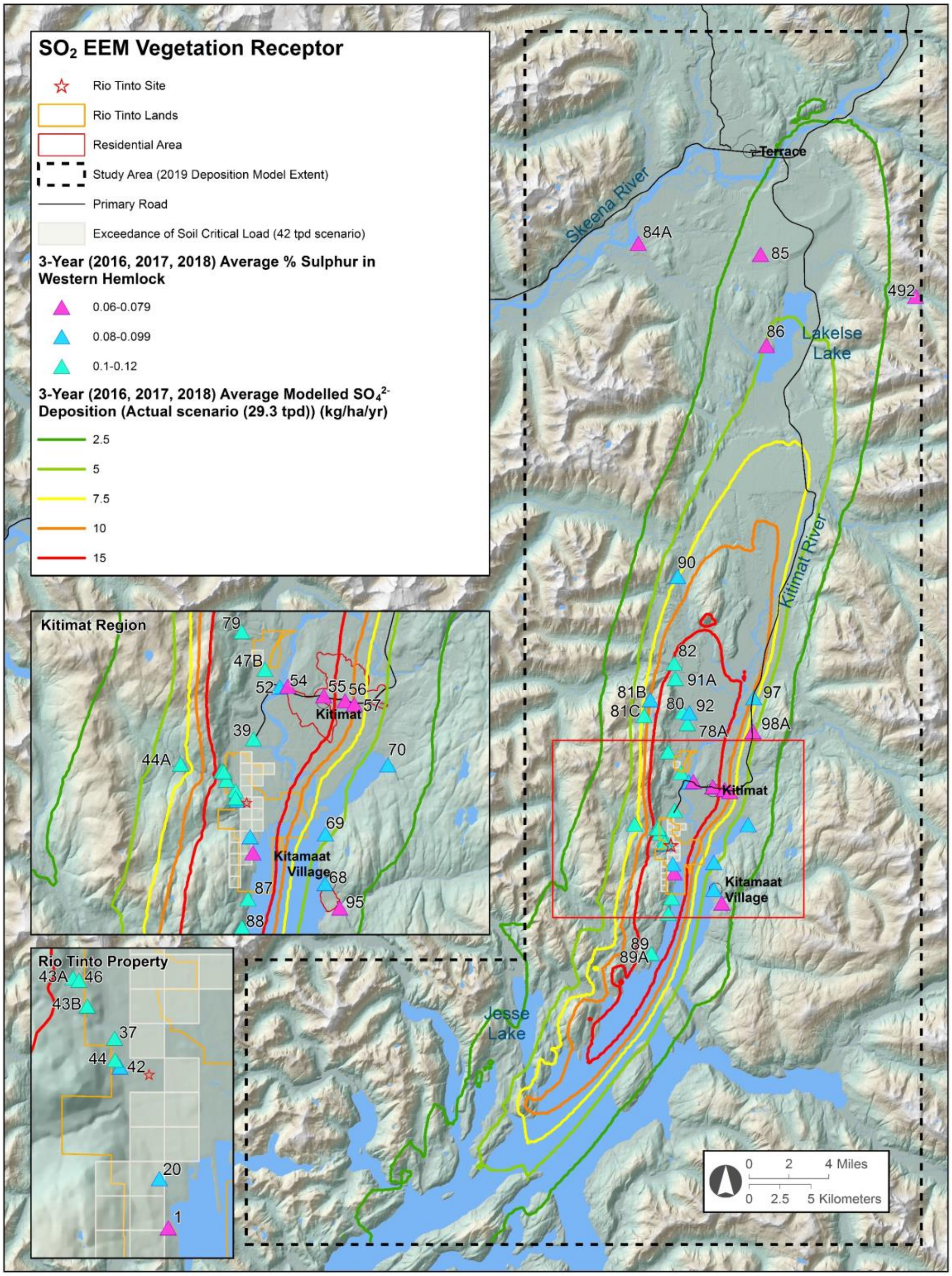


Figure 5.18: Main report Figure 5-12. The spatial distribution of %S in western hemlock needles in relation to SO_4^{2-} deposition as modelled by CALPUFF. Purple symbols are at sites that have a post-KMP average % S between 0.06 and 0.08; blue symbols % S between 0.08 and 0.10; cyan symbols % S between 0.10 and 0.12. Isopleths represent 2.5, 5, 7.5, and 10 kg SO_4^{2-}/ha/yr. Background deposition of 3.6 kg SO_4^{2-}/ha/yr is not included.

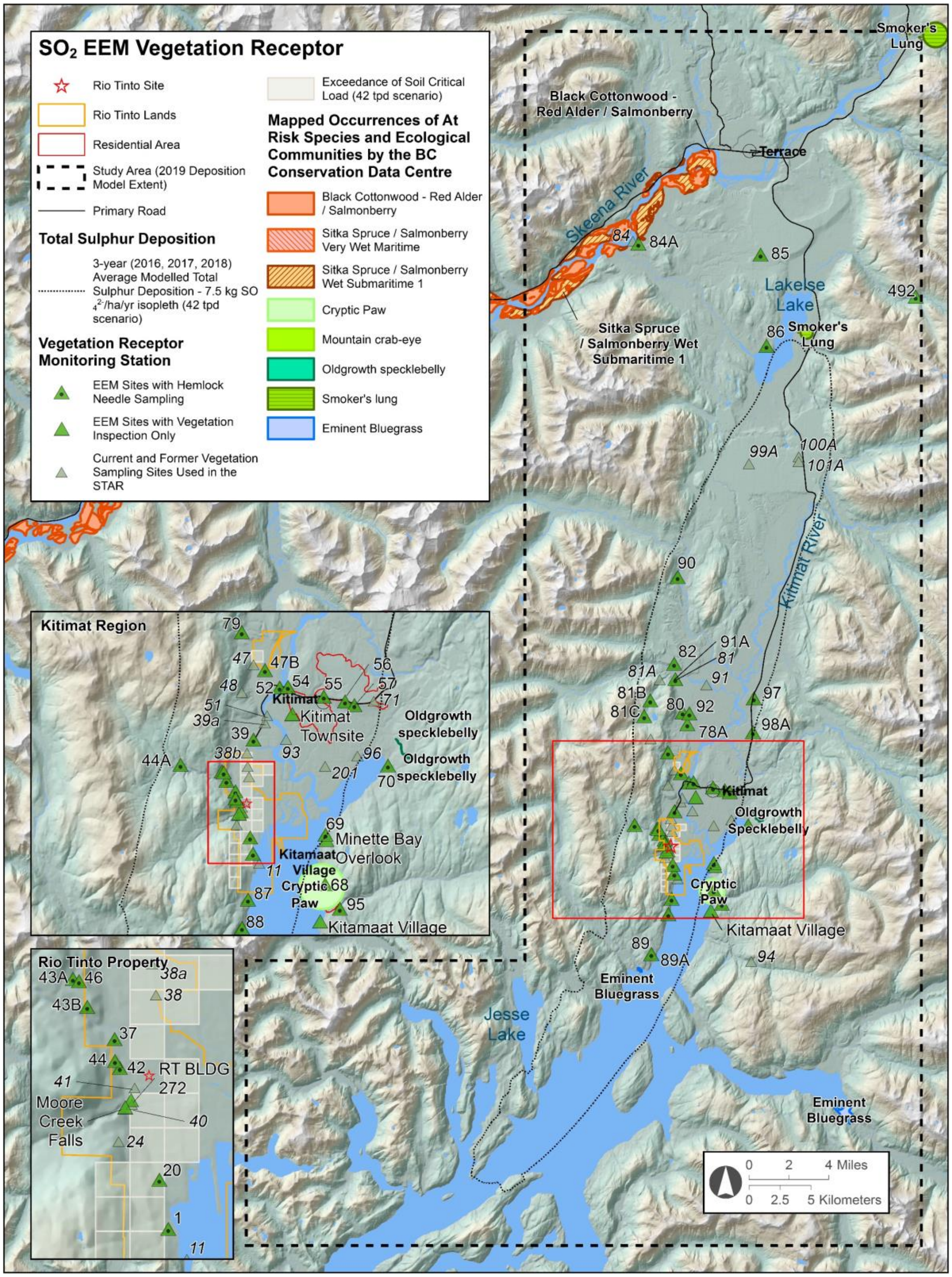


Figure 5.19: Main report Figure 5-15. Approximate locations of listed ecological communities, plants, and lichens at risk in the study domain. The data are from the British Columbia Conservation Data Centre, accessed on February 14th, 2020.

6 Appendix to Section 6 of the Comprehensive Review Report: Terrestrial Ecosystems (Soils)

6.1 Regional Soil Data

Table 6.1: Soil physicochemical characteristics for sites sampled for soils during the SO_2 EEM program (n = 31); site ID, sampling location (UTM Zone 09N), elevation (ALT), and profile average estimates of coarse fragment (CFG) by volume, bulk density (Db), loss-on-ignition (LOI), particle size (sand, silt and clay) and soil pH (H2O) averaged (weighted by depth and bulk density) over 0–50 cm depth.

Site ID	Easting m	Northing m	ALT m	CFG %v	Db g/cm^3	LOI %	pH H_2O	Sand %	Silt %	Clay %
L02	523594	6020539	191	0.26	0.954	7.23	5.49	70.0	27.6	2.4
S02	517413	5977553	171	1.34	0.600	9.15	5.66	64.3	32.4	2.7
L03	524232	6020376	130	1.36	1.323	5.26	5.78	72.3	24.9	2.8
S03	517940	5976248	115	1.02	0.546	11.19	4.93	52.4	43.0	4.2
EP712 312 Ss	523045	6010822	208	10.80	0.825	11.20	4.75	64.9	32.0	3.2
EP712 132 Hw	526493	6015024	202	7.59	0.727	11.58	4.46	68.2	28.6	3.1
SS1	519445	5986513	12	39.72	0.834	6.96	5.45	64.7	33.4	1.9
L01	522859	6018576	216	5.79	0.652	9.02	5.65	76.1	22.1	1.6
E02	518413	5986415	159	11.95	0.560	9.72	5.24	58.4	37.6	3.8
E01	518998	5985172	76	4.40	0.535	7.31	5.81	65.6	31.5	2.7
A05	516558	6007946	792	0.48	0.415	19.60	5.77	40.1	57.3	2.6
A04	519704	6018724	1128	11.87	0.758	12.61	5.93	55.7	41.4	2.8
A03	519367	6016713	1128	13.96	0.834	13.77	5.62	72.3	24.7	0.9
A01	517056	6007036	1097	2.35	0.814	12.61	5.95	55.0	42.2	2.6
A02	517912	6013609	1250	2.56	0.861	16.18	5.55	47.5	48.4	4.1
P01	528159	6036327	220	0.00	1.027	4.64	6.82	41.0	53.0	5.5
L28	519336	5992515	107	0.63	0.820	7.33	5.38	57.5	38.3	4.2
S01	513680	5974041	137	1.93	0.589	8.26	5.70	71.8	25.4	2.8
EP712 S1 Ss	526559	6015028	202							
EP712 S1 Hw	526291	6015021	202							
EP712 S3 Hw	523288	6010181	242							
EP712 S3 Ss	523040	6010872	208							
V-81A	518748	5998651	250							
V-39	519812	5987827	15							
V-69	523009	5983626	51							
V-47B	520331	5990894	20							
V-56	523898	5989507	99							
V-68	522990	5981427	26							
CF-P	522823	5992101	73	5.01	0.335	5.68	.	21.6	68.2	10.3
LE-P	527286	6025691	87	5.94	0.863	4.87	.	20.8	67.1	12.1
L28-S2	519229	5993269	222	.	.	15.86	3.58	16.2	72.6	11.2

Note: In total, 115 regional soil sites (see Section 6 Figure 6-1 in the main report) are used for mapping and modelling soil properties. These include 51 soil pits from the STAR (ESSA et al. 2013), 11 from the KAEEA (ESSA et al. 2014) and 22 from the LNG Canada Project [URL: lngcanada.ca; n =]. The physicochemical soil properties for 'new' sites sampled under the SO_2 EEM program (n = 31) are only shown here; please see related technical reports for soil data for the other sites.

Table 6.2: Major oxide content and loss-on-ignition (LOI) per soil profile (n = 31) used for the determination of soil mineralogy and base cation weathering rate. See Table 6.1 above for further details on sampling location.

