Citizen Science in Severn Sound

2017 Report:

Citizen Science Stream Monitoring in Copeland Forest

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Ontario
Ministry of the Environment and Climate Change

Severn Sound Environmental Association

copeland forest friends

Lake Huron - Georgian Bay Watershed
A Canadian Initiative for Community Action

WWF
WWF Supported Project
WWF Canada Go Wild Community Grants
presented by TELUS

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Introduction

Severn Sound is a group of bays covering approximately 130 km^2 located in the Southeast corner of Georgian Bay. Covering and area of approximately 1000 km^2, its watershed includes seven major tributaries: the Coldwater, Sturgeon, Wye, North, and Severn Rivers, and Hogg and Copeland Creeks. Severn Sound was listed as an Area of Concern on the Great Lakes, and through the implementation of a Remedial Action Plan, was delisted in 2003. The Severn Sound Environmental Association (SSEA) was established to coordinate implementation of this plan, and currently continues as a joint municipal service board with 8 municipal partners: Oro-Medonte, Severn, Springwater, Tiny and Tay Townships, and Towns of Midland and Penetanguishene.

Copeland Forest is a 1780 ha (4400 acre) Resource Management Area owned and managed by the Ministry of Natural Resources and Forestry (MNRF) in the Township of Oro-Medonte, Simcoe County, approximately 1.5 hr north of Toronto (Figure 1). It is the headwaters for 3 rivers within the Georgian Bay catchment area – the Sturgeon and Coldwater Rivers which flow to Severn Sound, and Willow Creek, which flows to Nottawasaga Bay via the Nottawasaga River. The majority of the forest falls within the Severn Sound watershed, with the remainder falling in the Nottawasaga River watershed (under jurisdiction of the Nottawasaga Valley Conservation Authority).

The area is at the northern edge of the Oro Moraine, and parts of the Copeland Forest are considered significant groundwater recharge areas (South Georgian Bay-Lake Simcoe Source Protection Committee, 2011). Copeland Forest overlays a highly vulnerable aquifer, a designation given to aquifers that can be easily changed or affected by contamination from both human activities and natural processes (South Georgian Bay-Lake Simcoe Source Protection Committee, 2011). Copeland Forest is also a regionally significant Area of Natural and Scientific Interest (ANSI). The area is dominated by wetland and forest cover, much of which meets the criteria of being interior habitat (Environment Canada, 2013). It is home to rare and at-risk flora and fauna, including Eastern Pondmussels and Butternut trees, and has a high diversity of plants (Jones and Morton, 2012).

Given its importance as a headwater area and high quality, diverse habitat, it is critical that ecological integrity and water quality be monitored in the forest. Current pressures on the area include development, climate change, and invasive species.

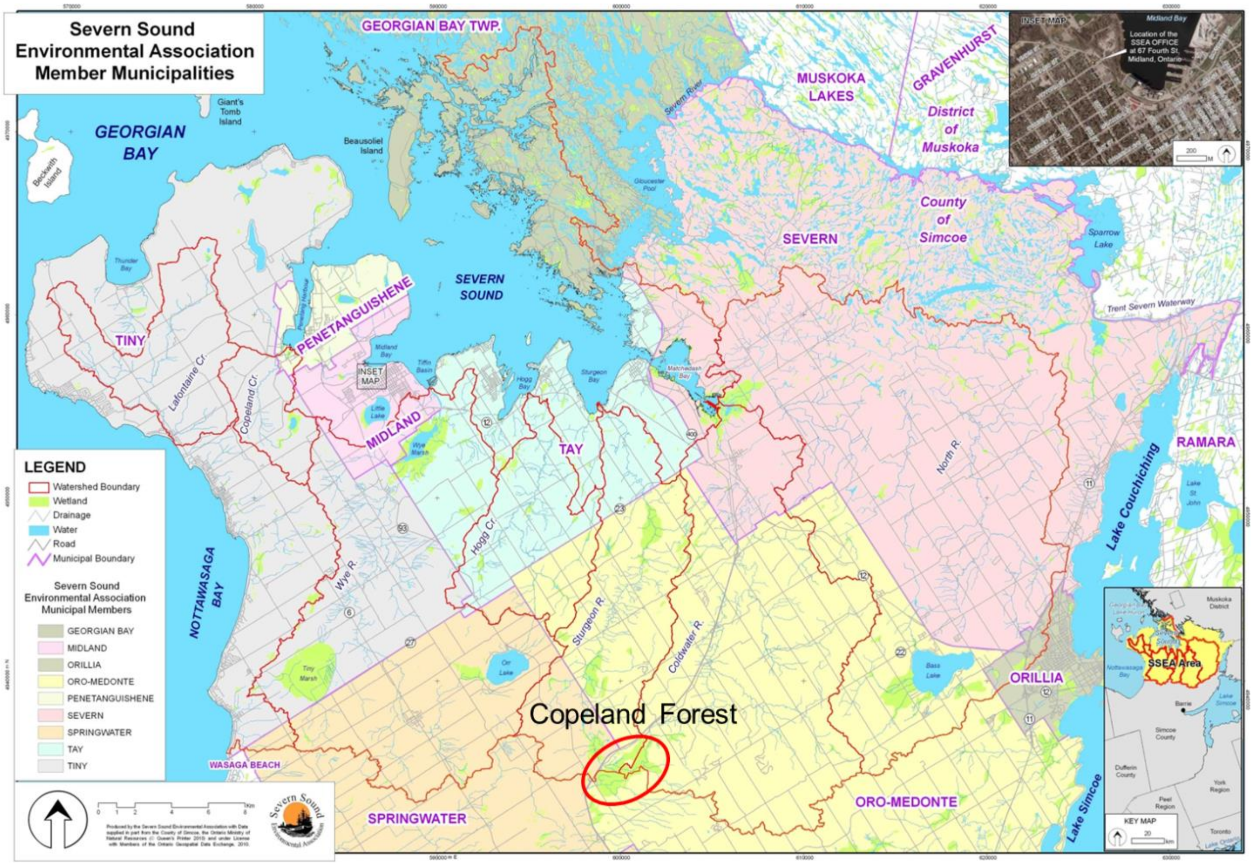


Figure 1. Map showing the location of Copeland Forest within the Severn Sound Watershed.

Existing development around Copeland Forest is within the Coldwater River subwatershed and to a lesser extent within the Willow Creek subwatershed. Land uses adjacent to Copeland Forest include downhill ski resorts, golf courses, and residential development. Due to the sensitivity of Copeland Forest, it is important that potential impacts of any activities in and around the forest be carefully considered and managed.

Copeland Forest contains a labyrinth of trails, and is enjoyed by a diversity of user groups, including mountain bikers, horseback riders, cross-country skiers, hikers, hunters and anglers, and nature enthusiasts. The Copeland Forest Friends Association (CFFA) was formed to act as a liaison between these user groups and the MNRF, ensuring equal representation for all recreational users. The CFFA's mandate is to: *conserve the natural integrity of Copeland Forest while facilitating compatible recreational use.* To this end, a volunteer water testing program was established in 2016 to monitor seven tributaries in the forest (six in the Severn Sound watershed, see Figure 2, Table 1).

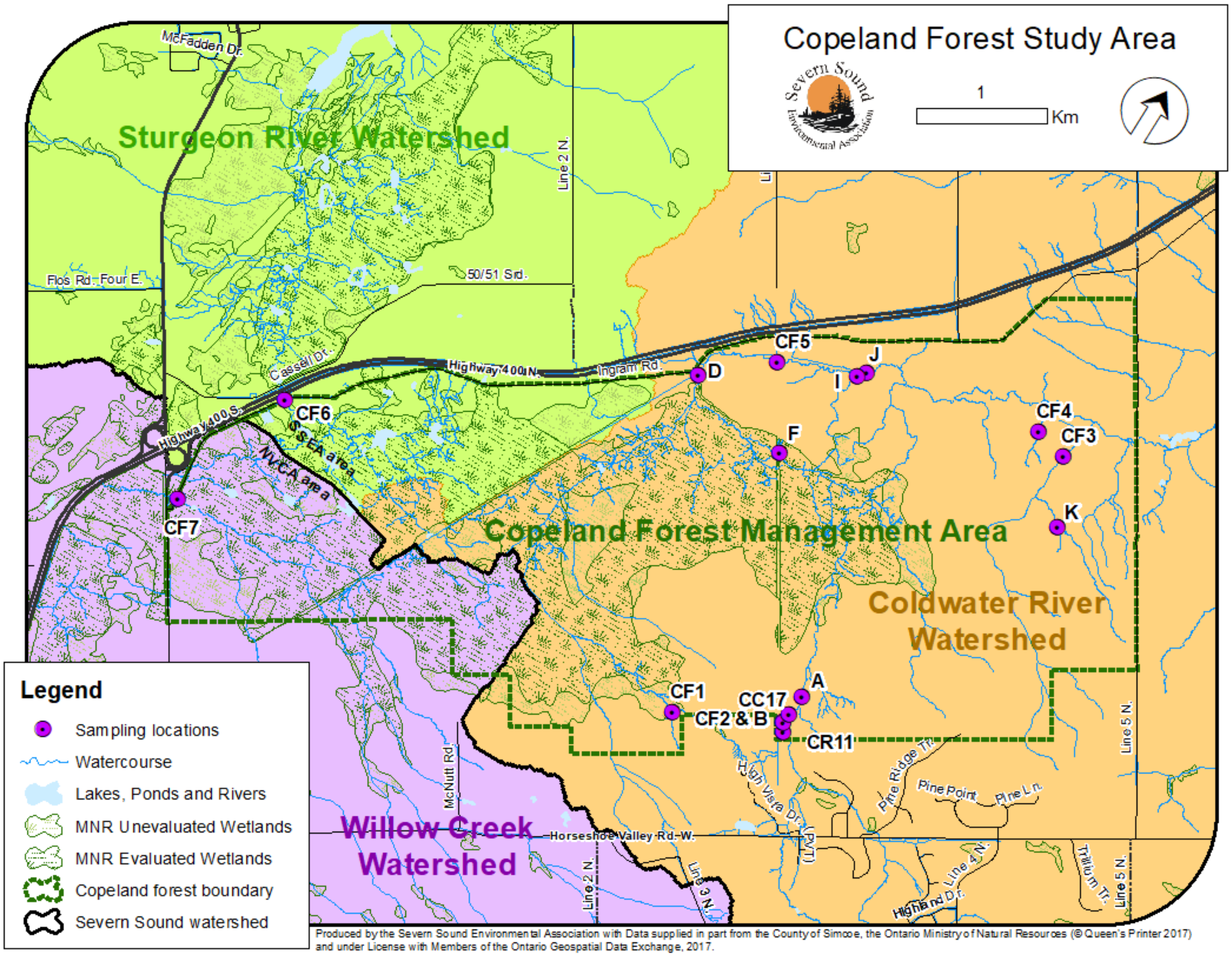


Figure 2. CFFA sampling sites visited in 2017 by CFFA water tester volunteers. Note that CF7 was not sampled by SSEA but was sampled by CFFA volunteers. All sampling locations shown also had temperature loggers installed with the exception of CF3.