Site ID	SiO2 %	TiO2 %	Al2O3 %	Fe2O3 %	MnO %	MgO %	CaO %	K2O %	Na2O %	P2O5 %	LOI %
L02	58.57	0.70	14.48	5.04	0.07	1.01	2.05	1.68	3.01	0.19	13.23
S02	49.40	0.63	11.88	5.57	0.06	1.03	1.45	1.16	1.73	0.07	26.96
L03	60.17	0.71	15.11	6.41	0.07	1.22	1.21	1.44	2.72	0.19	10.63
S03	49.48	0.76	12.54	5.56	0.05	0.96	1.45	1.09	1.72	0.06	26.31
EP712 312 Ss	59.47	0.68	13.24	5.55	0.07	0.88	1.70	1.43	2.69	0.11	13.87
EP712 132 Hw	57.15	0.86	13.07	7.02	0.06	0.85	1.15	1.16	2.29	0.17	15.97
SS1	58.28	0.48	14.67	5.31	0.11	2.28	4.16	0.71	3.01	0.12	10.80
L01	58.30	0.68	14.34	5.90	0.08	1.16	1.49	1.59	2.71	0.20	13.41
E02	52.76	0.72	14.97	6.96	0.11	1.46	1.57	1.25	2.20	0.12	17.87
E01	56.26	0.71	13.99	6.84	0.09	1.41	2.73	1.16	2.68	0.14	14.00
A05	31.94	0.42	11.41	5.16	0.07	2.89	2.79	0.75	1.16	0.15	43.04
A04	42.22	0.82	14.21	7.05	0.06	1.58	2.20	1.86	2.78	0.20	26.99
A03	42.21	0.78	14.98	7.05	0.09	2.49	4.20	1.02	2.32	0.31	24.54
A01	48.11	0.52	12.81	6.32	0.07	1.20	1.84	1.96	2.46	0.19	24.36
A02	39.81	0.77	13.89	8.27	0.08	1.19	1.86	2.03	2.85	0.29	29.05
P01	62.11	0.88	15.23	6.92	0.07	1.20	1.07	1.28	2.64	0.27	8.20
L28	50.70	0.81	15.63	6.87	0.09	1.35	1.07	1.42	1.76	0.14	20.07
S01	59.55	0.48	13.33	4.42	0.06	0.73	2.85	1.24	2.73	0.05	14.32
EP712 S1 Ss	59.03	0.80	13.41	5.68	0.07	0.99	2.05	1.31	2.66	0.15	13.71
EP712 S1 Hw	62.01	0.68	13.41	4.81	0.07	1.00	2.04	1.36	2.83	0.13	11.37
EP712 S3 Hw	58.12	0.81	14.30	6.84	0.07	1.22	1.09	1.25	2.51	0.18	12.81
EP712 S3 Ss	55.90	0.95	13.90	7.20	0.07	1.03	1.09	1.11	2.20	0.18	16.28
V-81A	59.01	0.80	10.62	4.10	0.06	1.03	2.40	1.21	2.08	0.11	18.25
V-39	61.27	0.72	14.81	6.03	0.12	2.41	3.94	1.53	3.26	0.22	5.51
V-69	70.39	0.31	12.01	1.83	0.06	0.28	0.91	3.16	3.91	0.06	7.13
V-47B	53.66	0.78	13.69	6.16	0.11	2.30	3.29	1.24	2.63	0.23	15.67
V-56	44.92	0.63	11.44	4.90	0.05	0.55	1.34	0.96	2.00	0.14	32.79
V-68	54.83	0.43	12.52	4.14	0.11	0.88	2.44	1.29	2.74	0.11	20.45
CF-P	46.80	0.80	14.20	7.46	0.07	1.28	1.65	1.22	2.43	0.11	23.50
LE-P	61.80	0.82	15.70	6.75	0.11	1.60	1.22	1.42	2.69	0.09	8.12
L28-S2	52.90	0.93	12.10	9.42	0.08	1.40	2.58	0.71	2.22	0.07	17.30

Note: In total, 115 regional soil sites (see Section 6 Figure 6-1 in the main report) are used for mapping and modelling soil properties. These include 51 soil pits from the STAR (ESSA et al. 2013), 11 from the KAEEA (ESSA et al. 2014) and 22 from the LNG Canada Project [URL: lngcanada.ca; n =]. The major oxide contents for 'new' sites sampled under the SO_2 EEM program (n = 31) are only shown here; please see related technical reports for soil oxide data for the other sites.

6.2 Soil Laboratory Analysis

The soils from the regional surveys and long-term soils plots were analysed for a suite of soil physicochemical properties. The laboratory analysis including sample preparation is described below. Prior to analysis all mineral soil samples were air dried and sieved to 2 mm, i.e., here after known as the 'fine' fraction.

Soil bulk density core samples were oven dried at 105°C for 24 hours and weighed. The dried soil was sieved to < 2 mm (fine fraction), the volume of the coarse fragment (>2 mm) was measured by displacement. Bulk density was estimated using the dry weight of the fine fraction (<2 mm) and the volume of the core (adjusted for coarse fragment volume).

The soils (fine fraction) from the regional surveys and long-term plots were analysed for organic matter content by loss on ignition (LOI); 5 g of soil was placed into a muffle furnace at 400°C for 10 hours and then reweighed to determine percent loss. Soil pH was measured by mixing 5 g of soil with 20 mL of water and analysed using a pH probe.

Soils from the primary plots at Coho Flats and Lakelse Lake (2015 and 2018) were analysed for exchangeable base cations and exchangeable acidity. Exchangeable base cations were measured using an ammonium acetate (NH_4OAc) extraction, 5 g of mineral soil was mixed with 25 mL of NH_4OAc, the solution was extracted via vacuum filtration. The sample then received two addition washes of 10 mL NH_4OAc, the extractant was analyzed by ICP–OES for exchangeable base cations (Ca^{2+}, Mg^{2+}, K^+ and Na^+).

Exchangeable acidity was measured using a potassium chloride (KCl) extraction; 5 g of soil was mixed with 25 mL of KCl, the solution was extracted via vacuum filtration. The sample then received five addition washes of 25 mL KCl. The extractant (135 mL) was titrated with sodium hydroxide (NaOH) to determine exchange acidity ($H^+ + Al^{3+}$).

The regional soil samples were pulverized to ~ 100 µm for analysis of oxide and qualitative mineralogy. Total oxide analysis was carried out by the Analytical Sciences Laboratory, Western University, Ontario on a PANalytical PW-2400 X-ray Fluorescence Spectrometer. Qualitative mineralogy analysis was carried out by the Department of Earth, Oceans and Atmospheric Sciences, University of British Columbia by X-ray Diffraction on a Siemens (Bruker) D5000 Bragg-Brentano diffractometer.

6.3 Modelling and Mapping of Soil Properties

The modelling and mapping of critical loads of acidity (sulphur) for terrestrial ecosystems (soils) required the development of regional maps for soil properties (see Figure 6.1 in this appendix). The spatial prediction or regionalisation of soil input parameters, e.g., base cation weathering rates and soil organic matter, was carried out using established geostatistical mapping techniques (McBrantley et al. 2003), i.e., regression-kriging following Hengl et al. (2004).

In brief, site-specific estimates of base cation weathering rates were estimated at each location (n = 115; Section 6 Figure 6-1 in the main report) from measurements of soil major oxide content (Appendix 6.1 Table 6.2) using the Analysis to Mineralogy (A2M) solver (Posch and Kurz 2007) and the PROFILE model (Sverdrup and Warfvinge 1988; Warfvinge and Sverdrup 1992), following the same approach as the STAR (ESSA et al. 2013; see Figure 6.1 in this appendix). Base cation weathering was determined for the top 50 cm of the mineral soil (using bulked soil observation data; see Appendix 6.1 Table 6.2), which was assumed to represent tree rooting depth. The soil rooting depth of 50 cm was modified by coarse fragment (%) to reflect the amount of fine earth (soil < 2 mm) in the top 50 cm of soil.

Base cation weathering rates ($Bc_{we} = Ca^{2+} + Mg^{2+} + K^{+}$ and $BC_{we} = Ca^{2+} + Mg^{2+} + K^{+} + Na^{+}$), sand and clay fractions, coarse fragment (CF_v), bulk density (Db and organic matter (LOI) content (estimated as loss-on-ignition) at each point location was regionalised using regression-kriging (Hengl et al. 2004). Geostatistical methods are optimal when data are normally distributed and stationary. Predictor variables with continuous coverage (n = 70) assumed to represent soil forming processes (i.e., scorpan factors: McBratney et al. 2003) were assembled for each point location. All predictor (explanatory or auxiliary) variables were transformed into principal components and their predictive capacity evaluated against the dependent variables using linear regression. The components with the greatest predictive capacity were selected for each dependent variable; a semi-variogram model was fitted to the residuals of each dependent variable to characterise their spatial correlation and interpolated (on a 0.25 km × 0.25 km grid) across the study domain using kriging. Continuous coverage maps for each dependent variable (base cation weathering rates, sand fraction, coarse fragment, and organic matter content) were produced by combining the linear regression model and interpolated residuals. Continuous coverage maps were used to derive input parameters (see main report Section 6 Table 6-3) and estimate critical loads (see main report Section 6 Table 6-2) for terrestrial ecosystems in each 0.25 km × 0.25 km grid square (see main report Section 6 Figure 6-3).

Logistic regression kriging was chosen as a mapping method because it provides better results than regression or universal kriging alone (Hengl et al., 2007). Regression kriging is an approach that combines a regression of a dependent variable on covariate map layers (such as soil or forest maps) kriging on the residuals (see Figure 6.2 in this appendix).

Covariates were obtained from global soil maps, forest cover maps, geological surveys, and land use (see Section 6 Table 6-1 in the main report). All maps were projected to EPSG:26909 and resampled using cubic spline interpolation to align them to the modelled sulphur deposition grid (250 m by 250 m). Covariates were transformed to principal components (PC) for inclusion in each model; this has the advantage of reducing collinearity, at the expense of some obfuscation of contributing covariates. The first 12 PCs were included in the covariate selection process for each model (see Figure 6.3 in this appendix); the rest had eigenvalues below 1 (below Kaiser's criterion) and were discarded. Variables of interest were logistic transformed to provide log transformation (and enable back-transformation of the final predictions, not possible with log transformation alone) and bounding of realistic values. Generalized linear models (GLM) were then built using the GSIF package (Hengl, 2019) using R software (R Core Team, 2019) to help select the optimal spatial and regression models (Table 6.3 in this appendix). Five-fold validation was performed on each model (Figure 6.4 in this appendix) before prediction and back-transformation for the final maps.

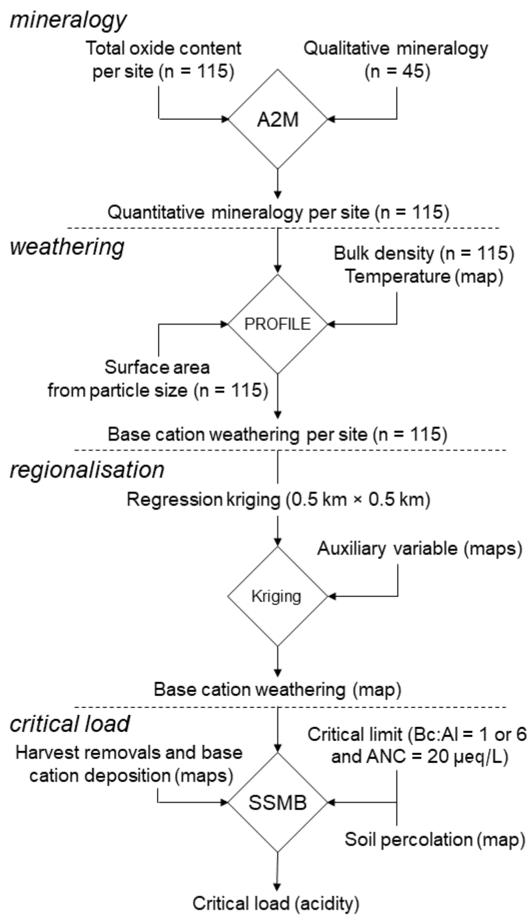


Figure 6.1: Overview of the modelling process for the regional determination of critical loads for soils. The approach used site specific estimates of total oxide (element) content to predict soil mineralogy (via A2M), these data were used to model site-specific estimates of soil weathering rate (via PROFILE model). The point estimates (n = 115) were regionalised using regression kriging, i.e., the were mapped at a 250 m by 250 m grid resolution and used in the determination of critical loads of acidity for soils via the Steady-State Mass Balance (SSMB) model.

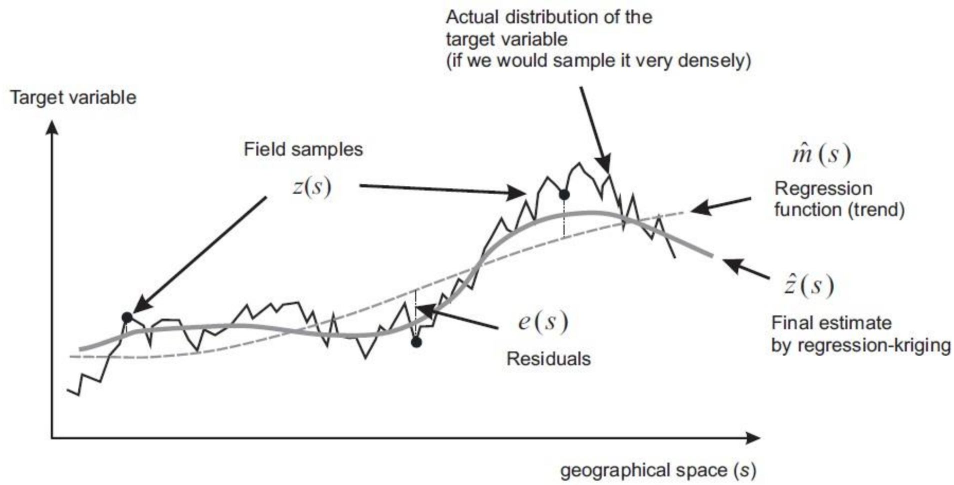


Figure 6.2: A representation of regression kriging with three main components, the observations or field samples, residuals, and the regression function (source: Hengl, 2012).

Table 6.3: Logistic regression models with total variation explained as well as the significance of each covariate used for the predicted soil properties. See Figure 6.3 in this appendix for a description of the loadings in each principal component (PC).

Predicted variable	Variation explained	Significance of Covariates 0.0001	0.001	0.01	0.1–1.0
Bulk density (Db)	25.7	PC3, PC12	PC6, PC7	PC4	PC11
Organic matter (LOI)	54.5	Db		PC8	PC2, PC9
Sand	17.2	Clay, LOI	PC1, PC6	PC2	PC4, PC11, PC12
Clay	12.8		Db	PC2, PC11, PC12	PC1, PC6
Coarse fragment (CFv)	12.4		PC8, PC9	PC12	PC2, PC5, LOI, Db
Weathering (Bcwe)	22.0	PC3, PC4, PC12	PC 7		PC1, PC5
Weathering (BCwe)	14.0	PC4	PC3, PC12	PC7	PC5

Bcwe = (Ca + Mg + K) and BCwe (Ca + Mg + K + Na)

Cited References:

R Core Team (2019). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Hengl, T. (2012). The scheme showing the universal model of spatial variation with three main components, Wikimedia Commons. https://commons.wikimedia.org/wiki/File:The_universal_model_of_spatial_variation.jpg.