Table 1. CFFA sampling sites visited by CFFA water testers, and locations where temperature loggers were installed in 2017. Two historic SSEA stations were used for temperature sites as well.

Station	Easting	Northing	Chem/Temp	Site Description
CF1	603987	4934315	Both	By pump house on southern boundary of Copeland Forest; turn west of Grand Allee at 30 on trail map
CF2	604742	4934695	Chem	Just east of Grand Allee, between 31 and 32 on trail map
CF3	605486	4937544	Chem	Enter on path just south of Coldwater River heading west off Line 5
CF4	605226	4937600	Both	On next stream just west of Site 3
CF5	603255	4937000	Both	Coldwater River just south of P1 on trail map
CF6	600216	4934771	Both	Where Sturgeon River leaves Copeland Forest and crosses Ingram Rd.
CF7	599919	4933701	Both	Where Matheson Creek leaves Copeland Forest and crosses Ingram Rd.
A	604760	4934936	Temp	Upstream from station CF2

Station	Easting	Northing	Chem/Temp	Site Description
B	604745	4934687	Temp	Slightly upstream from CF2; considered same station
D	602800	4936597	Temp	At the Ducks Unlimited pond
F	603630	4936420	Temp	Along the 3rd line road allowance where the stream crosses
I	603881	4937287	Temp	Where southern tributary joins main Coldwater R branch downstream of CF5
J	603827	4937228	Temp	Where northern tributary joins main Coldwater R branch downstream of CF5
K	605735	4937064	Temp	Downstream of pond, upstream of CF3
CC17	604750	4934767	Temp	Upstream from station CF2, SSEA station
CR11	604786	4934627	Temp	East branch, SSEA station

In 2017, the SSEA partnered with the CFFA to establish a citizen science program to monitor Copeland Forest tributaries. This work supports historical CFFA sampling, and provides a means of data verification. More detailed sampling also helps to establish a baseline of water quality and temperature information for Copeland Forest tributaries. This report summarizes the data collected through the citizen science pilot project.

Sampling Methods

A variety of sampling was conducted using different methods under different sampling programs. SSEA's citizen science monitoring was designed to augment existing volunteer based CFFA water testing program.

SSEA Citizen Science Program

A Community Environmental Monitoring (CEM) kit was developed by SSEA and was used by the CFFA volunteers alongside their testing program. The kit contained Hannah meters, which take instantaneous measurements of temperature, conductivity, pH and total dissolved solids (TDS) and temperature loggers, which take continuous measurements at pre-set intervals, in this case 30 min. The meters were used at each site on between one to three sampling visits through the summer/fall season. Temperature loggers were installed in late spring at stations all sites (except CF3 due to insufficient depth), plus 7 additional sites, and were retrieved and downloaded in late fall. A thermal stability model will be used to classify reaches of streams based on suitability for cold, cool or warm water fish communities once all data has been processed.

CFFA Water Testing Program

The CFFA volunteers used a LaMotte water quality test kit that measures: water and air temperature, pH, dissolved oxygen concentration, phosphate, nitrate, alkalinity, and turbidity. Tests were conducted with this kit on a monthly basis at 7 locations in Copeland Forest. The testing methods for phosphate and nitrate using these kits are not sensitive enough to detect low range of concentrations found in relatively pristine surface waters, so these data will not be used in this report. To give some context, the kit measures concentrations as low as 0.2 ppm, or 200 µg/L for phosphate (which is a fraction of total phosphorus) whereas the anticipated range for total phosphorus in Copeland Forest is 2-15 µg/L. Similarly for nitrate, the kit measures nitrate concentrations as low as 0.1 ppm, or 100 µg/L, whereas the anticipated range is 5-1000 µg/L. Most sites are anticipated to have concentrations less than 100 µg/L during the growing season.

SSEA Tributary Monitoring Program

Under this program, SSEA was able to send samples collected on Oct 30 from each site (except CF7) to the Ministry of Environment and Climate Change (MOECC) lab at the Dorset Environmental Science Centre (DESC). Samples were analyzed for a suite of variables including: dissolved organic and inorganic carbon, colour, total nitrogen, total ammonia, total nitrate, total Kjeldahl nitrogen, total phosphorus, silicate, total and gran alkalinity, conductivity, pH, calcium, potassium, magnesium, and sodium. All nitrogen and phosphorus analyses are done using low level methods.

Results and Discussion

Based on data collected by the CFFA volunteers using their test kits and the CEM kit, some patterns begin to emerge that provides more information about the nature of the tributaries within Copeland Forest, and the potential stresses on some of them. Measurements were made with the Hannah meters in spring (May 24), and fall (Sept 20, Oct 30 and/or Nov 14) at all stations, except CF6 and CF7. Conductivity measured using the Hannah meters at CF2 (range of 729-770 µS/cm) was more than or nearly double the value for all other sites (range of 240-433 µS/cm) (Table 2). There was a relatively narrow range for field pH of 7.32-8.31. Given the high conductivity of all the tributaries sampled, which likely indicates strong groundwater influence, high pH values were expected. Sites CF5 and CF6 were colder in late fall (Oct 30) than the others, but were warmer in late spring (May 24) and early fall (Sept 20). This is likely due to the influence of the wetlands upstream of these sites.

Table 2. Field data collected using the Hannah meters in 2017 for all Copeland Forest sites, including CF7. Data for CF5 and CF6 on Oct 30 was collected using a YSI ProDSS multi-parameter sonde, and pH was not functioning at the time. A site directly downstream of the cross country centre parking lot was also sampled on Sept 20.

Date	Station	Conductivity (µS/cm)	pH	Water Temp (°C)
24/05/2017	CF1	394	7.80	9.9
20/09/2017	CF1	398	7.84	9.9
30/10/2017	CF1	401	8.06	7.3
24/05/2017	CF2	770	7.77	11.2
20/09/2017	CF2	729	8.31	15.7
30/10/2017	CF2	756	7.85	7.7
24/05/2017	CF3	298	7.57	13.3
30/10/2017	CF3	358	7.59	7.5
24/05/2017	CF4	294	7.62	12.8
30/10/2017	CF4	353	8.00	7.4
14/11/2017	CF4	240	8.20	5.3
24/05/2017	CF5	405	7.46	18.4
20/09/2017	CF5	433	7.60	18.9
30/10/2017	CF5	393	n.d.	6.8
24/05/2017	CF6	335	7.44	18.5
30/10/2017	CF6	341	n.d.	6.9
24/05/2017	CF7	306	7.32	18.4
20/09/2017	DS of parking lot	590	7.89	17.7

Temperature loggers provided high resolution data for 12 of the 14 locations within Copeland Forest. A logger went missing from station CF2/B, and the logger at station CC17 was mistakenly set to record every 5 sec, so the battery died after 2 days. The minimum and maximum temperature was calculated for each location for the season, as well as the minimum and maximum daily temperature range (Table 3). Note that for stations A-K, loggers were installed in mid to late June, while all other loggers were installed in late May. The high maximum temperature and large temperature range at stations D, and CF5 are due to the influence of the Ducks Unlimited pond upstream of the site. Similarly, CF6 is influenced by the nearby beaver pond and upstream wetlands. It also appears that stations F, CF7, and J are influence to a greater degree by surface water than by groundwater. Station J has particularly high maximum temperatures; most of the flow to this stream comes from roadside drainage ditches along Highway 400. Based on low maximum temperatures and generally small daily temperature ranges, stations CF1, CR11, CF4, A, I, and K are largely groundwater influenced and represent excellent coldwater habitat. An example of seasonal temperature fluctuations and daily ranges is shown for CF5 in Figure 3 (graphs for all other stations are in Appendix A,

Figure 6). Note the dramatic increase in stream temperature in September to nearly mid-summer values, and to a lesser extent in early October, following the periods of hot weather in the area (Figure 4). This pattern was observed at all of the other stations to varying degrees. The spikes in temperature at CF1 (Figure 6) were directly linked to rainfall greater than 20 mm as recorded in Orillia.

Table 3. Summary statistics for temperature measurements in Copeland Forest tributary.