Hengl, T. (2019). GSIF: Global Soil Information Facilities. R package version 0.5-5. https://CRAN.R-project.org/package=GSIF

Hengl, T., Heuvelink, G. B. M., and Rossiter, D. G. (2007). About regression-kriging: From equations to case studies. Computers & Geosciences, 33(10), 1301–1315. https://doi.org/10.1016/j.cageo.2007.05.001

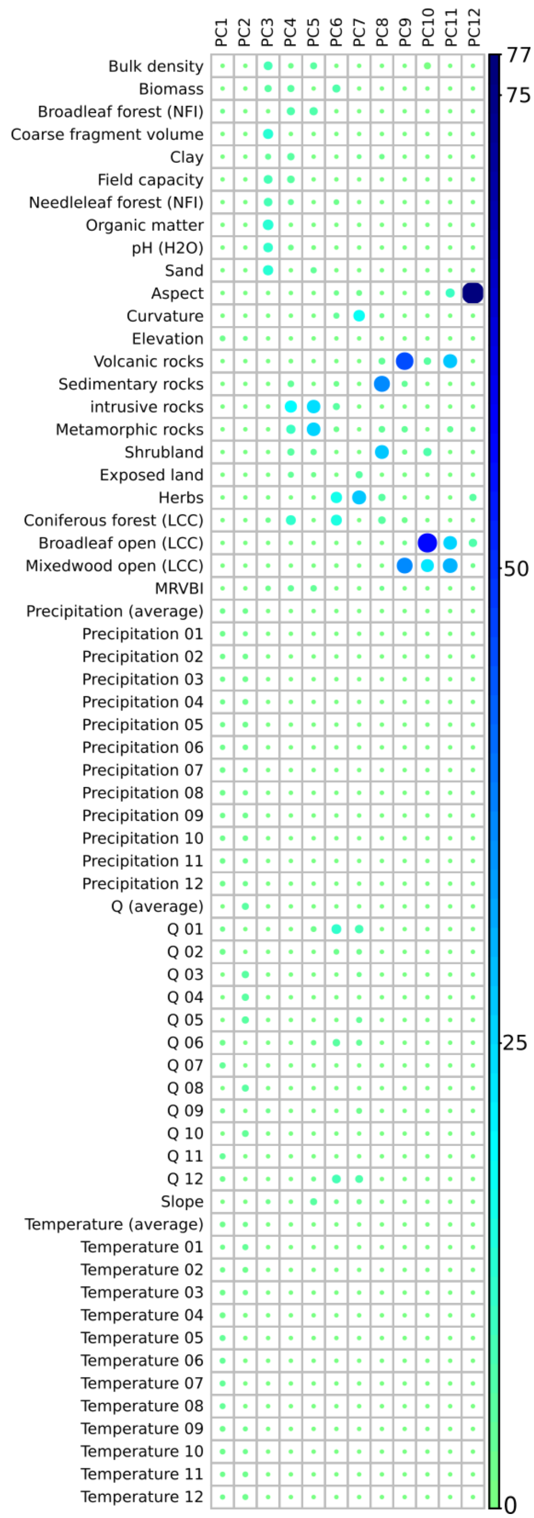


Figure 6.3: Correlation plot of the principal component's analysis matrix showing contributions of individual covariates to the first 12 dimensions. Note that two different sources of forest cover were used, one from the National Forest Inventory (NFI) and another from the Canadian Land Cover circa 2000 (LCC); see Section 6 Table 6-1 in the main report.

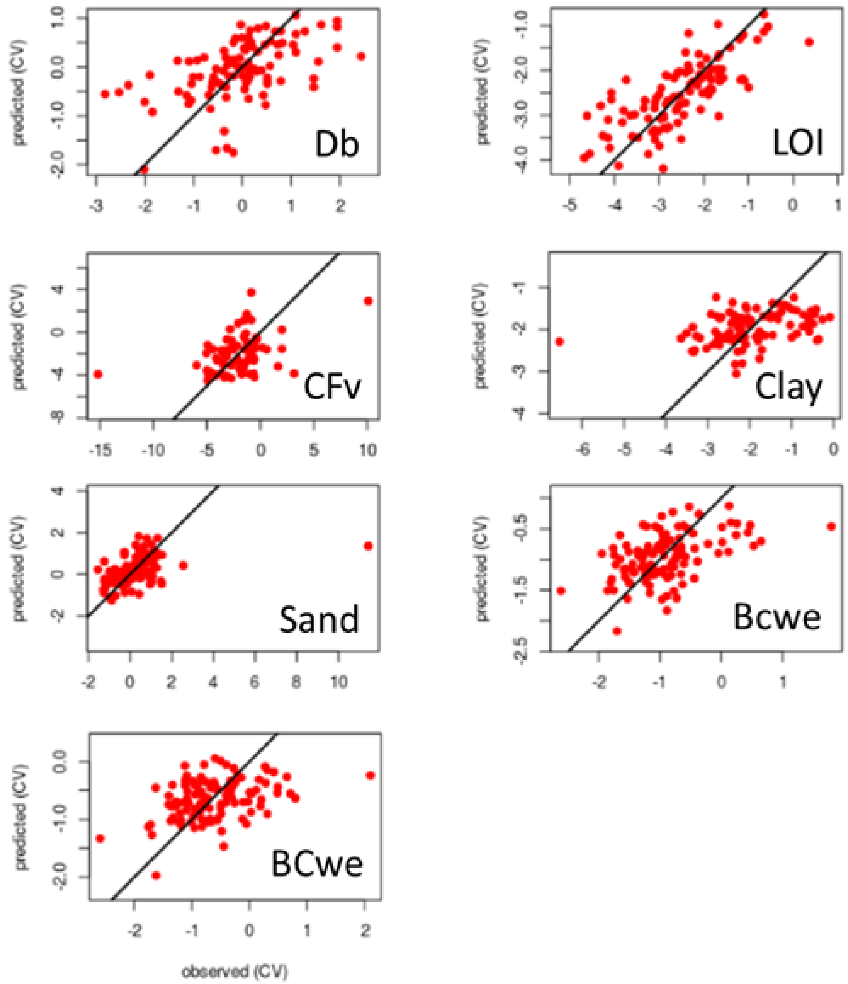


Figure 6.4: Goodness of fit for five-fold cross validated datasets for bulk density (Db), loss on ignition (LOI), coarse fragment by volume (CF_v), clay, sand, base cation weathering (Bcwe = Ca^{2+} + Mg^{2+} + K^+) and base cation weathering (BCwe = Ca^{2+} + Mg^{2+} + K^+ + Na^+). Note that units in these graphs are transformed.

6.4 Predictive Maps of Soil Properties

Predictive maps of soil organic matter content (as loss-on-ignition [LOI]) and base cation weathering (Bcwe = Ca^{2+} + Mg^{2+} + K^+) are displayed below. For details on the mapping procedure see Appendix 6.3.

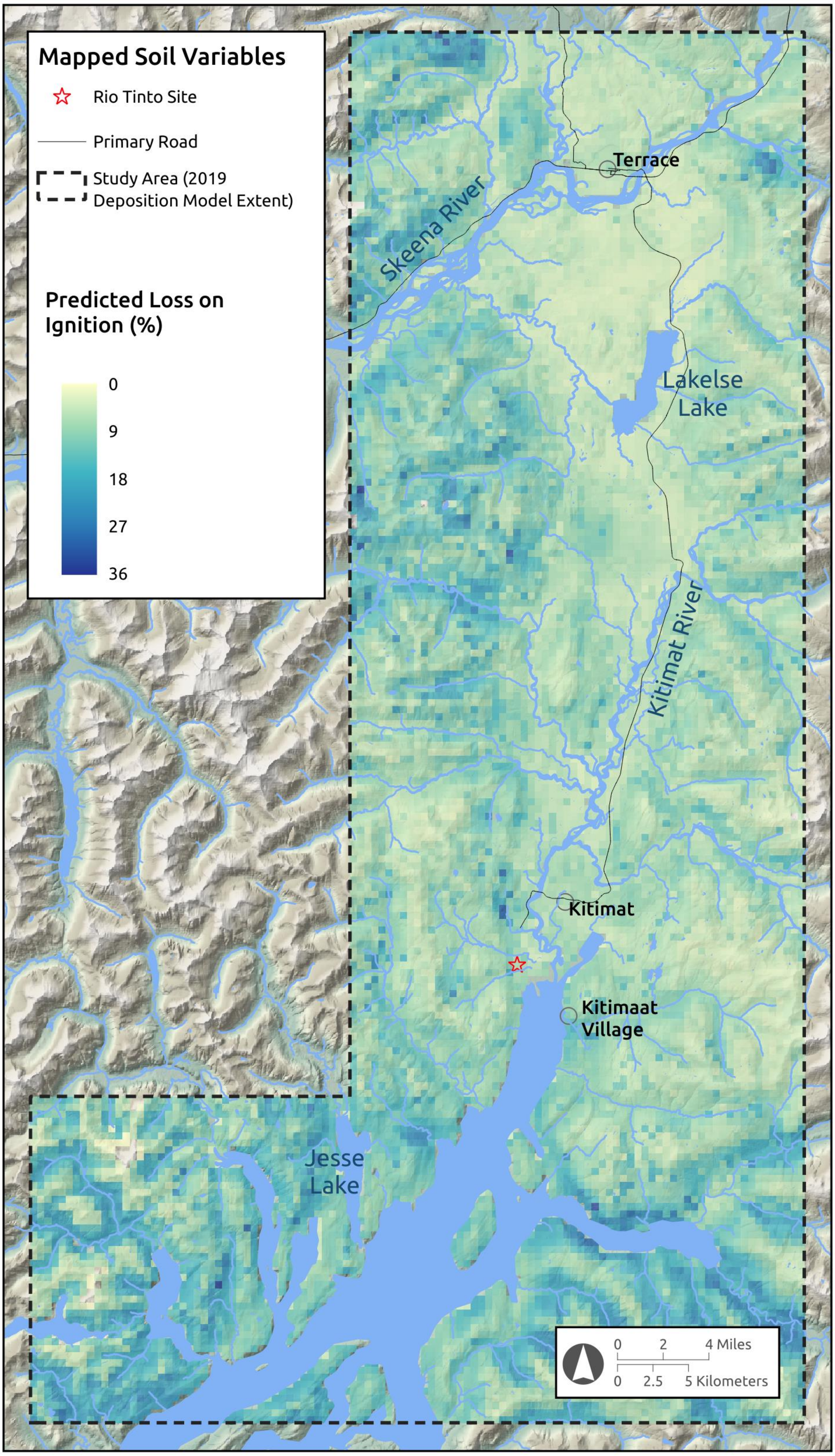


Figure 6.5: Predicted average soil percent loss-on-ignition (organic matter content) in the top 0–50 cm of mineral soil.

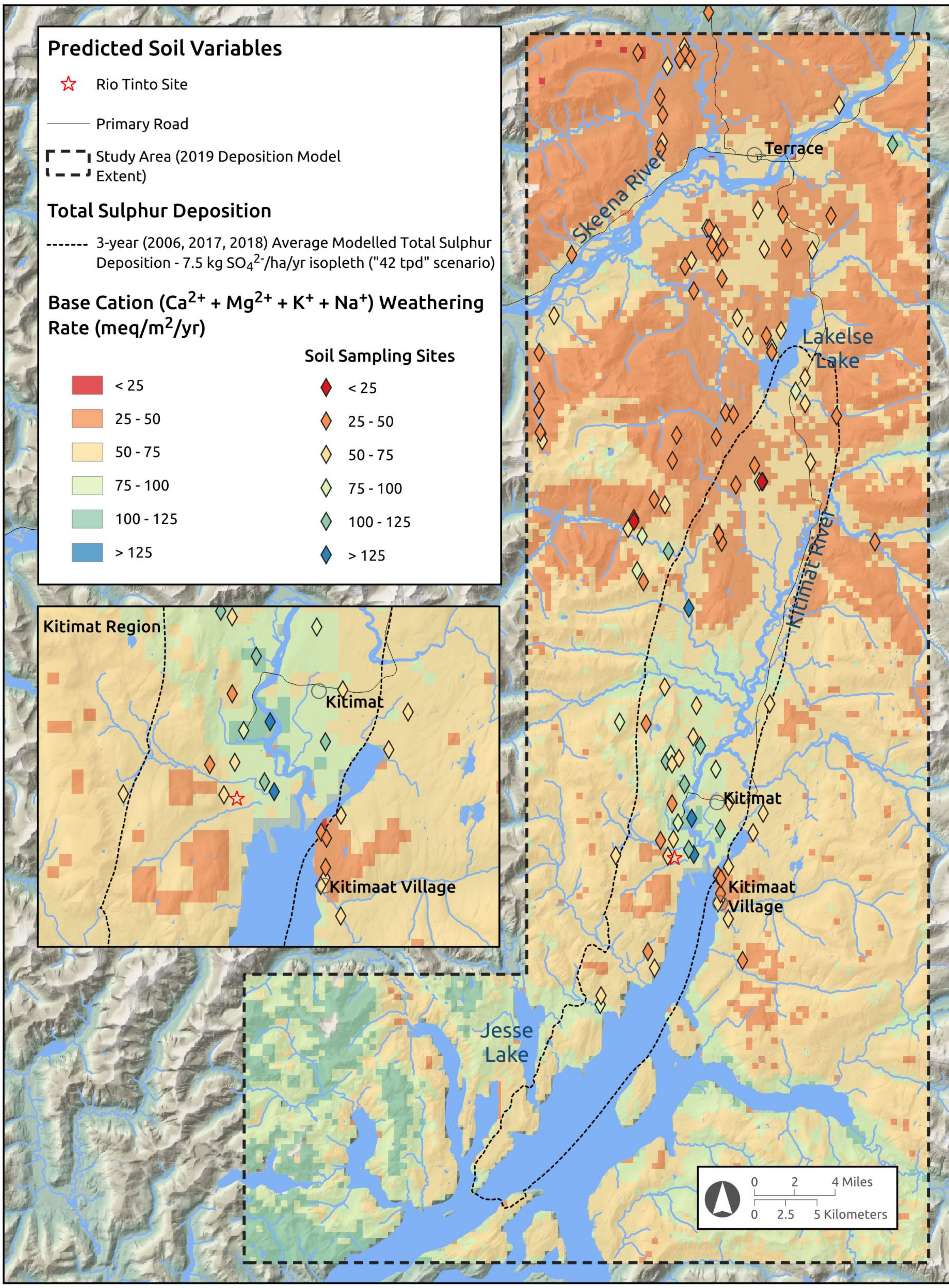


Figure 6.6: Predicted average soil base cation (Ca^{2+} + Mg^{2+} + K^{+}) weathering rates excluding sodium (meq/m²/yr) in the top 0–50 cm of mineral soil. Diamonds represent site-specific estimates of weathering rates used to develop the predictive map (using regression kriging, see Appendix 6.3). The dotted line indicates the isoline for modelled total sulphur deposition > 7.5 kg SO_4^{2-}/ha/yr based on permitted emissions of 42 tonnes of sulphur dioxide per day.

6.5 Modelling and Mapping of Terrestrial Critical Loads

The mapping and modelling of critical loads of acidity (sulphur) for terrestrial ecosystems (soil) under the SO_2 EEM Program primarily followed the methodology described in the STAR (ESSA et al., 2013) with the inclusion of seven revisions (labelled A to G).

A. All new soil data will be captured and incorporated into the STAR soils database. Base cation weathering rates will be estimated for all soil sampling pits with total element content data following the methodology used in the STAR. See Appendix 6.1.
B. Spatial prediction or regionalisation of soil input parameters for the determination of critical loads, e.g., weathering rates and soil organic matter will be carried out using regression-kriging. The approach will incorporate all available soil data in the study area (see revision A). See Appendix 6.3.
C. Base cation deposition will be mapped across the study domain and incorporated into the determination of critical loads of acidity for (upland) forest soils. See Appendix 6.6.
D. Incorporation of background sulphur deposition in the determination of exceedance of critical loads following the KAEEA (ESSA et al. 2014). See Appendix 6.7.
E. Spatial delineation of unique vegetation types within the study domain and assignment of vegetation-specific Bc:Al ratios. Incorporation of vegetation-specific Bc:Al ratios into the determination of critical loads of acidity.
F. Determination of exceedance of critical load under multiple chemical criteria to assess the influence of the chosen criterion on predicted exceedance following the KAEEA (ESSA et al. 2014).
G. Determination of proportional areal exceedance using the original domain and an effects domain defined by the area under the 7.5 kg SO_4^{2-}/ha/yr deposition plume.

6.6 Base Cation Deposition

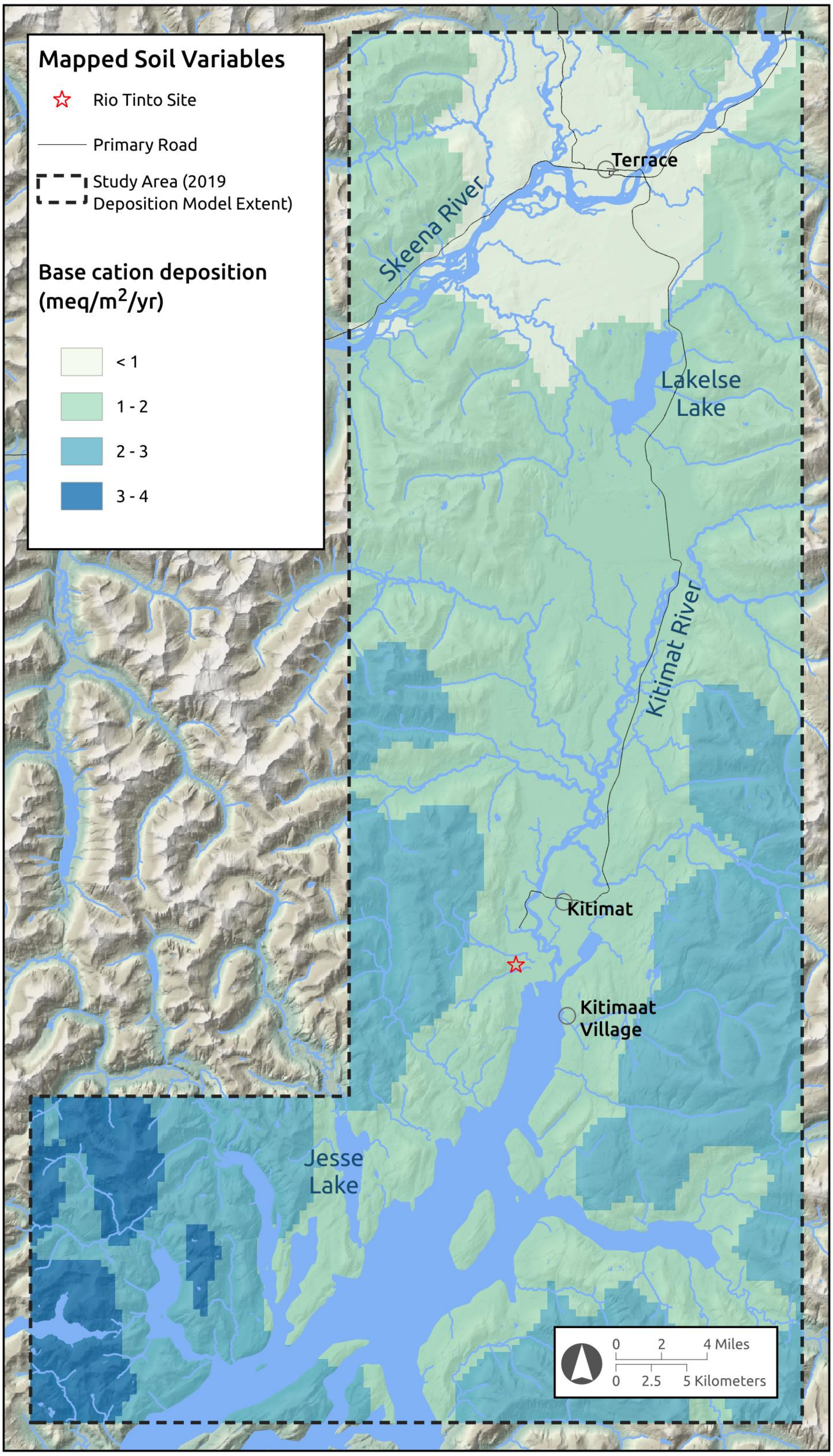


Figure 6.7: Predicted non-marine base cation wet deposition derived from a constant precipitation concentration across the study area combined with mapped rainfall volume. Base cation concentration in precipitation was set to 0.71 µeq/L based on annual average observations during 2014–2018 at two National Atmospheric Deposition Program (NADP) precipitation chemistry monitoring stations (Port Edward [BC24] and Lakelse Lake [BC23]).

6.7 Background Sulphur Deposition

Modelled sulphur deposition estimates under the comprehensive review do not include background transboundary deposition estimates, i.e., modelled deposition only represents the contribution of all stationary and mobile emissions sources in the study domain. However, transboundary atmospheric sources contribute a significant amount of anthropogenic sulphur deposition, as observed by monitoring stations in background regions (see CAPMoN and NADP).

There have been large changes in global sulphur dioxide (SO_2) emissions during the last four decades. Between ~1980 and 2000, there was a global decrease in SO_2 emissions followed by an increased until ~2006, owing to a sharp rise in emissions from China; since then there has been a declining global trend (Aas et al., 2019). Global anthropogenic sulphur emissions during 2010 were approximately 100 Tg SO_2, with China responsible for approximately one third of all global emissions (Klimont et al. 2013). Modelled global predictions of sulphur deposition indicate that shipping and emissions from China are sources of transboundary anthropogenic deposition to northwestern British Columbia (Lamarque et al. 2013).

Observations of wet deposition from the National Atmospheric Deposition Program (NADP) monitoring station at Port Edward (BC24) indicated that non-sea salt sulphate deposition decreased by 23% between the three-year periods 2013–2015 and 2016–2018. A similar decrease was observed at NADP monitoring stations in Washington state (WA19: 26% decrease) and Alaska (AK02: 25% decrease). This is consistent with the annual average trend of −2.78% in sulphate wet deposition observed at monitoring stations (n = 217) across North America (Aas et al., 2019).

Current observations at background wet deposition monitoring stations in Alaska and Washington (NADP AK02, AK03, AK96, WA14 and WA19) show that the concentration of sulphate in precipitation is 0.10 mg/L. This suggests that background total deposition of non-sea salt sulphur (owing to transboundary sources) in the Kitimat Valley ranges from 5–10 meq/m2/yr based on recent (2016–2018) annual rainfall volume at Lakelse Lake and Haul Road, and the contribution of wet deposition to total deposition at both stations. Wet deposition in general represents 40–60% of total deposition in the Kitimat Valley. Based on wider monitoring networks, and recent reductions in atmospheric sulphur, we chose a constant sulphur deposition of 7.5 meq/m2/yr to represent background deposition, compared with 10 meq/m2/yr used in the Kitimat Airshed Emissions Effects Assessment (ESSA et al., 2014). It is recognised that actual background deposition will vary across the region, and that the selected value represents a precautionary estimate of background deposition.

Cited References:

Aas, W., A. Mortier, V. Bowersox, R. Cherian, G. Faluvegi, H. Fagerli, J. Hand, Z. Klimont, C. Galy-Lacaux, C.M.B. Lehmann, C.L. Myhre, G. Myhre, D. Olivié, K. Sato, J. Quaas, P.S.P. Rao, M. Schulz, D. Shindell, R.B. Skeie, A. Stein, T. Takemura, S. Tsyro, R. Vet, and X. Xu, 2019. Global and regional trends of atmospheric sulfur. Scientific Reports, 9:1, 953.

ESSA Technologies, J. Laurence, Risk Sciences International, Trent University, and Trinity Consultants. 2014. Kitimat Airshed Emissions Effects Assessment. Report prepared for BC Ministry of Environment, Smithers, BC. 205 pp. + appendices.

Klimont, Z., S.J. Smith, and J. Cofala. 2013. The last decade of global anthropogenic sulfur dioxide: 2000–2011 emissions. Environmental Research Letters 8: 014003.

Lamarque, J.-F., F. Dentener, J. McConnell, C.-U. Ro, M. Shaw, R. Vet, and 20 others. 2013. Multi-model mean nitrogen and sulfur deposition from the Atmospheric Chemistry and Climate Model Intercomparison Project (ACCMIP): evaluation of historical and projected future changes. Atmospheric Chemistry and Physics 13: 7997-8018.

6.8 Close-up of Exceedance of Critical Loads of Acidity

Figure 6.8: Predicted exceedance of critical loads of acidity for forest and wetland soils (grids cells with white outline; n = 21) under modelled total sulphur deposition based on permitted emissions of 42 tonnes of sulphur dioxide per day. The Rio Tinto fence line (red outline) is also shown.

6.9 Exceedance of Critical Loads of Acidity

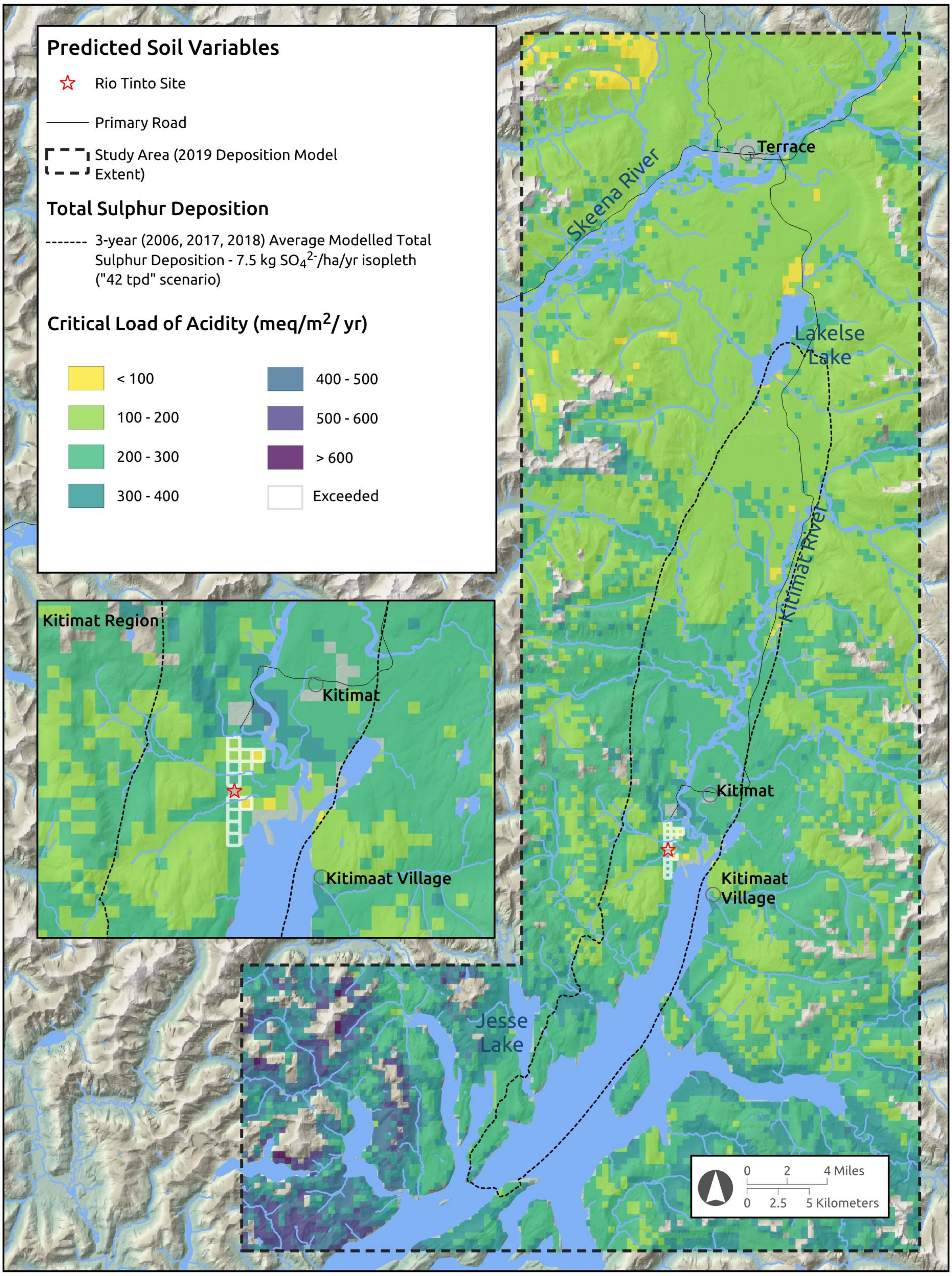


Figure 6.9: Predicted critical loads of acidity for forest and wetland soils (meq/m²/yr), and their exceedance (grids cells with white outline; n = 12) under modelled total sulphur deposition based on actual emissions of sulphur dioxide (during 2016–2018). The dotted line indicates the isoline for modelled total sulphur deposition > 7.5 kg SO_4^{2-}/ha/yr based on permitted emissions of 42 tonnes of sulphur dioxide per day.