Station	Date Range	Min Temp (°C)	Max Temp (°C)	Min of Range (°C)	Max of Range (°C)
CF1	May 24-Oct 19	7.1	15.5	0.4	6.0
CR11	May 24-Oct 19	8.2	20.1	1.0	6.1
CF4	May 24-Oct 19	7.8	17.2	0.3	3.8
CF5	May 24-Oct 19	9.0	26.8	0.9	7.7
CF6	May 24-Oct 30	6.5	25.1	0.1	8.3
CF7	Jun 29-Oct 20	8.6	22.8	0.7	5.6
A	Jun 15-Oct 19	7.9	18.8	0.4	5.0
D	Jun 29-Oct 19	8.7	29.3	0.1	7.3
F	Jun 29-Oct 20	7.8	26.1	0.9	5.3
I	Jun 29-Oct 20	7.7	21.7	0.5	10.4
J	Jun 29-Oct 20	8.0	29.0	1.5	9.4
K	Jun 29-Oct 19	7.2	19.2	0.4	4.2

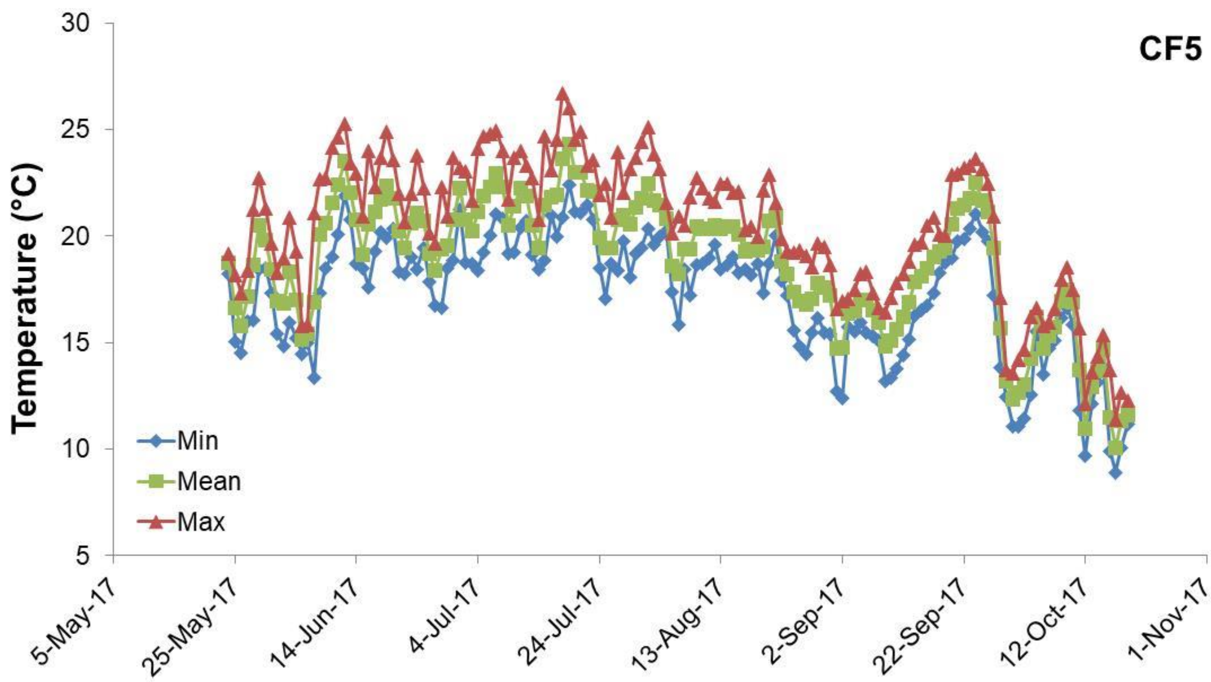


Figure 3. Daily minimum, mean and maximum water temperature for station CF5.

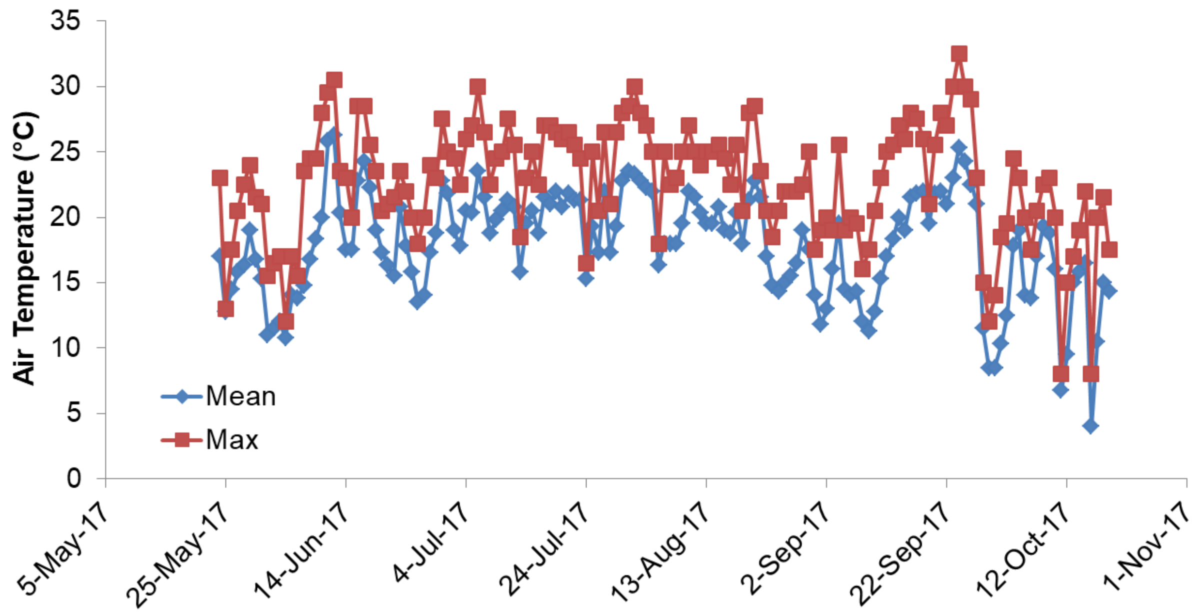
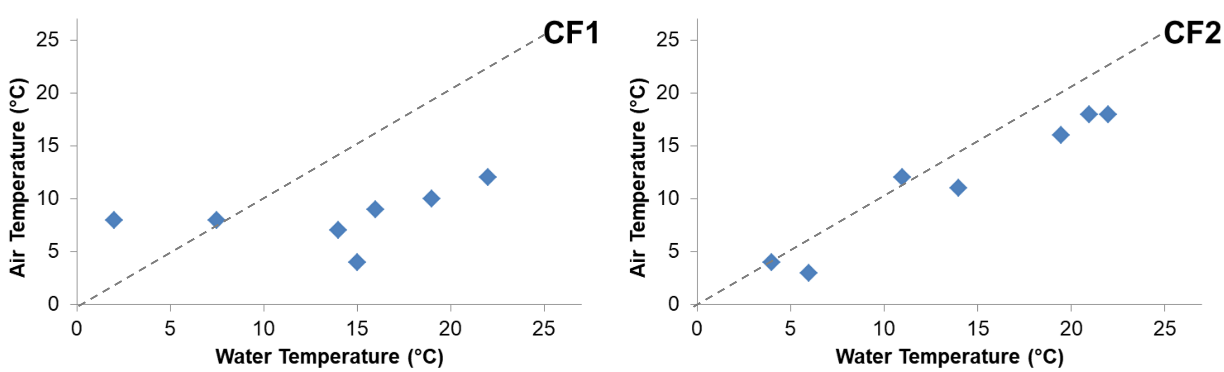


Figure 4. Mean and maximum daily air temperature from the Environment Canada and Climate Change weather station in Coldwater.

Data from the LaMotte kits summarized as annual medians and standard deviation verify the patterns described above (Table 4, see Appendix B - Table 7 for full dataset). CF5 and CF6 are warmer on average based on temperature data, which was verified by the temperature logger data. Tributaries that are mainly influenced by groundwater and are classified as cold or coolwater streams in terms of fish habitat suitability have temperatures that do not increase as much with rising air temperature as tributaries classified as warm water streams, a characteristic called thermal stability. Tributaries that are groundwater fed provide excellent habitat for coldwater fish species such as brook trout. Based on a coarse analysis using CFFA air and water temperature data, it is apparent that CF1, CF3 and CF4 have the strongest groundwater influence with temperatures that do not exceed 12°C despite air temperatures reaching 27°C (Figure 5). In contrast, sites CF2, CF5, CF6 and CF7 had maximum water temperatures of 19-20°C with air temperatures of approximately 22°C.



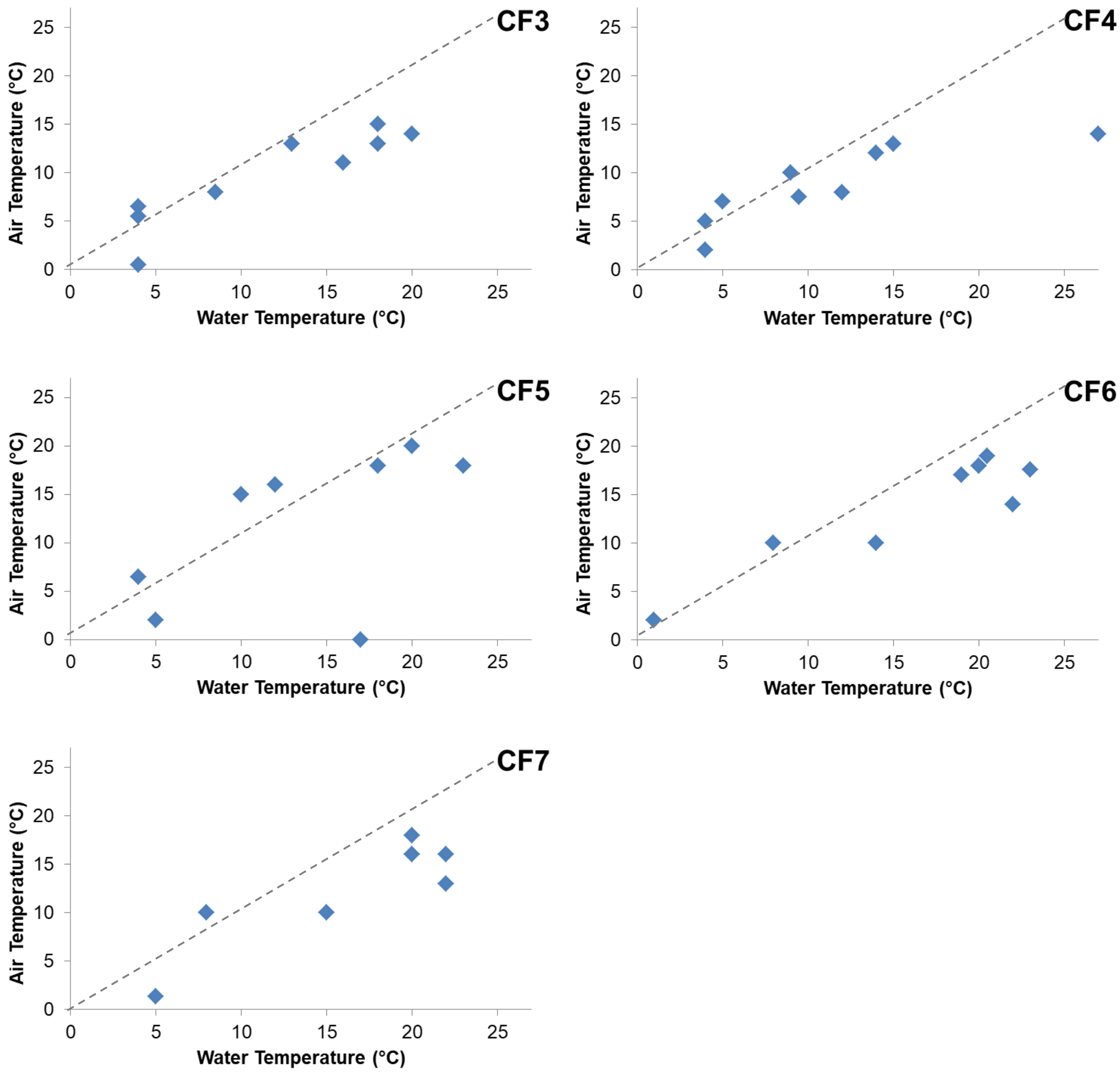


Figure 5. Air versus water temperature using volunteer data from Copeland Forest sites. The dashed line represents a 1:1 relationship for reference.

In terms of water chemistry, pH results showed a narrow range, from 6.5-7.0. The pH is likely underestimated by the LaMotte kits. Dissolved oxygen (DO) ranged from 6.7-9.2, which is above the threshold required for invertebrates and coldwater fish survival and reproduction. Alkalinity at CF2 was higher (240 mg/L) than all of the other stations (medians ranged 150-184 mg/L), pointing to a calcium carbonate-based material influencing this site.

Table 4. Summary statistics from field data collected by CFFA volunteers in 2017 using the LaMotte kits. Annual median and standard deviations are shown.

Station	Parameter	Water Temp (°C)	Water Depth (cm)	pH	DO (mg/L)	Alkalinity (mg/L)
CF1	Median	8	18	7.0	8.8	184
CF1	SD	2	78	0.2	0.7	23
CF2	Median	12	14	7.0	7.4	240
CF2	SD	6	4	0.5	2.4	49
CF3	Median	11	10	7.0	8.1	156
CF3	SD	5	11	0.3	2.6	31
CF4	Median	8	10	7.0	9.2	150
CF4	SD	4	4	0.4	1.3	27
CF5	Median	16	28	6.5	6.7	168
CF5	SD	7	13	0.4	1.5	19
CF6	Median	16	51	6.8	6.7	160
CF6	SD	6	104	0.5	2.1	43
CF7	Median	13	31	7.0	7.0	160
CF7	SD	6	84	0.4	2.6	50

Data was collected using different methods at the same sites on May 24 and Oct 30, providing an opportunity to compare methods (Appendix C - Table 8, Table 9). Conductivity was comparable using the Hannah meter, ProDSS sonde and DESC lab. Temperature data was consistent using the LaMotte kit (alcohol thermometer), Hannah meter and ProDSS sonde. pH readings from the ProDSS sonde were higher than the Hannah meter, which in turn were higher than using the LaMotte kit. Hannah meter pH values compared best to lab results from DESC. Turbidity was measured in different units using the ProDSS sonde and LaMotte kits and so was not directly comparable. The LaMotte kit tended to underestimate dissolved oxygen both in concentration and percent saturation compared to the ProDSS sonde. Alkalinity was more variable using the LaMotte kit compared to results from the DESC lab.

Despite differences in analytical precision and accuracy, data from samples sent to the MOECC lab confirmed patterns that were observed using the CEM kit, and CFFA's sampling kits in terms of conductivity and alkalinity (Table 5). Further cation and anion analysis provided more information on the nature of the water chemistry at site CF2. Chloride, calcium, and sodium are all elevated far above what would be considered background level for Copeland Forest tributaries. The ranges for total alkalinity, conductivity, and calcium are fairly narrow for all sites other than CF2 (157-187 mg/L $CaCO_3$, 333-407 µS/cm, 67.13-71.01 mg/L, respectively). Chloride and sodium are slightly elevated at CF5 potentially indicating road salt influence from Highway 400. Sulphate is slightly elevated at CF1 and CF2, the reason for which is unclear at this time. CF3 and CF4 have very low ion content aside from calcium which shows high values consistent with limestone (calcium carbonate) geology, and smaller amounts of magnesium than the other sites. The following minerals are common components of sedimentary rock, and likely occur in varying amounts across the forest, explaining some of the differences in ion water chemistry: gypsum (calcium sulphate), calcite (calcium carbonate), halite (sodium chloride), and dolomite (calcium magnesium carbonate).

Table 5. Basic water chemistry lab results from samples collected Oct 30 and sent to MOECC DESC lab, including anions and cations.

Station	Total Alkalinity (mg/L $CaCO_3$)	Conductivity (µS/cm)	pH	Chloride (mg/L)	Sulphate (mg/L)
CF1	187	407	8.05	10.19	12.33
CF2	273	783	8.15	78.41	13.69
CF3	177	344	7.89	0.56	5.43
CF4	171	333	8.02	0.66	5.71
CF5	171	403	7.94	21.96	6.84
CF6	157	347	7.79	12.19	6.12
Station	**Calcium (mg/L)**	**Potassium (mg/L)**	**Magnesium (mg/L)**	**Sodium (mg/L)**	**Silicate (mg/L)**
CF1	61.80	1.71	17.43	4.47	5.56
CF2	98.00	2.27	15.48	28.21	4.34
CF3	71.01	1.11	6.97	1.65	4.32
CF4	68.09	0.91	6.43	1.49	4.16
CF5	61.13	1.92	14.68	11.37	4.64
CF6	52.19	1.73	13.97	5.51	5.08

Nutrient chemistry shows additional patterns (Table 6). Dissolved inorganic carbon was again highest at CF2, and indicates the high carbonate content of the water. Dissolved organic carbon, which gives water a tea-stained appearance as measured by colour, tended to be high downstream of wetlands, as evidenced by elevated levels at CF5 and CF6, and to a lesser extent CF3 and CF4. Total phosphorus was uniform across the forest, with the exception of CF3. This stream was very shallow, and it is likely that the sample was contaminated with sediment, resulting in a falsely elevated result. Total nitrogen was high at CF1 and CF2, due to high levels of nitrate, while ammonia and total Kjeldahl nitrogen (a measure of organic nitrogen) were low at all stations. These high nitrate levels warrant further investigation.

Table 6. Water quality lab results from samples collected Oct 30 and sent to MOECC DESC lab.

Station	Dissolved Inorganic Carbon (mg/L)	Dissolved Organic Carbon (mg/L)	Colour (TCU)	Total Phosphorus (µg/L)
CF1	45.8	0.7	3.9	4.07
CF2	61.2	1.9	8.1	3.81
CF3	45.1	3.3	27.7	11.81
CF4	42.8	3.0	18.6	4.30
CF5	42.3	5.2	24.1	4.63
CF6	39.7	7.0	40.5	3.41
Station	**Total Nitrogen (µg/L)**	**Total Kjedahl Nitrogen (µg/L)**	**Total Nitrate +Nitrite (µg/L)**	**Total Ammonia +Ammonium (µg/L)**
CF1	1530	81	1449	2.7
CF2	1570	134	1436	3.1
CF3	120	120	<5	1.1
CF4	120	120	<5	1.6
CF5	320	204	115	3.8
CF6	270	263	7.2	3.8

Summary and Recommendations

Copeland Forest is a pristine and important natural heritage feature, one that benefits local residents and visitors to the area. Protection of water quality in the forest is critical, as it serves as important habitat for numerous fish and wildlife species and its tributaries are the headwaters of several major tributaries that flow to Georgian Bay. Many of the tributaries within Copeland Forest are groundwater-fed, serving as important coldwater fish habitat.

The sampling conducted by the CFFA and the SSEA has demonstrated that water quality is good overall, however there are water quality impacts on the upper reaches of the Coldwater River at sites CF1 and CF2, which have been detected in the past.

It is recommended that the CFFA continue their water testing program, engaging their excellent volunteers. SSEA recommends that they continue to use the Hannah meters in their monitoring program. Although the LaMotte kits are not sensitive enough to detect nitrate at the concentrations they occur in most of the Copeland Forest tributaries, CFFA volunteers may wish to continue doing these tests at CF1 and CF2 since concentrations were within the detection limit of the nitrate test.