6.10 Uncertainty of Exceedance of Critical Loads of Acidity

The influence of critical load (critical limit) model parameters and uncertainty in modelled deposition on the determination of exceedance was examined through a simple one-at-a-time sensitivity analysis. The 'base' exceedance under 42 tpd was compared with exceedance under extreme ranges for K_{gibb}, Bc:Al and double deposition. In addition, following the Kitimat Airshed Emissions Effects Assessment (ESSA et al., 2014b), exceedance was estimated for multiple critical chemical criteria. Three criteria were selected following UNECE (2004) and evaluated under 42 tpd. The soil pH criterion was set at pH= 4.5 based on an approximate 0.5 pH unit shift from the average soil pH in the Kitimat valley. The other critical limits were taken from UNECE (2004), e.g., aluminium mobilisation (p) was set to 2. A calcium to aluminium (Ca:Al) ratio was not used as this criterion requires mapped calcium weathering rates. The three criteria show no exceedance under 42 tpd, as each criterion is less sensitive than the Bc:Al criterion. Similar results were observed in the Kitimat Airshed Emissions Effects Assessment (ESSA et al., 2014b).

Table 6.4: Exceedance of critical loads of acidity for forest soils and wetlands. See main report Section 6 Tables 6-2 and 6-3 for details on model parameters used to estimate critical load and exceedance.

Exceedance	Base	K_{gibb}	K_{gibb}	Bc:Al	Bc:Al	pH	Al	p	Base × 2
	42 tpd	7.5	9.0	1	10	4.2	0.2	1	42 tpd × 2
Average exceedance ($meq/m^2/yr$)	149.6	178.9	137.6	149.6	99.4	0	0	0	213.6
Exceeded area (km^2)	2.33	1.10	2.84	2.33	7.30	0	0	0	7.30
Exceeded area (%) *	0.58	0.28	0.71	0.58	1.83	0	0	0	1.25
Exceeded grids (n)	23	17	26	23	66	0	0	0	62
Mapped receptor area (km^2)	398.4	398.4	398.4	398.4	398.4	398.4	398.4	398.4	583.4

* as a percentage of the mapped receptor area under the 7.5 kg SO_4^{2-}/ha/yr deposition isoline

6.11 Long-term Soil Plots

During October–December 2015, near-field and far-field long-term soil plots were established at Coho and Lakelse Lake, respectively, to reflect the gradient in atmospheric deposition, and during 2016 a reference (or background) plot was established at Kemano. At each location, primary and secondary (backup) plots were established within forest stands dominated by western Hemlock; secondary plots (located generally within 500 m of the primary plot) provide a backup or replacement to the primary plot if disturbed or destroyed within the lifetime of the monitoring program. For further details, see Technical Memo S04 (2016), Technical Memo S06 (2017) and Technical Memo S07 (2018).

This appendix provides detailed data for the long-term soil plots including dates of establishment, initial field observations, and chemical analysis:

Table 6.5. Dates of establishment of the primary and secondary long-term soil plots.

Table 6.5: Dates of establishment of the primary and secondary long-term soil plots and their location (latitude, longitude and elevation).

Long-term Soil Plots	Established	Latitude	Longitude	Elevation (m)
Coho Flats Primary (CFP)	02–03/12/2015	54.07660	–128.65117	73.1
Coho Flats Secondary (CFS)	29/10/2015	54.07458	–128.65025	128.8
Lakelse Lake Primary (LEP)	28/10/2015	54.37827	–128.57991	87.3
Lakelse Lake Secondary (LES)	30/10/2015	54.37814	–128.57593	199.5
Kemano Primary (KMP)	25/06/2016	53.53032	–127.97384	53.0
Kemano Secondary (KMS)	25/06/2016	53.55259	–127.95502	57.0

Re-sampled on Sunday 24/06/2018

Table 6.6: List of (numbered) sub-grids from each lettered grid sampled during establishment (2015–2016) and re-sampling (2018) at the primary and secondary long-term soil plots are Coho Flats, Lakelse Lake and Kemano. See Figure 6.10 in this appendix for plot layout.

#	Coho Flats (CF)			Lakelse Lake (LE)			Kemano (KM)	
	Primary 2015	Primary 2018	Secondary 2015	Primary 2015	Primary 2018	Secondary 2015	Primary 2016	Secondary 2016
1	A12	A07	A10	A10	A04	A10	A09	A08
2	B08	B04	B06	B11	B02	B06	B02	B12
3	C05	C07	C03	C02	C11	C10	C10	C03
4	D04	D01	D07	D05	D12	D02	D09	D12
5	E11	E10	E07	E04	E11	E06	E03	E04
6	F03	F02	F01	F02	F01	F02	F04	F07
7	G06	G02	G05	G09	G01	G02	G12	G06
8	H06	H07	H01	H07	H05	H04	H03	H11
9	I11	I06	I04	I06	I07	I08	I12	I09
10	J05	J07	J12	J01	J05	J09	J06	J01
11	K12	K10	K05	K04	K12	K10	K09	K09
12	L02	L03	L06	L12	L05	L11	L08	L06
13	M03	M01	M01	M04	M03	M12	M08	M02
14	N12	N01	N02	N05	N06	N04	N09	N04
15	O07	O10	O03	O06	O09	O11	O04	O11
16	P11	P10	P06	P09	P05	P09	P03	P07
17	Q03	Q06	Q06	Q12	Q06	Q01	Q12	Q02
18	R02	R06	R02	R07	R02	R03	R07	R04
19	S03	S04	S07	S06	S01	S09	S06	S10
20	T02	T08	T05	T09	T02	T03	T09	T04

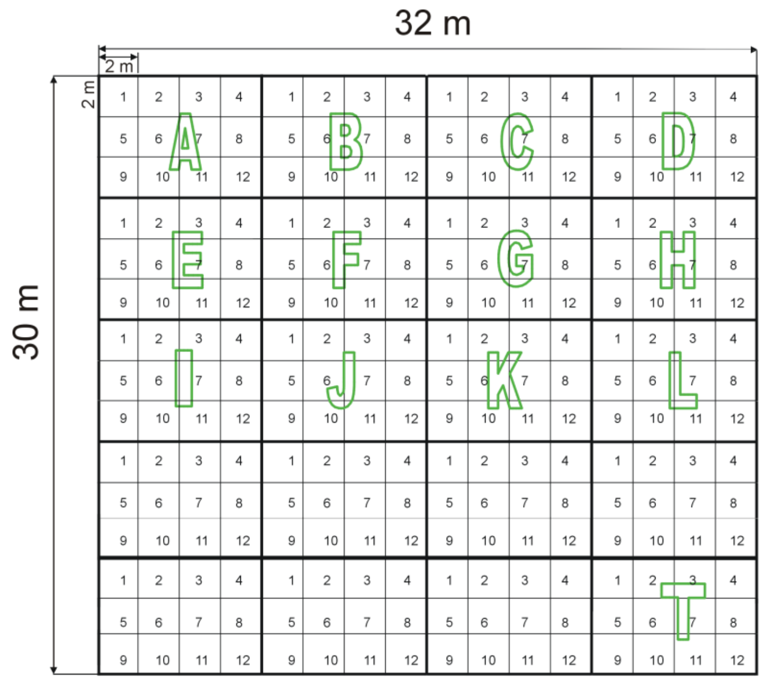


Figure 6.10: Plot layout showing the lettered grid (A–T) and number sub-grids (1–12). The plots are oriented so that the A grid is at North West corner. During each sampling campaign, one numbered sub-grid is randomly sampled (without replacement) from each lettered grid. A total of 20 sub-grids are sampled at three depths in the mineral soil 0–5 cm, 5–15 cm and 15–30 cm. See Table 6.6 in this appendix for a list of sub-grids sampled at the primary and second plots at Coho Flats, Lakelse Lake and Kemano during establishment (2015–2016) and during the first re-sampling (2018) at the Coho Flats and Lakelse Lake primary plots.

Table 6.7: Physicochemical soil properties (organic matter [LOI], pH and bulk density [Db]) at the primary (P) and secondary (S) plots at Coho Flats (CF) during establishment in 2015.

Depth	CFP	LOI	pH	Db	CFS	LOI	pH	Db
cm	ID	%		g cm⁻³	ID	%		g cm⁻³
0–5	A12	16.84	4.38	0.307	A10	21.7	4.45	.
5–15	A12	25.59	4.45	0.496	A10	21.5	4.71	.
15–30	A12	4.00	4.49	1.124	A10	13.3	4.84	.
0–5	B08	17.00	3.77	0.389	B06	16.6	4.63	0.480
5–15	B08	16.40	4.25	0.459	B06	16.3	4.94	0.596
15–30	B08	12.74	4.49	0.364	B06	10.6	5.02	0.600
0–5	C05	21.05	3.89	0.348	C03	25.1	4.45	0.787
5–15	C05	22.04	4.41	0.346	C03	15.9	4.88	0.713
15–30	C05	14.26	4.53	0.589	C03	9.9	5.27	0.685
0–5	D04	19.56	4.51	0.432	D07	17.4	4.47	0.438
5–15	D04	19.29	4.57	0.351	D07	9.2	5.09	0.536
15–30	D04	19.45	4.66	0.302	D07	6.4	5.07	0.459
0–5	E11	.	.	0.468	E07	27.8	4.80	0.295
5–15	E11	.	.	0.440	E07	26.2	5.04	0.364
15–30	E11	.	.	0.538	E07	16.3	5.25	0.600
0–5	F03	16.18	4.14	0.455	F01	14.1	4.82	0.529
5–15	F03	18.41	4.52	0.467	F01	15.7	4.90	0.547
15–30	F03	11.02	4.63	0.624	F01	14.2	5.16	0.555
0–5	G06	22.97	4.17	0.267	G05	20.2	4.16	.
5–15	G06	21.00	4.37	0.663	G05	15.4	4.63	.
15–30	G06	17.62	4.54	0.500	G05	21.3	4.75	.
0–5	H06	20.24	4.16	0.248	H01	11.3	5.20	0.392
5–15	H06	18.47	4.40	0.200	H01	.	.	0.410
15–30	H06	22.40	4.41	0.399	H01	.	.	0.367
0–5	I11	20.18	4.00	0.443	I04	21.2	4.77	0.497
5–15	I11	23.41	4.24	0.381	I04	18.5	4.66	0.323
15–30	I11	.	.	0.538	I04	15.7	4.86	0.324
0–5	J05	20.64	3.86	0.471	J12	23.9	4.73	0.598
5–15	J05	19.67	4.13	0.417	J12	21.3	4.87	0.502
15–30	J05	22.11	4.90	0.366	J12	14.2	5.12	0.454
0–5	K12	14.31	4.14	0.733	K05	25.4	4.87	.
5–15	K12	9.52	4.63	0.525	K05	24.3	4.39	.
15–30	K12	8.20	4.43	0.716	K05	19.4	5.08	.
0–5	L02	14.85	4.14	0.486	L06	16.5	4.66	0.864
5–15	L02	35.43	4.19	0.527	L06	.	.	0.581
15–30	L02	17.71	4.85	0.451	L06	.	.	0.570
0–5	M03	11.94	4.03	0.524	M01	16.8	4.76	0.658
5–15	M03	22.04	4.24	0.389	M01	16.1	4.66	0.474
15–30	M03	18.79	4.44	0.616	M01	15.5	4.82	0.350
0–5	N12	14.45	3.65	0.459	N02	16.2	5.21	0.773
5–15	N12	23.36	4.36	0.345	N02	16.7	4.96	0.402
15–30	N12	15.89	4.75	0.243	N02	21.6	5.01	0.315
0–5	O07	19.47	4.10	0.214	O03	17.7	4.60	0.492
5–15	O07	20.61	4.55	0.238	O03	23.5	4.48	0.635
15–30	O07	12.54	4.49	0.644	O03	12.9	4.88	0.483
0–5	P11	38.86	4.44	0.299	P06	19.8	4.91	0.614
5–15	P11	23.10	4.43	0.221	P06	.	.	0.444
15–30	P11	20.43	4.70	0.438	P06	.	.	0.433
0–5	Q03	8.70	4.37	0.684	Q06	15.8	4.51	0.264
5–15	Q03	10.31	4.07	0.560	Q06	15.8	4.82	0.253
15–30	Q03	.	.	0.260	Q06	11.8	4.95	0.216
0–5	R02	16.16	4.23	0.350	R02	36.9	4.34	0.359
5–15	R02	17.67	4.06	0.471	R02	23.5	4.78	0.386
15–30	R02	.	.	0.653	R02	20.6	4.91	0.382
0–5	S03	17.97	3.85	0.321	S07	26.4	4.48	0.671
5–15	S03	23.90	4.52	0.401	S07	24.9	4.39	0.467
15–30	S03	17.64	5.03	0.405	S07	16.2	4.74	0.694
0–5	T02	30.36	5.06	0.790	T05	16.3	5.27	0.413
5–15	T02	15.95	4.78	0.437	T05	11.9	5.30	0.474
15–30	T02	22.82	5.25	0.472	T05	11.8	5.46	0.540

Table 6.8: Physicochemical soil properties (organic matter [LOI], pH and bulk density [Db]) at the primary (P) and secondary (S) plots at Lakelse Lake (LE) during establishment in 2015.

Depth	LEP	LOI	pH	Db	LES	LOI	pH	Db
cm	ID	%		g cm^{-3}	ID	%		g cm^{-3}
0–5	A10	11.36	4.79	0.517	A10	7.6	5.17	1.096
5–15	A10	5.10	5.09	0.830	A10	8.0	5.48	0.818
15–30	A10	4.57	5.33	0.987	A10	5.4	5.50	1.139
0–5	B11	5.48	4.24	0.567	B06	8.1	4.77	0.668
5–15	B11	5.15	5.21	0.569	B06	6.2	5.09	0.719
15–30	B11	2.11	5.48	0.884	B06	4.2	5.67	0.654
0–5	C02	9.57	4.71	0.690	C10	13.5	5.23	0.667
5–15	C02	6.67	5.03	1.119	C10	5.4	5.31	0.976
15–30	C02	4.46	5.02	1.174	C10	4.9	5.37	0.867
0–5	D05	15.09	5.53	0.617	D02	10.1	5.19	0.789
5–15	D05	10.27	5.29	0.719	D02	6.6	5.63	0.967
15–30	D05	5.94	5.30	0.902	D02	8.0	5.52	0.950
0–5	E04	15.00	4.75	0.483	E06	8.0	5.29	1.058
5–15	E04	5.56	5.23	0.550	E06	2.8	5.57	1.028
15–30	E04	5.08	5.15	0.849	E06	2.0	6.00	1.138
0–5	F02	6.63	5.08	0.782	F02	8.3	5.20	0.941
5–15	F02	7.11	5.08	0.693	F02	6.9	5.15	1.109
15–30	F02	4.75	5.34	0.878	F02	7.7	5.21	0.983
0–5	G02	6.61	5.28	0.548	G02	13.5	5.11	0.615
5–15	G02	5.21	5.26	0.745	G02	4.9	5.58	0.828
15–30	G02	4.89	5.30	0.903	G02	2.8	5.79	1.043
0–5	H07	6.23	5.33	0.874	H04	9.7	4.80	0.525
5–15	H07	4.90	5.42	1.013	H04	4.5	5.42	0.809
15–30	H07	4.67	5.31	0.969	H04	4.3	5.47	1.060
0–5	I06	14.20	5.03	0.467	I08	8.7	5.14	0.672
5–15	I06	7.03	5.24	1.081	I08	5.6	5.27	0.861
15–30	I06	4.19	5.19	1.129	I08	3.3	5.57	0.724
0–5	J01	11.58	4.92	0.639	J09	10.2	4.73	0.539
5–15	J01	5.43	5.31	0.643	J09	5.7	5.40	0.675
15–30	J01	5.14	5.11	0.544	J09	5.5	5.31	0.849
0–5	K04	8.00	5.22	0.850	K10	12.5	4.90	0.656
5–15	K04	4.36	5.26	0.731	K10	9.1	5.41	0.563
15–30	K04	1.05	5.42	1.123	K10	8.5	5.51	0.521
0–5	L12	8.96	4.89	0.597	L11	9.5	5.01	0.634
5–15	L12	8.05	4.91	1.214	L11	6.5	5.16	0.689
15–30	L12	2.89	5.11	0.926	L11	4.8	5.39	0.993
0–5	M04	12.02	4.52	0.728	M12	16.4	5.15	0.766
5–15	M04	11.21	5.05	0.827	M12	7.2	5.62	0.643
15–30	M04	4.27	5.33	0.765	M12	6.4	5.56	0.955
0–5	N05	9.18	5.02	0.476	N04	9.8	5.07	1.178
5–15	N05	4.69	5.17	0.836	N04	10.2	5.25	1.116
15–30	N05	4.57	5.08	1.149	N04	7.4	5.44	0.498
0–5	O06	9.09	4.79	1.285	O11	13.1	5.28	0.768
5–15	O06	4.70	5.38	1.051	O11	5.3	5.35	0.851
15–30	O06	2.47	5.25	1.224	O11	3.7	5.26	0.930
0–5	P09	8.69	4.85	0.567	P09	7.7	4.62	1.205
5–15	P09	3.23	5.15	1.010	P09	5.6	5.51	1.254
15–30	P09	3.86	5.13	1.255	P09	3.8	6.01	1.272
0–5	Q12	12.87	5.00	0.804	Q01	7.1	5.44	1.186
5–15	Q12	9.28	5.08	1.012	Q01	5.5	5.28	1.177
15–30	Q12	4.74	5.11	0.882	Q01	5.9	5.38	1.137
0–5	R07	9.15	4.98	1.055	R03	8.6	5.28	0.605
5–15	R07	6.26	5.02	0.756	R03	6.1	5.55	0.717
15–30	R07	4.63	5.08	0.977	R03	4.9	5.60	0.586
0–5	S06	6.64	4.90	0.663	S09	9.1	4.84	1.087
5–15	S06	5.64	5.06	0.944	S09	5.2	5.55	1.087
15–30	S06	2.52	5.19	1.082	S09	4.9	5.52	0.848
0–5	T09	10.61	4.80	0.472	T03	10.0	4.60	0.894
5–15	T09	5.37	4.97	0.769	T03	4.7	5.60	1.112
15–30	T09	4.20	4.97	1.039	T03	3.2	5.58	1.015

Table 6.9: Physicochemical soil properties (organic matter [LOI], pH and bulk density [Db]) at the primary (P) and secondary (S) plots at Kemano (KM) during establishment in 2016.

Depth	KMP	LOI	pH	Db	KMS	LOI	pH	Db
cm	ID	%		g cm^{-3}	ID	%		g cm^{-3}
0–5	A09	15.0	5.10	1.106	A08	2.6	5.46	1.193
5–15	A09	6.2	5.04	0.883	A08	1.7	5.65	.
15–30	A09	8.7	5.20	.	A08	1.77	5.72	.
0–5	B02	9.6	4.91	1.135	B12	5.8	5.82	1.033
5–15	B02	8.3	4.97	.	B12	9.4	5.90	.
15–30	B02	14.4	4.96	.	B12	1.97	5.72	.
0–5	C10	10.2	5.14	0.778	C03	2.5	5.71	1.127
5–15	C10	10.2	5.02	0.860	C03	1.3	5.81	.
15–30	C10	10.9	5.07	0.797	C03	1.47	5.66	.
0–5	D09	16.9	4.90	1.146	D12	3.5	5.87	0.948
5–15	D09	10.0	4.94	0.910	D12	2.3	5.79	.
15–30	D09	9.5	4.97	0.801	D12	1.11	5.78	.
0–5	E03	4.0	4.55	0.938	E04	0.9	5.60	1.258
5–15	E03	19.5	4.65	0.605	E04	2.3	5.62	.
15–30	E03	9.7	5.20	0.336	E04	2.33	5.70	.
0–5	F04	10.3	5.16	0.714	F07	2.6	5.78	1.013
5–15	F04	9.5	5.02	0.919	F07	1.7	5.71	.
15–30	F04	10.4	5.12	.	F07	2.08	5.72	.
0–5	G12	11.8	5.20	1.094	G06	3.0	6.04	1.246
5–15	G12	7.4	5.14	0.942	G06	2.1	5.97	.
15–30	G12	12.2	5.22	.	G06	2.16	6.14	.
0–5	H03	19.4	4.97	0.826	H11	4.6	5.56	1.128
5–15	H03	9.7	5.05	0.813	H11	2.5	5.75	.
15–30	H03	12.0	4.99	.	H11	2.59	5.79	.
0–5	I12	9.3	4.99	1.090	I09	3.1	5.63	1.249
5–15	I12	9.2	5.07	1.032	I09	2.1	5.79	.
15–30	I12	8.8	5.14	.	I09	2.15	5.81	.
0–5	J06	12.0	4.95	1.061	J01	3.3	5.82	1.249
5–15	J06	9.7	5.10	1.025	J01	3.5	5.87	.
15–30	J06	11.0	5.09	.	J01	2.04	5.82	.
0–5	K09	6.9	4.98	0.980	K09	4.5	5.54	1.048
5–15	K09	10.5	5.00	.	K09	3.5	5.61	.
15–30	K09	8.0	5.05	.	K09	1.85	5.78	.
0–5	L08	14.9	5.10	0.641	L06	4.6	5.62	1.151
5–15	L08	30.7	5.00	0.678	L06	3.0	5.73	.
15–30	L08	12.1	5.07	.	L06	1.81	5.70	.
0–5	M08	11.6	5.02	0.604	M02	4.1	5.84	1.233
5–15	M08	11.2	5.08	0.838	M02	2.2	5.87	.
15–30	M08	13.8	5.12	0.700	M02	2.26	5.78	.
0–5	N09	13.8	4.99	1.023	N04	3.3	5.93	1.152
5–15	N09	9.5	5.19	.	N04	2.3	5.75	.
15–30	N09	11.2	4.97	.	N04	1.77	5.85	.
0–5	O04	11.2	5.24	0.788	O11	3.7	5.80	1.161
5–15	O04	10.4	5.09	0.836	O11	2.5	5.41	.
15–30	O04	12.4	5.08	0.899	O11	1.77	5.84	.
0–5	P03	28.1	4.96	.	P07	3.3	5.62	1.100
5–15	P03	15.1	5.14	0.885	P07	3.1	5.56	.
15–30	P03	14.0	5.10	0.941	P07	3.32	5.65	.
0–5	Q12	5.9	4.55	0.799	Q02	3.2	5.81	1.023
5–15	Q12	6.3	4.95	0.720	Q02	1.9	5.70	.
15–30	Q12	8.1	5.03	0.791	Q02	1.02	5.84	.
0–5	R07	10.9	4.92	0.917	R04	2.6	5.75	1.215
5–15	R07	8.8	5.14	.	R04	1.8	5.87	.
15–30	R07	8.5	5.21	.	R04	1.85	5.82	.
0–5	S06	11.9	5.06	0.681	S10	3.2	5.53	1.149
5–15	S06	16.1	5.06	0.865	S10	3.2	5.73	.
15–30	S06	9.0	5.22	0.883	S10	2.08	5.72	.
0–5	T09	7.3	4.64	0.963	T04	3.6	5.77	1.210
5–15	T09	8.5	4.71	0.792	T04	2.6	5.79	.
15–30	T09	12.7	5.15	0.831	T04	2.17	5.54	.

Table 6.10: Basal area (m^2/ha), stem density (stems per ha) and the percentage Western hemlock and Sitka spruce as a proportion of total trees observed at the primary and secondary plots at Cho Flats, Lakelse Lake and Kemano. See Figure 6.11 in this appendix for layout of trees at the primary plots.

Long-term Soil Plots	Basal Area	Density	Western hemlock	Sitka spruce
	m^2/ha	stems/ha	% of stems	% of stems
Coho Flats Primary (CFP)	70.1	489.6	59.5	
Coho Flats Secondary (CFS)	68.3	416.7	100.0	
Lakelse Lake Primary (LEP)	55.6	1125.0	50.5	23.6
Lakelse Lake Secondary (LES)	54.2	2365.0	34.9	16.7
Kemano Primary (KMP)	79.6	718.8	51.1	24.0
Kemano Secondary (KMS)	76.3	510.4	19.2	66.8

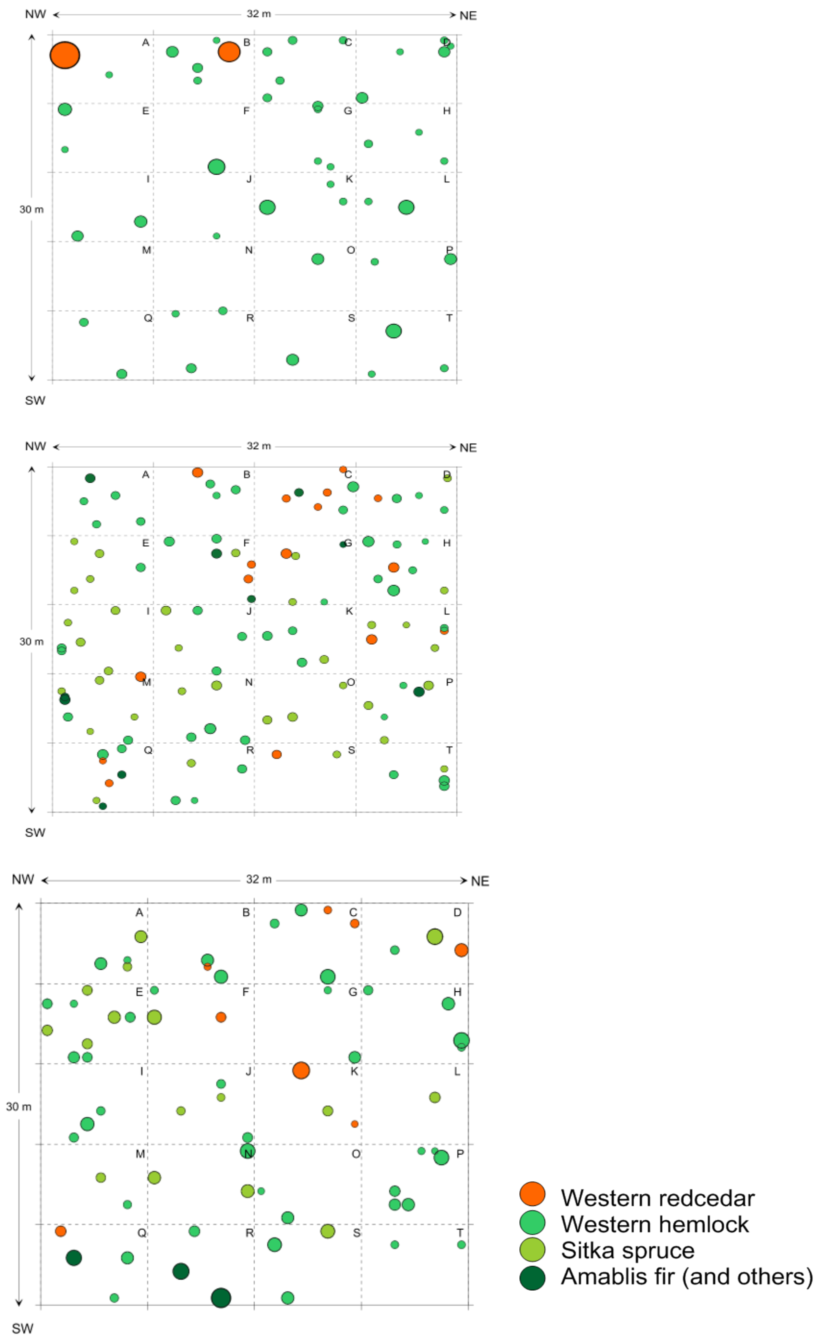


Figure 6.11: Layout of the primary long-term soil monitoring plots at Coho Flats (upper), Lakelse Lake (middle), and Kemano (lower) showing the location and relative size of each tree species.