Acknowledgements

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References

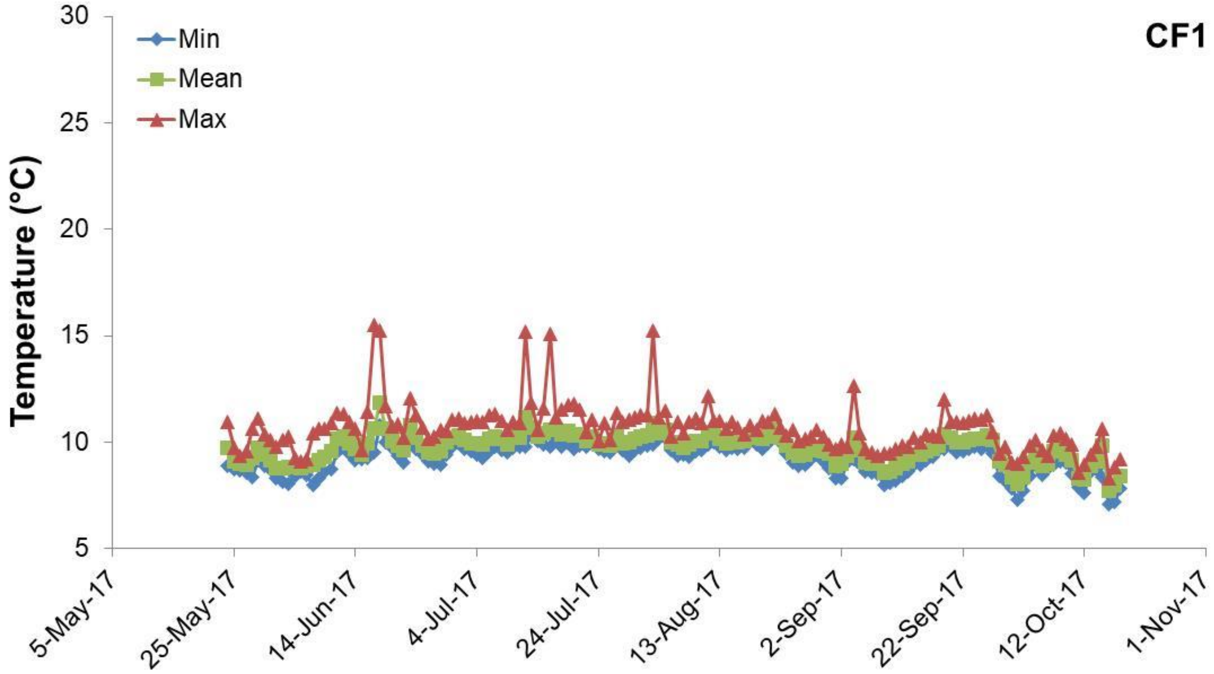
Environment Canada. 2013. How Much Habitat is Enough, 3rd Ed. Environment Canada, Toronto, Ontario.

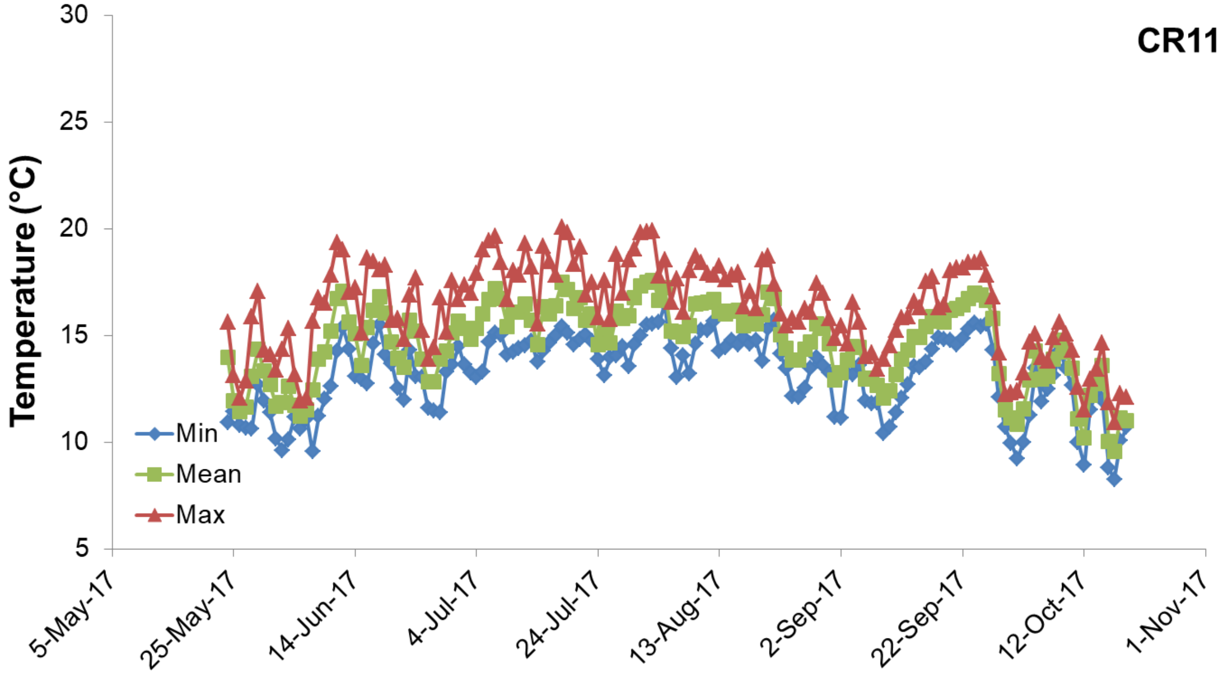
Jones J., and J. Morton, 2012. Life Science Inventory of Copeland Forest Resource Management Area.

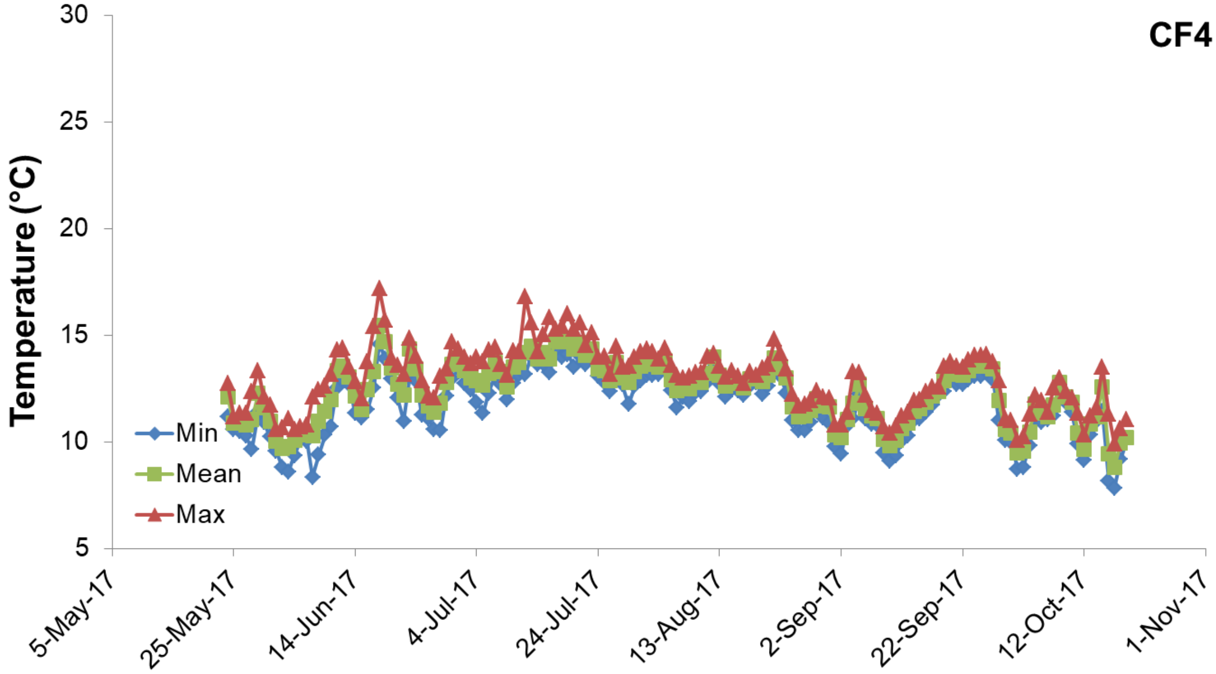
South Georgian Bay-Lake Simcoe Source Protection Committee., 2011. Approved Assessment Report: Severn Sound Source Protection Area.

Appendix A

Figure 6. Daily minimum, mean and maximum water temperature for stations CF1, CR11, CF4, CF5, CF6, CF7, A, D, F, I, J, K.



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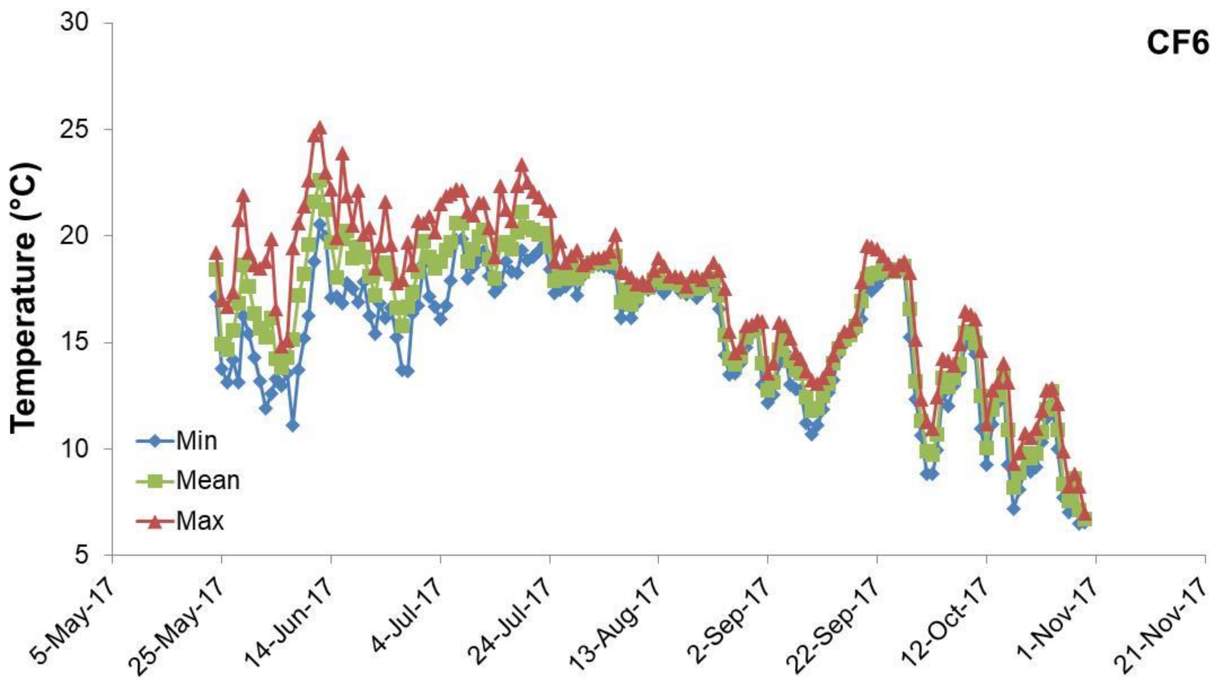
22-Sep-17
12-Oct-17
1-Nov-17


CF6
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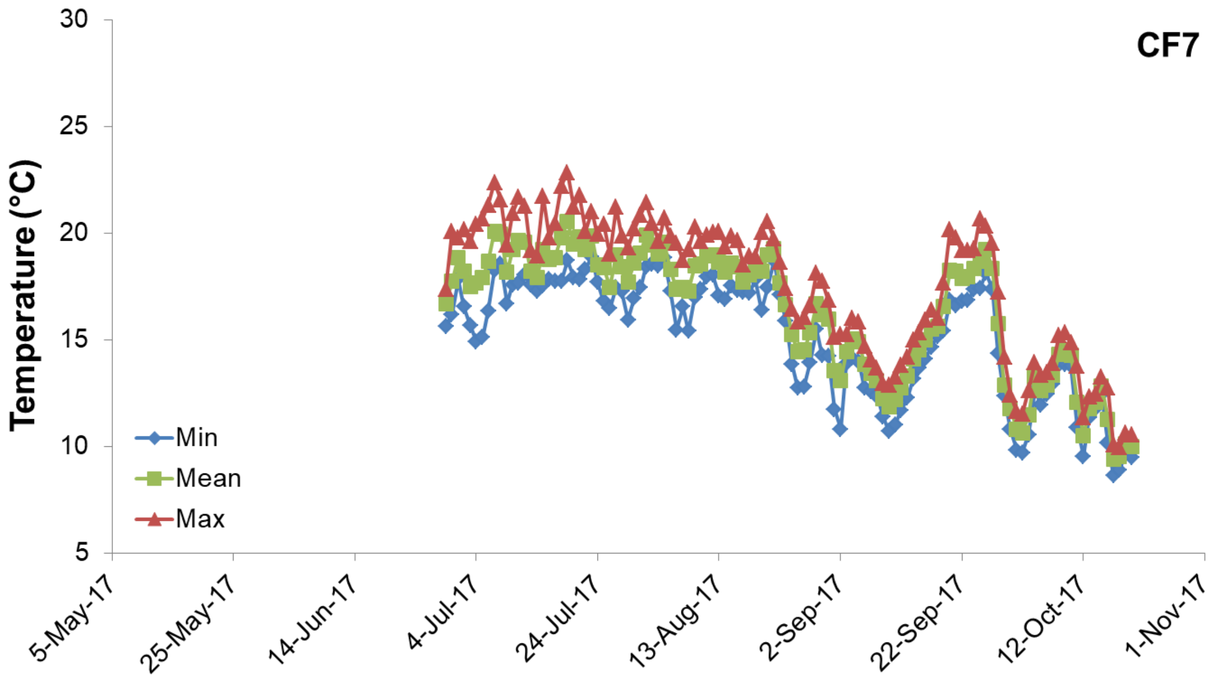
1-Nov-17
21-Nov-17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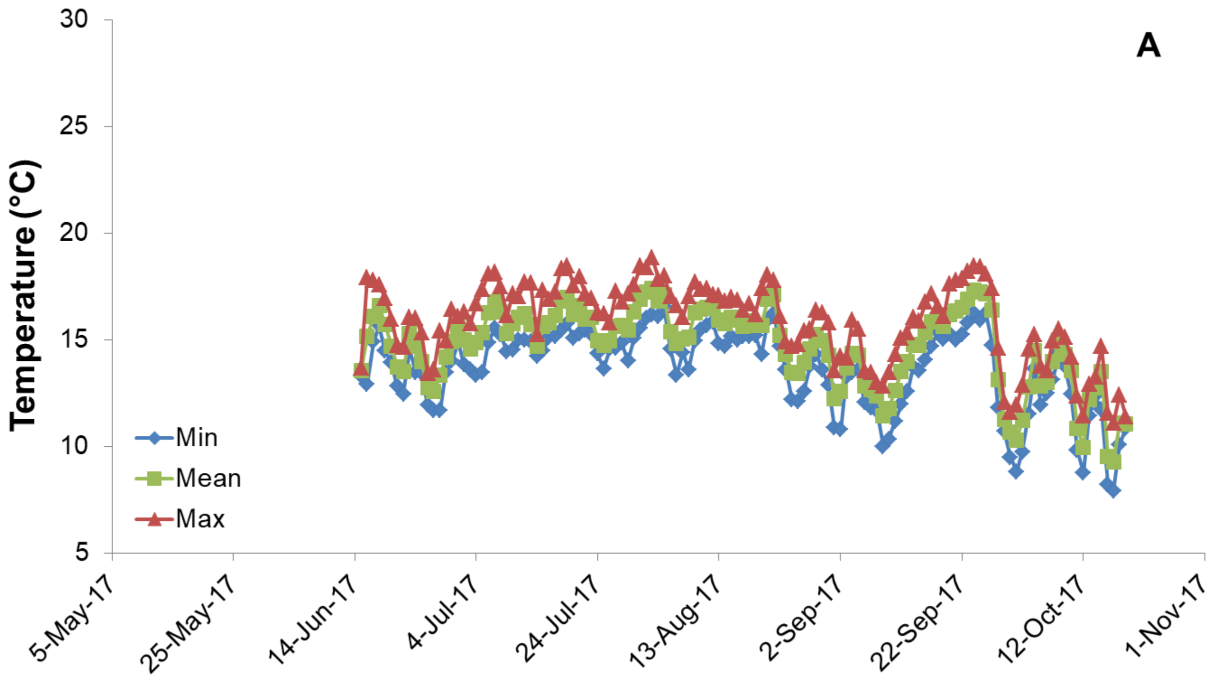
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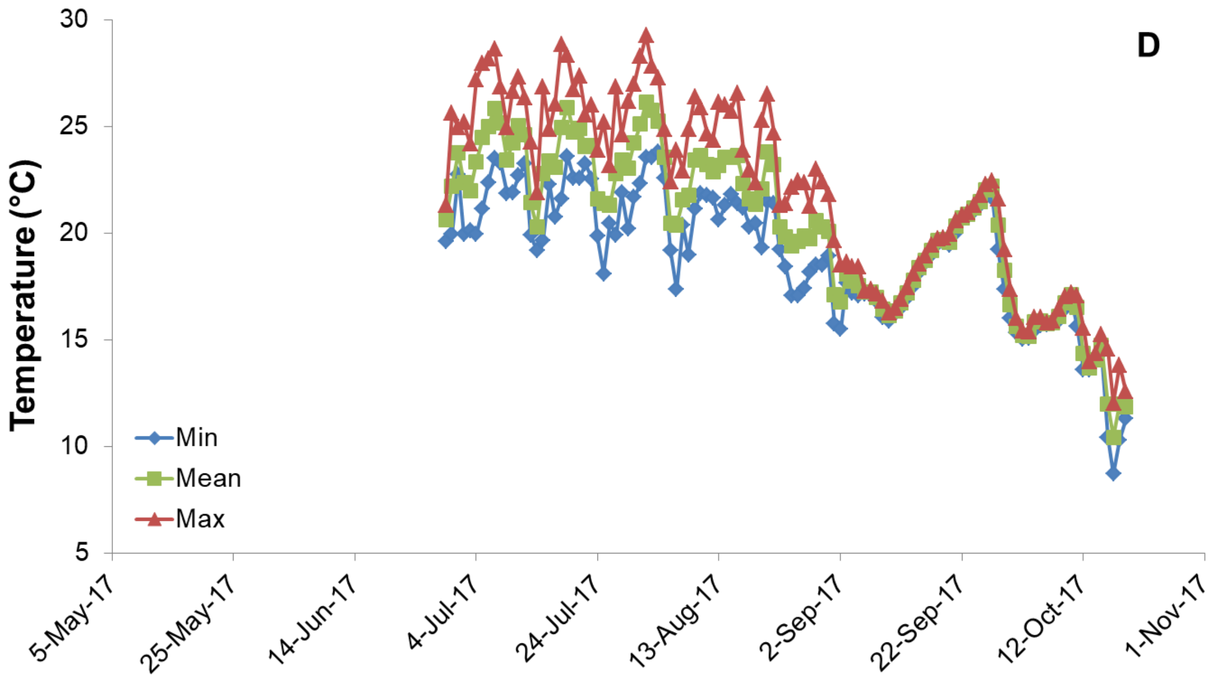
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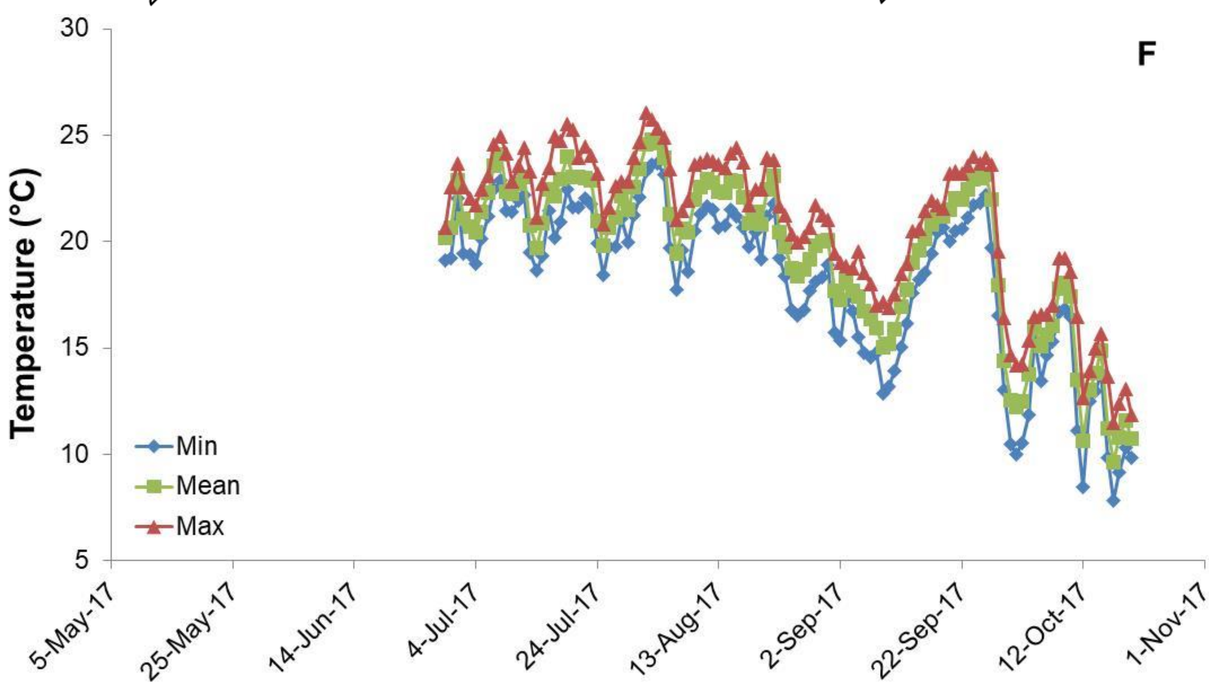
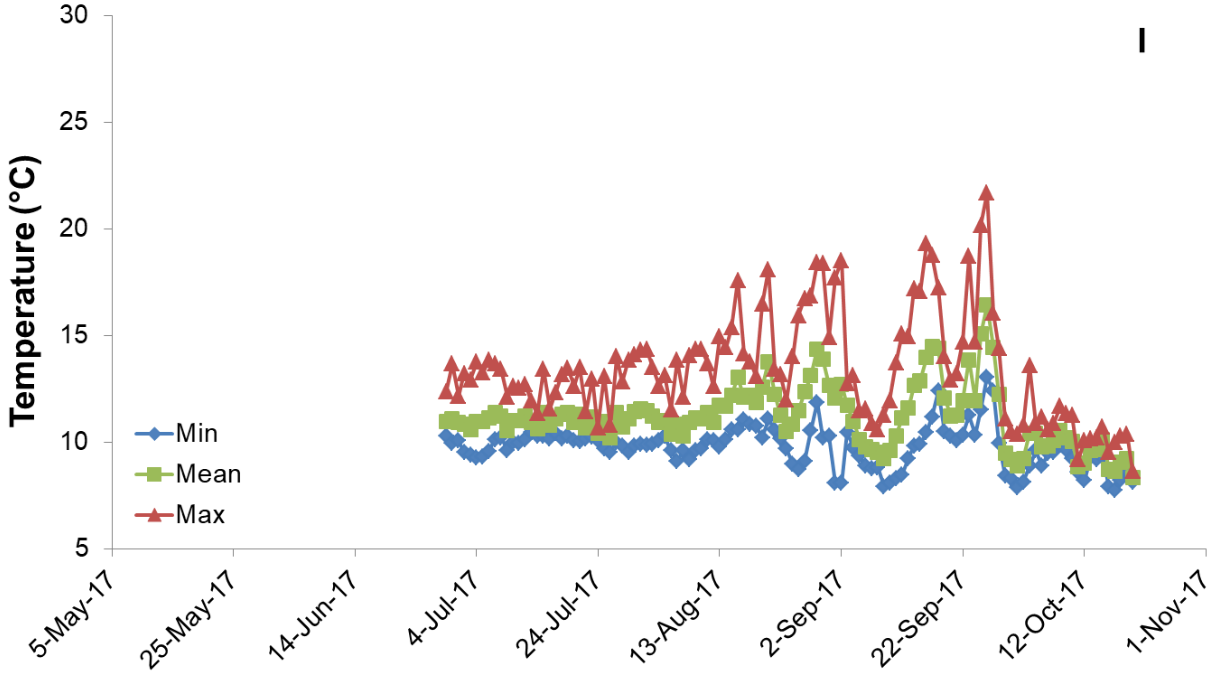
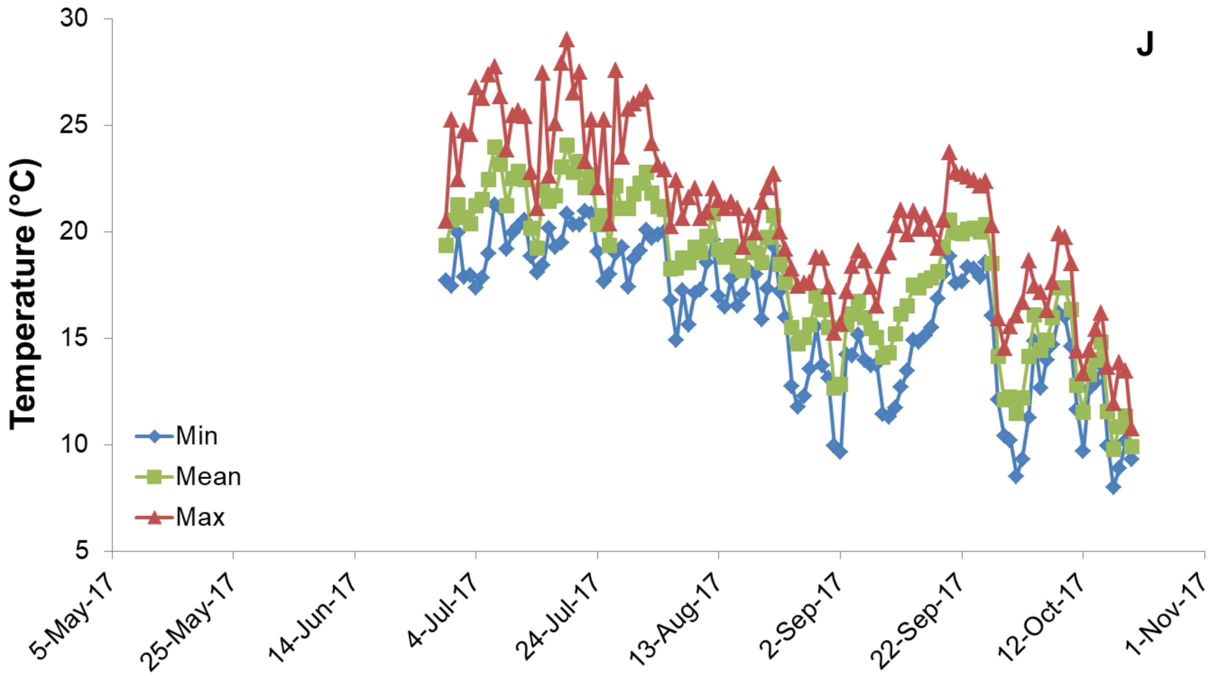
22-Sep-17
12-Oct-17
1-Nov-17