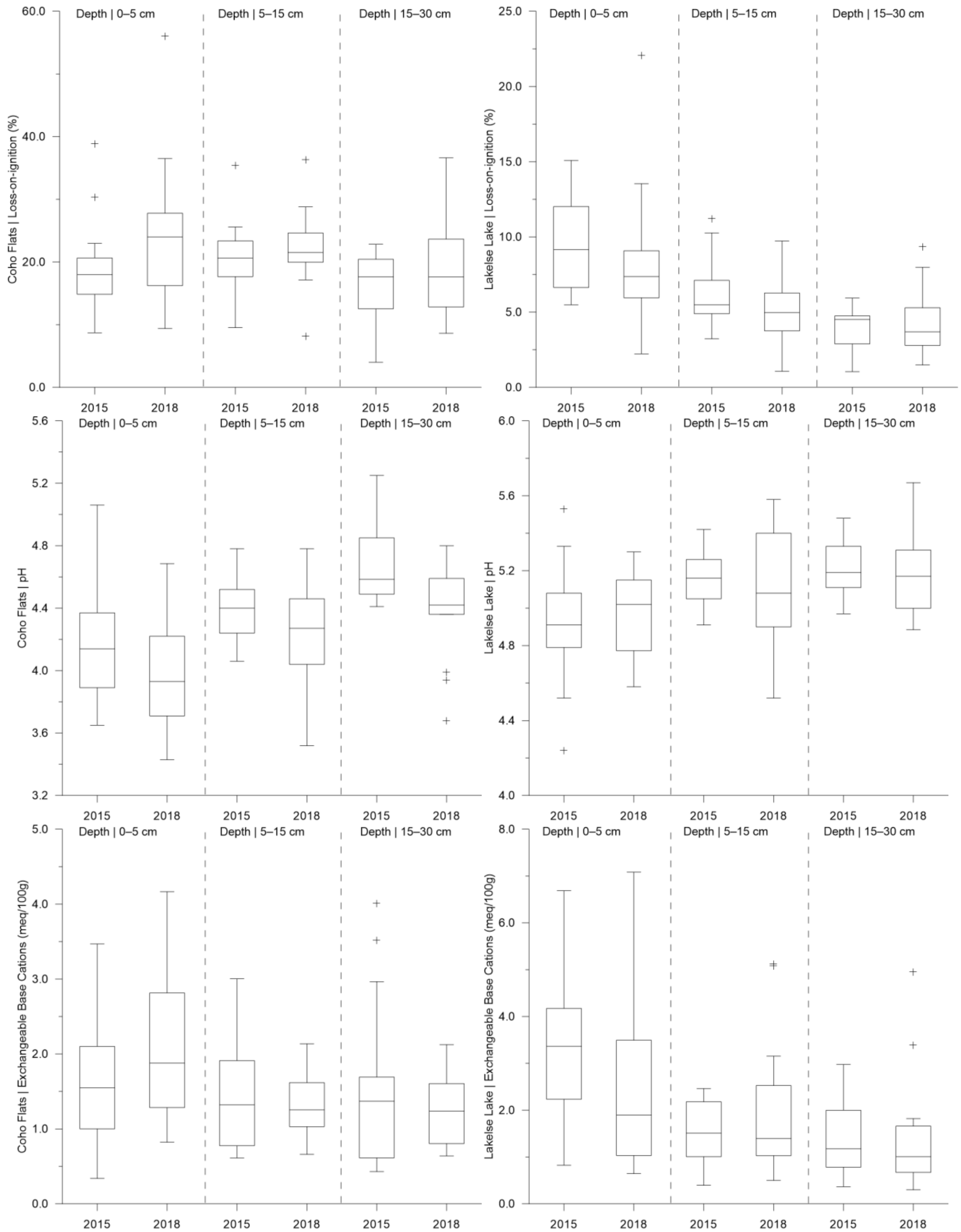


Figure 6.12: Boxplots showing loss-on-ignition (%), pH and exchangeable base cations (meq/100g) by depth during 2015 and 2018 at Coho Flats and Lakelse Lake long-term soil plots. There up to 20 observations per depth.

Table 6.11: Average soil pools by depth during 2015 and 2018, probability of decrease between 2015 and 2018, magnitude of difference (MOD) and minimum detectable difference (MDD) based on the variability during 2015 and pooled variability during 2015 and 2018 at Coho Flats Primary (CFP) and Lakelse Lake Primary (LEP) plots.

Plot	Depth	Param	Units	Test[a]	n 2015	Trans[b]	MCT 2015	MCT 2018	p-value	MOD[d] %	MDD 2015	MDD pSD
CFP	0–5	Ca^{2+}	meq/m²	tequal	19	Log10	177	205	0.737	16	-51	-53
		Mg^{2+}	meq/m²	tunequal	19	None	66	138	1.000	109	-37	-81
		BC	meq/m²	tequal	19	None	333	446	0.953	34	-47	-57
		EA	meq/m²	tequal	18	Log10	1,584	1,181	0.026	-25	-26	-34
		CEC_e	meq/m²	tequal	18	None	1,989	1,796	0.215	-10	-29	-35
		BS_e	%	tequal	18	Log10	15	24	0.999	62	-38	-43
LEP	0–5	Ca^{2+}	meq/m²	tequal	20	Log10	719	386	0.015	-46	-49	-56
		Mg^{2+}	meq/m²	tequal	20	Log10	205	120	0.024	-42	-45	-54
		BC	meq/m²	tequal	20	Log10	998	565	0.016	-43	-45	-53
		EA	meq/m²	tequal	20	None	1,252	997	0.066	-20	-34	-39
		CEC_e	meq/m²	tequal	20	Log10	2,279	1,476	0.013	-35	-31	-43
		BS_e	%	tequal	20	None	47	41	0.150	-11	-31	-32
CFP	0–15	Ca^{2+}	meq/m²	tunequal	19	Log10	485	453	0.363	-6.6	-48	-58
		Mg^{2+}	meq/m²	tunequal	19	None	188	301	0.994	60	-39	-62
		BC	meq/m²	tequal	19	None	938	927	0.468	-1.3	-49	-59
		EA	meq/m²	tequal	18	None	4,445	3,525	0.034	-21	-29	-31
		CEC_e	meq/m²	tequal	18	None	5,377	4,452	0.060	-17	-29	-30
		BS_e	%	tequal	18	None	17	22	0.988	28	-34	-35
LEP	0–15	Ca^{2+}	meq/m²	tequal	20	Log10	1,578	1,156	0.097	-27	-44	-50
		Mg^{2+}	meq/m²	tequal	20	Log10	466	339	0.083	-27	-40	-49
		BC	meq/m²	tequal	20	Log10	2,228	1,691	0.108	-24	-40	-48
		EA	meq/m²	tequal	20	None	3,632	3,046	0.113	-16	-38	-39
		CEC_e	meq/m²	tequal	20	Log10	5,722	4,565	0.088	-20	-32	-39
		BS_e	%	tequal	20	None	41	39	0.389	-3.0	-28	-31
CFP	0–30	Ca^{2+}	meq/m²	tequal	18	Log10	1,012	899	0.295	-11	-47	-57
		Mg^{2+}	meq/m²	tunequal	18	Log10	324	435	0.895	34	-36	-44
		BC	meq/m²	tequal	18	Log10	1,708	1,651	0.426	-3.3	-39	-41
		EA	meq/m²	tequal	18	Log10	8,447	5,598	0.008	-34	-24	-36
		CEC_e	meq/m²	tequal	18	Log10	10,297	7,293	0.017	-29	-24	-35
		BS_e	%	tequal	18	None	18	23	0.992	31	-35	-44
LEP	0–30	Ca^{2+}	meq/m²	tequal	20	Log10	2,714	2,279	0.223	-16	-44	-49
		Mg^{2+}	meq/m²	tequal	20	Log10	794	679	0.236	-14	-42	-47
		BC	meq/m²	tequal	20	Log10	4,041	3,367	0.189	-17	-38	-45
		EA	meq/m²	tequal	20	None	6,938	6,245	0.221	-10	-32	-38
		CEC_e	meq/m²	tequal	20	Log10	10,742	9,205	0.164	-14	-31	-37
		BS_e	%	tequal	20	None	39	39	0.504	0.11	-23	-29

† Soil parameters (Param) included exchangeable calcium (Ca^{2+}), magnesium (Mg^{2+}), base cations (BC), exchangeable acidity (EA), effective cation exchange capacity (CEC_e) and effective base saturation (BS_e). [a] One-sided t-test assuming equal variances (tequal) or not (tunequal) according to a Levene's test for equal variances ($\alpha = 0.05$) and testing for a decrease in values for 2018. [b] Statistical comparisons were conducted using untransformed (None) or log10 transformed (Log10) data depending on the normality of the residuals determined from a Shapiro-Wilk's test ($\alpha = 0.05$). [c] The measure of central tendency (MCT) was calculated as a mean or geometric mean with untransformed or log10 transformed data, respectively. [d] The magnitude of difference was calculated as 2018 – 2015/ 2015 × 100% using the MCT. [e] The Minimum Detectable Difference (MDD) was conducted using a t-test power analysis (α=0.05, β = 0.1) using the standard deviation in 2015 and the pooled standard deviation (2015 and 2018) and accounting for unequal variances where appropriate. MDD was expressed as a percent decrease from 2015 (–MDD/MCT2015). For transformed data, power analysis was conducted with log transform data, but back-transformed to raw scale for % MDD relative to 2015.

Table 6.12: Soil chemistry (organic matter [LOI], pH, exchangeable cations [Ca^{2+}, K^{+}, Mg^{2+} and Na^{+}] and exchangeable acidity [EA]) by sampling layer at Coho Flats primary plot for 2015 and 2018.

Year Depth Unit	2015 Plot	2015 LOI %	2015 pH	2015 Ca^{2+} meq / 100 g	2015 K^{+}	2015 Mg^{2+}	2015 Na^{+}	2015 EA	2018 Plot	2018 LOI %	2018 pH	2018 Ca^{2+} meq / 100 g	2018 K^{+}	2018 Mg^{2+}	2018 Na^{+}	2018 EA
0–5	A12	16.8	4.38	0.83	0.24	0.44	0.04	8.5	A07	9.4	3.43	1.39	0.04	0.57	0.02	7.67
5–15	A12	25.6	4.45	0.33	0.12	0.31	0.08	5.7	A07	8.2	3.52	0.82	0.02	0.35	0.06	8.79
15–30	A12	4.0	4.49	0.35	0.06	0.07	.	6.5	A07	11.4	3.68	0.89	0.04	0.39	0.05	9.53
0–5	B08	17.0	3.77	2.81	0.14	0.44	0.03	8.5	B04	27.7	4.32	1.54	0.10	0.34	0.06	5.43
5–15	B08	16.4	4.25	1.90	0.10	0.33	0.21	7.1	B04	21.5	3.73	0.30	0.22	0.58	0.05	9.59
15–30	B08	12.7	4.49	3.25	0.12	0.43	0.20	5.7	B04	.	.					
0–5	C05	21.1	3.89	1.03	0.13	0.33	0.16	8.5	C07	22.9	3.60	2.06	0.31	0.93	0.16	2.38
5–15	C05	22.0	4.41	1.19	0.06	0.19	0.04	5.9	C07	22.9	4.31	0.96	0.18	0.42	0.09	5.41
15–30	C05	14.3	4.53	1.05	0.10	0.30	.	.	C07	23.7	4.38	0.46	0.19	0.21	0.06	4.45
0–5	D04	19.6	4.51	0.55	0.07	0.14	0.11	5.7	D01	18.0	4.18	0.35	0.17	0.27	0.04	5.17
5–15	D04	19.3	4.57	0.47	0.07	0.11	0.21	5.3	D01	21.0	4.36	0.32	0.13	0.17	0.04	3.63
15–30	D04	19.4	4.66	0.35	0.05	0.05	0.17	3.5	D01	21.9	4.59	0.46	0.13	0.15	0.06	2.73
0–5	E11	.	.	.	.	.	.	.	E10	18.6	4.06	0.69	0.20	0.66	0.08	6.63
5–15	E11	.	.	.	.	.	.	.	E10	21.4	3.89	0.46	0.17	0.72	0.01	7.43
15–30	E11	.	.	.	.	.	.	.	E10	.	.					
0–5	F03	16.2	4.14	0.31	0.07	0.23	0.18	9.5	F02	36.5	4.06	1.05	0.26	0.64	0.07	5.13
5–15	F03	18.4	4.52	0.38	0.05	0.13	0.20	4.5	F02	21.7	4.43	0.58	0.17	0.29	0.19	3.79
15–30	F03	11.0	4.63	0.18	0.03	0.05	0.25	2.7	F02	8.6	4.46	0.45	0.11	0.08	0.05	1.75
0–5	G06	23.0	4.17	2.70	0.15	0.51	0.10	9.7	G02	27.7	4.22	0.56	0.14	0.28	0.06	5.67
5–15	G06	21.0	4.37	0.65	0.06	0.27	0.19	8.9	G02	20.0	4.46	0.52	0.10	0.24	0.02	3.09
15–30	G06	17.6	4.54	0.16	0.05	0.09	0.19	4.9	G02	12.8	4.36	0.78	0.13	0.20	0.23	2.57
0–5	H06	20.2	4.16	0.29	0.08	0.18	.	7.9	H07	24.1	4.68	0.59	0.16	0.17	0.06	3.35
5–15	H06	18.5	4.40	0.43	0.09	0.18	0.07	6.9	H07	24.6	4.78	0.56	0.13	0.12	0.09	2.83
15–30	H06	22.4	4.41	0.37	0.10	0.21	0.06	7.7	H07	17.5	4.80	0.44	0.05	0.10	0.05	2.13
0–5	I11	20.2	4.00	0.17	0.05	0.11	0.01	7.9	I06	25.5	3.76	0.37	0.17	0.87	0.05	5.91
5–15	I11	23.4	4.24	0.29	0.15	0.26	0.09	11.3	I06	28.8	3.89	0.53	0.22	0.74	0.05	6.79
15–30	I11	.	.	.	.	.	.	.	I06	32.1	3.99	0.48	0.12	0.58	0.05	4.63
0–5	J05	20.6	3.86	1.50	0.11	0.35	.	6.3	J07	23.9	3.82	0.93	0.18	0.51	0.07	8.19
5–15	J05	19.7	4.13	1.92	0.13	0.63	0.05	8.3	J07	25.8	4.11	0.89	0.17	0.40	0.05	6.93
15–30	J05	22.1	4.90	1.00	0.08	0.32	.	5.3	J07	21.0	4.42	1.23	0.18	0.48	0.24	5.75
0–5	K12	14.3	4.14	0.66	0.06	0.29	0.05	5.9	K10	11.2	3.57	0.79	0.16	0.61	0.10	7.85
5–15	K12	9.5	4.63	0.42	0.04	0.18	0.02	3.9	K10	18.0	4.04	0.65	0.17	0.69	0.09	6.13
15–30	K12	8.2	4.43	0.28	0.05	0.12	0.17	3.1	K10	17.9	3.94	0.63	0.11	0.85	0.16	6.37
0–5	L02	14.8	4.14	1.04	0.07	0.25	0.03	6.7	L03	56.0	4.43	0.63	0.25	0.34	0.06	3.63
5–15	L02	35.4	4.19	1.14	0.21	0.46	0.10	7.7	L03	36.3	4.40	0.49	0.13	0.22	0.05	3.21
15–30	L02	17.7	4.85	1.08	0.15	0.32	0.14	8.3	L03	36.6	4.52	0.78	0.19	0.42	0.09	2.73
0–5	M03	11.9	4.03	0.84	0.15	0.27	0.04	10.3	M01	24.9	3.70	0.44	0.21	0.92	0.17	10.55
5–15	M03	22.0	4.24	0.17	0.08	0.21	0.15	7.3	M01	.	.					
15–30	M03	18.8	4.44	0.17	0.08	0.19	0.10	5.3	M01	.	.					
0–5	N12	14.4	3.65	1.24	0.10	0.52	0.11	8.5	N01	27.9	3.93	1.15	0.09	1.04	0.13	7.31
5–15	N12	23.4	4.36	0.22	0.12	0.08	0.18	3.1	N01	21.1	4.27	0.83	0.10	0.57	0.11	5.23
15–30	N12	15.9	4.75	1.19	0.11	0.49	0.17	8.3	N01	17.6	4.42	0.90	0.14	0.45	0.12	4.33
0–5	O07	19.5	4.10	1.28	0.14	0.44	0.24	8.7	O10	27.8	3.84	2.86	0.14	1.06	0.11	9.63
5–15	O07	20.6	4.55	1.04	0.21	0.40	0.23	7.3	O10	17.1	4.20	0.65	0.06	0.37	0.05	7.77
15–30	O07	12.5	4.49	0.17	0.05	0.05	0.15	4.3	O10	.	.					
0–5	P11	38.9	4.44	1.23	0.30	0.39	0.21	7.9	P10	13.3	3.94	1.89	0.04	0.83	0.06	6.70
5–15	P11	23.1	4.43	1.95	0.36	0.51	0.19	8.5	P10	22.1	4.57	1.30	0.09	0.49	0.05	3.45
15–30	P11	20.4	4.70	0.84	0.14	0.22	0.16	6.3	P10	14.3	4.60	0.45	0.07	0.13	0.06	2.23
0–5	Q03	8.7	4.37	1.28	0.08	0.29	0.20	5.7	Q06	29.2	.	2.19	0.09	0.61	0.10	2.29
5–15	Q03	10.3	4.07	1.93	0.10	0.29	0.14	6.5	Q06	.	.					
15–30	Q03	.	.	2.91	0.09	0.35	0.16	6.7	Q06	.	.					
0–5	R02	16.2	4.23	1.73	0.09	0.49	0.19	.	R06	16.2	3.79	2.83	0.14	0.89	0.14	9.35
5–15	R02	17.7	4.06	0.90	0.08	0.23	0.12	.	R06	.	.					
15–30	R02	.	.	2.18	0.13	0.46	0.20	7.9	R06	.	.					
0–5	S03	18.0	3.85	0.65	0.09	0.30	0.10	7.9	S04	12.9	4.25	0.76	0.13	0.30	0.07	5.11
5–15	S03	23.9	4.52	1.04	0.13	0.57	0.12	6.9	S04	22.1	4.51	0.72	0.06	0.20	0.05	3.05
15–30	S03	17.6	5.03	0.79	0.10	0.37	0.11	6.5	S04	12.0	4.57	0.67	0.09	0.21	0.06	3.09
0–5	T02	30.4	5.06	0.57	0.16	0.16	0.11	7.1	T08	16.3	3.71	1.31	0.11	0.72	0.11	6.71
5–15	T02	16.0	4.78	1.03	0.10	0.27	0.19	6.7	T08	17.8	4.05	1.28	0.13	0.62	0.11	5.75
15–30	T02	22.8	5.25	1.02	0.13	0.25	.	5.9	T08	.	.					

Table 6.13: Soil chemistry (organic matter [LOI], pH, exchangeable cations [Ca^{2+}, K^{+}, Mg^{2+} and Na^{+}] and exchangeable acidity [EA]) by sampling layer at Lakelse Lake primary plot for 2015 and 2018.

Year Depth	2015 Plot	2015 LOI	2015 pH	2015 Ca^{2+}	2015 K^{+}	2015 Mg^{2+}	2015 Na^{+}	2015 EA	2018 Plot	2018 LOI	2018 pH	2018 Ca^{2+}	2018 K^{+}	2018 Mg^{2+}	2018 Na^{+}	2018 EA
Unit		%		meq / 100 g						%		meq / 100 g				
0–5	A10	11.4	4.79	2.02	.	0.44	0.07	4.70	A04	8.5	5.02	0.65	0.13	0.10	.	1.82
5–15	A10	5.1	5.09	1.49	0.02	0.29	0.07	2.70	A04	3.6	5.35	0.43	0.04	0.08	.	1.03
15–30	A10	4.6	5.33	0.48	0.11	0.10	0.09	1.70	A04	3.3	5.30	0.22	0.03	0.05	.	0.67
0–5	B11	5.5	4.24	1.19	0.04	0.40	0.07	2.70	B02	9.1	5.14	0.42	0.07	0.13	0.01	1.07
5–15	B11	5.1	5.21	0.94	0.03	0.27	0.07	1.70	B02	4.8	5.53	0.80	0.07	0.21	0.00	2.19
15–30	B11	2.1	5.48	1.41	0.10	0.36	0.12	1.50	B02	1.5	5.67	0.56	0.04	0.09	0.01	0.91
0–5	C02	9.6	4.71	0.32	0.06	0.29	0.05	4.50	C11	5.9	5.14	0.39	0.03	0.11	.	2.01
5–15	C02	6.7	5.03	0.18	0.05	0.11	0.04	0.70	C11	3.2	5.08	0.51	0.06	0.13	0.00	1.57
15–30	C02	4.5	5.02	0.11	0.07	0.04	0.15	0.70	C11	3.4	5.00	0.48	0.08	0.16	0.02	1.47
0–5	D05	15.1	5.53	2.65	0.19	0.57	0.03	5.50	D12	2.2	5.27	0.37	0.04	0.13	0.15	1.50
5–15	D05	10.3	5.29	1.00	0.05	0.36	0.04	2.70	D12	1.1	5.52	0.59	0.08	0.17	0.08	1.71
15–30	D05	5.9	5.30	0.68	0.16	0.22	0.14	1.10	D12	.	.					
0–5	E04	15.0	4.75	1.82	0.16	0.41	0.04	4.70	E11	22.1	5.30	0.54	0.04	0.11	0.06	1.47
5–15	E04	5.6	5.23	0.46	0.08	0.18	0.03	1.20	E11	3.8	5.40	0.29	0.03	0.07	0.03	1.25
15–30	E04	5.1	5.15	0.33	0.08	0.10	0.04	0.90	E11	2.1	5.50	1.68	0.08	0.67	0.05	0.84
0–5	F02	6.6	5.08	2.84	0.12	0.68	0.03	1.20	F01	10.4	.	1.37	0.07	0.55	0.05	4.79
5–15	F02	7.1	5.08	0.71	0.04	0.21	0.05	1.20	F01	6.5	5.08	0.56	0.05	0.18	0.09	2.07
15–30	F02	4.8	5.34	1.19	0.15	0.26	0.03	4.10	F01	8.0	5.27	0.36	0.10	0.12	0.11	1.57
0–5	G02	6.6	5.28	2.22	0.05	0.31	0.05	2.89	G01	3.7	5.22	0.38	0.06	0.15	0.08	0.53
5–15	G02	5.2	5.26	1.64	0.05	0.33	0.03	1.70	G01	3.4	5.28	0.83	0.44	0.25	.	1.41
15–30	G02	4.9	5.30	1.73	0.18	0.29	0.19	1.70	G01	2.3	5.35	0.30	0.06	0.09	0.13	0.97
0–5	H07	6.2	5.33	1.11	0.13	0.27	0.04	2.70	H05	10.3	5.23	5.82	0.46	1.03	.	1.49
5–15	H07	4.9	5.42	0.86	0.04	0.20	0.04	3.70	H05	9.7	5.44	4.00	0.18	0.63	0.10	2.09
15–30	H07	4.7	5.31	0.71	.	0.15	0.13	2.50	H05	9.3	5.31	4.16	0.13	0.53	0.06	2.03
0–5	I06	14.2	5.03	2.60	0.15	0.52	0.04	2.50	I07	7.9	4.89	0.95	0.05	0.33	0.01	4.15
5–15	I06	7.0	5.24	0.75	0.02	0.18	0.05	3.69	I07	8.5	4.97	0.68	0.06	0.22	0.02	4.05
15–30	I06	4.2	5.19	0.22	0.05	0.07	0.09	1.50	I07	1.9	5.28	0.21	0.02	0.07	0.01	1.27
0–5	J01	11.6	4.92	5.19	0.17	0.86	0.03	3.10	J05	5.9	4.61	0.67	0.04	0.38	0.08	4.43
5–15	J01	5.4	5.31	1.22	0.05	0.17	0.03	1.80	J05	4.9	4.52	0.33	0.04	0.12	0.06	2.51
15–30	J01	5.1	5.11	0.60	0.11	0.20	0.11	2.10	J05	3.8	4.88	0.35	0.03	0.13	0.07	2.49
0–5	K04	8.0	5.22	1.29	0.15	0.48	0.05	5.10	K12	7.0	5.03	1.96	0.06	0.57	0.08	3.05
5–15	K04	4.4	5.26	1.09	0.08	0.35	0.04	4.30	K12	5.8	5.07	1.60	0.07	0.40	0.07	2.85
15–30	K04	1.0	5.42	0.59	0.08	0.16	0.04	1.50	K12	3.7	5.00	1.02	0.05	0.32	0.06	2.83
0–5	L12	9.0	4.89	4.42	0.10	1.02	0.05	4.20	L05	8.2	4.87	3.52	0.13	0.77	0.10	3.87
5–15	L12	8.1	4.91	1.35	0.10	0.64	0.07	4.29	L05	5.6	4.98	1.29	0.08	0.42	0.06	3.23
15–30	L12	2.9	5.11	1.16	0.09	0.42	0.07	2.30	L05	3.9	5.24	1.10	0.09	0.26	0.12	2.11
0–5	M04	12.0	4.52	2.19	0.15	1.07	0.07	4.19	M03	7.7	5.14	0.67	0.07	0.35	0.05	1.99
5–15	M04	11.2	5.05	1.84	0.04	0.54	0.04	3.19	M03	4.0	5.58	0.40	0.04	0.12	0.09	0.99
15–30	M04	4.3	5.33	0.62	0.07	0.16	0.08	2.09	M03	2.8	5.46	0.27	0.01	0.10	0.09	1.03
0–5	N05	9.2	5.02	1.61	0.10	0.49	0.05	4.29	N06	6.0	4.58	0.78	0.06	0.35	0.07	4.19
5–15	N05	4.7	5.17	0.39	0.00	0.17	0.05	2.90	N06	5.1	5.10	0.75	0.11	0.25	0.04	2.01
15–30	N05	4.6	5.08	0.37	0.08	0.15	0.11	2.70	N06	4.1	5.16	0.74	0.11	0.21	0.03	1.74
0–5	O06	9.1	4.79	5.19	0.09	1.33	0.06	2.89	O09	6.7	4.77	2.91	0.25	1.07	0.06	3.59
5–15	O06	4.7	5.38	1.40	0.05	0.41	0.06	3.70	O09	7.5	4.85	1.88	0.33	0.68	0.11	3.53
15–30	O06	2.5	5.25	2.03	0.10	0.71	0.13	2.90	O09	5.3	4.89	0.72	0.07	0.23	.	3.09
0–5	P09	8.7	4.85	3.54	0.14	1.16	0.06	3.19	P05	6.0	5.00	2.79	0.20	0.91	0.05	3.21
5–15	P09	3.2	5.15	1.50	0.09	0.54	0.09	1.70	P05	6.3	4.80	2.45	0.13	0.78	0.06	3.41
15–30	P09	3.9	5.13	1.49	0.08	0.50	0.17	2.49	P05	3.5	5.09	1.66	0.19	0.56	0.08	4.91
0–5	Q12	12.9	5.00	2.19	0.14	0.65	0.04	3.90	Q06	6.9	4.94	1.25	0.08	0.39	0.03	3.55
5–15	Q12	9.3	5.08	0.97	0.07	0.26	0.06	2.50	Q06	4.7	4.52	0.53	0.09	0.21	0.02	3.31
15–30	Q12	4.7	5.11	0.73	0.08	0.25	0.09	3.30	Q06	5.3	4.96	0.40	0.04	0.16	0.04	3.13
0–5	R07	9.1	4.98	2.98	0.15	0.92	0.08	3.70	R02	8.2	4.77	1.49	0.10	0.38	0.01	3.83
5–15	R07	6.3	5.02	1.68	0.13	0.51	0.05	1.70	R02	6.1	4.90	0.96	0.10	0.15	0.03	3.21
15–30	R07	4.6	5.08	1.15	0.09	0.38	0.06	3.50	R02	5.4	5.11	0.49	0.08	0.14	0.03	2.33
0–5	S06	6.6	4.90	2.63	0.08	1.04	0.04	3.90	S01	6.9	5.15	4.04	0.17	0.90	0.04	2.53
5–15	S06	5.6	5.06	1.45	0.15	0.54	0.05	4.10	S01	5.9	5.20	2.93	0.10	0.72	0.04	2.67
15–30	S06	2.5	5.19	1.28	0.09	0.49	0.18	3.10	S01	4.8	5.17	1.51	0.10	0.46	0.05	2.65
0–5	T09	10.6	4.80	2.77	0.19	1.17	0.04	4.79	T02	13.5	4.67	2.83	0.17	1.14	0.06	4.03
5–15	T09	5.4	4.97	0.97	0.15	0.30	0.11	4.30	T02	4.4	5.07	1.12	0.09	0.45	0.11	0.82
15–30	T09	4.2	4.97	0.88	0.11	0.25	0.13	3.10	T02	3.1	4.98	1.40	0.08	0.55	0.10	2.83