F
Temperature (°C)
30
25
20
15
10
5
Min
Mean
Max
5-May-17
25-May-17
14-Jun-17
4-Jul-17
24-Jul-17
13-Aug-17
2-Sep-17
22-Sep-17
12-Oct-17
1-Nov-17


I
Temperature (°C)
30
25
20
15
10
5
Min
Mean
Max
5-May-17
25-May-17
14-Jun-17
4-Jul-17
24-Jul-17
13-Aug-17
2-Sep-17
22-Sep-17
12-Oct-17
1-Nov-17


J
Temperature (°C)
30
25
20
15
10
5
Min
Mean
Max
5-May-17
25-May-17
14-Jun-17
4-Jul-17
24-Jul-17
13-Aug-17
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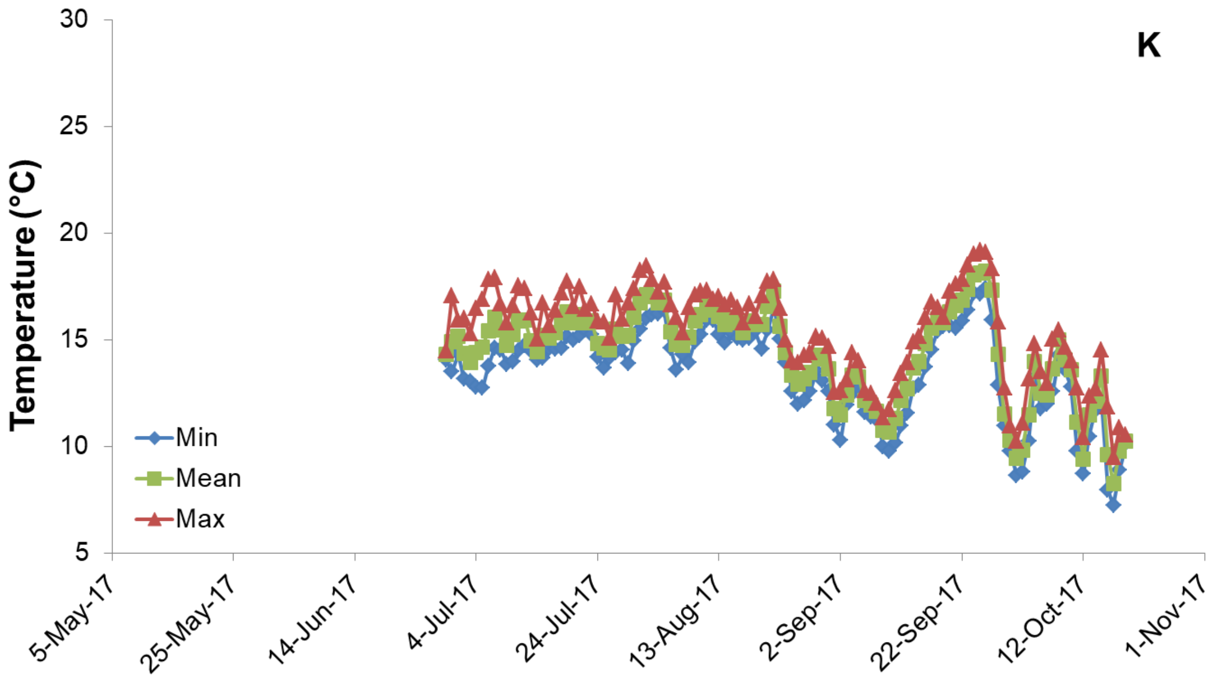
22-Sep-17
12-Oct-17
1-Nov-17



K
Temperature (°C)
30
25
20
15
10
5
Min
Mean
Max
5-May-17
25-May-17
14-Jun-17
4-Jul-17
24-Jul-17
13-Aug-17
2-Sep-17
22-Sep-17
12-Oct-17
1-Nov-17

Appendix B

Table 7. Data collected by CFFA water tester volunteers, 2017. "n.d." indicates no data available.

Station	Date	Time	Air Temp (°C)	Water Temp (°C)	Water Depth (cm)	pH	DO (mg/L)	Alkalinity (mg/L)
CF1	03/04/2017	14:16	14	7	15	7.0	n.d.	160
CF1	15/05/2017	14:30	15	4	18	6.5	9.0	165
CF1	24/05/2017	10:55	16	9	126	7.0	8.4	168
CF1	09/07/2017	15:00	22	12	13	7.0	7.2	188
CF1	29/08/2017	10:30	19	10	23	7.0	8.8	184
CF1	29/09/2017	10:00	8	8	10	7.0	8.8	224
CF1	26/10/2017	10:00	2	8	210	6.5	9.0	200
CF2	19/02/2017	10:40	6	3	19	8.0	12.0	220
CF2	01/04/2017	10:30	4	4	21	8.0	11.8	146
CF2	24/05/2017	10:00	14	11	17	7.0	9.0	300
CF2	19/06/2017	16:25	22	18	11	7.0	6.8	264
CF2	09/08/2017	16:30	21	18	13	7.0	7.0	244
CF2	19/09/2017	16:25	20	16	10	7.0	7.4	200
CF2	24/10/2017	16:30	11	12	14	7.0	6.6	240
CF3	25/02/2017	10:57	4	1	13	7.5	12.8	90
CF3	12/04/2017	10:45	4	6	16	7.0	10.0	112
CF3	09/05/2017	10:00	9	8	10	7.0	9.6	128
CF3	24/05/2017	12:35	18	13	15	7.0	8.1	156
CF3	21/06/2017	11:30	13	13	40	7.0	8.6	156
CF3	07/07/2017	10:00	20	14	6	6.5	7.6	172
CF3	20/08/2017	9:30	18	15	7	7.0	7.8	143
CF3	30/09/2017	12:55	16	11	7	7.0	5.2	156
CF3	30/10/2017	10:00	4	7	5	7.0	4.0	190
CF4	25/02/2017	11:50	4	2	13	7.0	10.8	108
CF4	12/04/2017	11:40	4	5	16	7.0	10.2	128
CF4	09/05/2017	11:00	10	8	10	6.5	9.6	108
CF4	21/06/2017	12:00	14	12	13	7.3	8.4	172
CF4	12/07/2017	13:00	27	14	10	6.5	8.0	156
CF4	23/08/2017	11:30	15	13	7	7.0	6.9	148
CF4	30/09/2017	14:00	9	10	5	7.0	9.4	172
CF4	17/10/2017	10:45	12	8	5	6.5	9.2	180
CF4	30/10/2017	10:00	5	7	8	7.5	7.2	150
CF5	08/03/2017	14:00	5	2	43	6.5	9.2	150
CF5	28/04/2017	13:30	17	n.d.	26	6.5	6.8	148
CF5	24/05/2017	14:00	23	18	40	7.5	7.8	200
CF5	04/07/2017	9:00	18	18	29	6.5	6.0	180
CF5	03/08/2017	10:00	20	20	16	6.5	6.3	154

Station	Date	Time	Air Temp (°C)	Water Temp (°C)	Water Depth (cm)	pH	DO (mg/L)	Alkalinity (mg/L)
CF5	31/08/2017	10:00	12	16	14	6.5	4.8	176
CF5	28/09/2017	10:00	10	15	11	6.5	6.6	184
CF5	30/10/2017	10:30	4	7	40	7.0	9.2	160
CF6	09/03/2017	14:45	1	2	59	7.0	10.0	88
CF6	26/04/2017	11:00	14	10	43	6.0	n.d.	100
CF6	24/05/2017	14:35	20	18	65	7.0	8.2	150
CF6	28/06/2017	11:11	22	14	250	6.5	n.d.	160
CF6	26/07/2017	11:20	19	17	19	6.0	6.0	n.d.
CF6	17/08/2017	11:30	23	18	23	7.0	4.8	180
CF6	27/09/2017	11:00	21	19	23	6.0	4.6	200
CF6	25/10/2017	12:10	8	10	270	7.0	7.4	184
CF7	28/03/2017	10:15	5	1	66	7.0	11.4	85
CF7	26/04/2017	10:00	15	10	43	7.0	8.6	100
CF7	24/05/2017	14:55	20	18	31	7.0	7.0	138
CF7	28/06/2017	10:00	22	13	15	7.0	7.5	160
CF7	26/07/2017	9:48	20	16	23	6.0	4.0	224
CF7	30/08/2017	10:30	22	16	19	7.0	4.0	200
CF7	25/10/2017	11:00	8	10	250	7.0	6.0	168

Appendix C

Table 8. Comparison of data collected using a Hannah meter, SSEA's ProDSS sonde, and the LaMotte kits.

		Conductivity (µS/cm)		Water Temp (°C)		
Date	**Station**	**Hannah**	**ProDSS**	**Hannah**	**ProDSS**	**Kit**
24/05/2017	CF1	394	392.8	9.9	9.2	9
24/05/2017	CF2	770	770.0	11.2	10.7	11
24/05/2017	CF3	298	289.1	13.3	12.8	13
24/05/2017	CF4	294	287.4	12.8	12.2	12
24/05/2017	CF5	405	395.9	18.4	17.9	18
24/05/2017	CF6	335	326.1	18.5	18.2	18
24/05/2017	CF7	306	297.0	18.4	18.0	18
30/10/2017	CF3	358	328.0	7.5	7.5	6.5
30/10/2017	CF4	353	324.5	7.4	7.3	7
30/10/2017	CF5		392.6		6.8	6.5

		pH			Turbidity	
Date	**Station**	**Hannah**	**ProDSS**	**Kit**	**ProDSS (FNU)**	**Kit (JTU)**
24/05/2017	CF1	7.8	8.17	7	1.5	0
24/05/2017	CF2	7.8	8.05	7	3.2	5
24/05/2017	CF3	7.6	8.11	7	0.5	0
24/05/2017	CF4	7.6	7.80	7.5	1.2	0
24/05/2017	CF5	7.5	7.64	7.5	1.5	2
24/05/2017	CF6	7.4	7.80	7	0.7	0
24/05/2017	CF7	7.3	7.55	7		0
30/10/2017	CF3	7.6	9.00	7	1.1	5
30/10/2017	CF4	8.0	9.20	7.5	0.8	0
30/10/2017	CF5		9.50	7	1.1	2.5

		Dissolved oxygen (mg/L)		Dissolved oxygen, %	
Date	**Station**	**ProDSS**	**Kit**	**ProDSS**	**Kit**
24/05/2017	CF1	10.37	8.4	90	75
24/05/2017	CF2	11.5	9.0	99	84
24/05/2017	CF3	9.03	8.1	86	80
24/05/2017	CF4	9.51	6.8	89	65
24/05/2017	CF5	8.86	7.8	94	85
24/05/2017	CF6	8.21	8.2	88	90
24/05/2017	CF7	7.76	7.0	82	77
30/10/2017	CF3	8.8	4.0	72	35
30/10/2017	CF4	10.19	7.2	85	62
30/10/2017	CF5	10.04	9.2	82	79

Table 9. Comparison of water chemistry data collected from samples sent to the DESC lab and using the Hannah meter, ProDSS sonde and LaMotte kit.

	Alkalinity (mg/L)		Conductivity (µS/cm)		
Station	**DESC**	**LaMotte**	**DESC**	**Hannah**	**ProDSS**
CF1	187		407	401	
CF2	273		783	756	
CF3	177	190	344	358	328.0
CF4	171	150	333	353	324.5
CF5	171	160	403		392.6
CF6	157		347		341.0
	pH				
Station	**DESC**	**Hannah**	**ProDSS**	**LaMotte**	
CF1	8.05	8.06			
CF2	8.15	7.85			
CF3	7.89	7.59	9	7	
CF4	8.02	8.00	9	8	
CF5	7.94		10	7	
CF6	7.79		12		
	Nitrate (mg/L)		**Phosphate (mg/L)**	**Total Phosphorus (mg/L)**	
Station	**LaMotte**	**DESC**	**LaMotte**	**DESC**	
CF1		1.4489		0.00408	
CF2		1.4359		0.00381	
CF3	0	0	0	0.01181	
CF4	0	0	0	0.00431	
CF5	0	0.1155	0	0.00463	
CF6		0.0072		0.00341	