2017-18 Project Summary Report:

Wildcat Brook Shale Pit Remediation & Wetland Expansion Project, Petite Rivière Watershed

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Bluenose Coastal Action Foundation
37 Tannery Road, Lunenburg, N.S., B0J 2C0

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Bluenose Coastal Action Foundation (Coastal Action) is a community-based charitable organization with a mandate to address environmental concerns along the South Shore of Nova Scotia. Coastal Action's mission is to restore and protect the environment through research, education, and action.

The organization has been an established member of the Lunenburg County community since its inception in December 1993. Over the past 20 years, Bluenose Coastal Action has successfully completed a vast number of projects within the South Shore region of the province. One of Coastal Action's greatest ongoing concerns is healthy watersheds and we have experience in successfully conducting several fish habitat-related projects, along with water quality monitoring.

Introduction

Project Overview

Wildcat Brook is a part of the Petite Riviere watershed, which is situated just outside of the town of Bridgewater. Monthly water quality monitoring by Coastal Action within the brook has revealed high acidity, which has in turn sparked further investigations initiating action for the Wildcat Brook Shale Pit Remediation & Wetland Expansion Project.

Coastal Action is particularly interested in monitoring Wildcat Brook, as it is a tributary to Hebb Lake. Hebb Lake is included in the Town of Bridgewater's water supply and serves as the last of three lakes that host the globally endangered Atlantic Whitefish (*Coregonus huntsmani*).

The acidity found in Wildcat Brook has been associated to the bedrock geology of the area causing acid rock drainage. Acid rock drainage is a process where naturally occurring sulfide minerals in rock exposed to the atmosphere and water chemically react through oxidation to create an acid. Pyritic shale found in the bedrock of the several abandoned shale pit sites within the drainage area of Wildcat Brook chemically reacts to create sulfuric acid. This acid rock drainage not only lowers the acidity of the natural waters but can also impact freshwater aquatic life through the release of dissolved metals (e.g. aluminum, cadmium, copper, iron, zinc, manganese) (White et al, 2013; Dennis et al, 2012).

The Wildcat Brook Shale Pit Remediation & Wetland Expansion Project was conducted on a 1.10-hectare shale pit site in the Wildcat Brook drainage area. The projects aim was to limit the acidic discharge from the pit by capping the exposed bedrock with organic hydric soils and re-vegetate the area – transforming the site into a wetland habitat. Approximately 3,500 m^3 of organic soil material was spread, and then the area was seeded and planed with native wetland species.

Restoration efforts were concluded in the fall of 2016 but monitoring of the site continued to document the successes of the project. The aim of this report is to summarize the monitoring from the 2017 field season at the 1.10-hectare restoration site.

The expected benefits of the creation of wetland habitat are in providing shelter, food, space, and nesting habitat for a variety of wetland species as well as to reduce the severity, frequency, and duration of toxic pH episodes to improve the ability of Wildcat Brook to support healthy aquatic life. The monitoring plan will seek to evaluate the success of the project.

Monitoring Methods

Monitoring at the 1.10-hectare restoration site for the 2017 field season included water quality monitoring, benthic invertebrates sampling, electrofishing, wildlife observations, and vegetation surveys. Additional monitoring had occurred prior to and throughout the restoration process which will be compared to the 2017 results in the Monitoring Results section.

Water quality monitoring includes: annual grab samples, monthly sampling of surface water readings taken with YSI field probes, and four 15-mintue data loggers.

Annual grab samples were taken using proper protocol for grab sampling, and delivered to Maxxam Analytics' certified lab, who analyzed for metals, inorganics, and general chemistry parameters. Water quality grab samples were taken at six sites in the winter of 2018. Sites include: downstream from restoration site in Wildcat Brook, in outlet of restoration site, in the eastern pond of restoration site,

western pond of restoration site, in a large pond in neighbouring 7.0-hectare shale pit site, and upstream from restoration site and other shale pits sites.

Water quality was taken at the locations mentioned above in the fall of 2014 and 2016. Values from the 2018 samples were compared to the samples from 2016 and 2014. Data were analyzed using the "R" statistical software version 3.1.0. The 15-minute interval data of water level, pH, and temperature collected from the dataloggers were compressed into daily values (using the maximum value of that day) for plotting purposes only; no data were changed or altered for the purposes of reporting statistics. Values were also compared against Canadian Environmental Quality Guidelines from the Canadian Council for Ministers of the Environment (CCME) and the British Columbia Water Quality Guidelines (CCME, 2018).

Monthly sampling occurred in the western pond, eastern pond, outflow of restoration site, and in Wildcat Brook downstream from restoration site. These sites are situated in easily accessible areas by persons on foot. Field probes were placed in water at site locations and left to stabilize for five to 10 minutes before readings were recorded. Coastal Action has been collecting water data from Wildcat Brook at the Lapland Road crossing since 2011 as part of their monthly water quality route for the Petite Rivère watershed. This data is used in analysis for a comparation to past readings to the 2017 field season readings.

The four data loggers were installed in secure stationary monitoring wells within the restoration site, and Wildcat Brook. These data loggers measured water quality every 15-minutes. Three of the data loggers measured water level, temperature, and pressure from May to November 2017 - The first of the three was placed in the western pond of the restoration site, the second placed in the eastern pond of the restoration site, and the third is placed downstream from restoration site in Wildcat Brook. The fourth data logger measured pH, temperature, and redox was located by the outflow weir of the restoration site in the eastern end.

Benthic macroinvertebrate samples had been collected at four sites by Coastal Action within Wildcat Brook in November 2015, November 2016, and again in November 2017. Taxonomic identification and analysis was completed by BioTech Taxonomy, Hampton, NB. However, taxonomic identification for the 2017 results has not be completed to date. Samples were collected using the Canadian Aquatic Biomonitoring Network (CABIN) protocol. Sites were in Wildcat Brook approximately 300-meters downstream from restoration site, immediately downstream from restoration site, between restoration site and 7.0-hectare shale pit site, and upstream from restoration site and other shale pit sites.

Electrofishing has been completed in Wildcat Brook by Coastal Action in the fall of 2013, 2015 and 2017. Proper protocol using a backpack electro-fisher were followed. Approximately one kilometre of Wildcat Brook was surveyed with backpack electro-fisher. Areas surveyed include downstream of restoration site, between restoration site and 7.0-hectare shale pit site, and upstream from restoration site and other site pit sites.

Prior to restoration efforts the site was surveyed in detail for existing wildlife and vegetation. Continual observations of wildlife were recorded anytime the site was visited. Point photos were taken to document vegetation growth and type in the 2017 field season to be compared to past point photos. There were three main point photo taken at the western end, northern end, and eastern end of the restoration site to document vegetation changes. More detailed surveys for wildlife and vegetation are planned to occur this 2018 field season.

Monitoring Results

Water Quality

A summary of the water quality results can be seen in the Figures 1, 2, 3, 4 and 5. Raw data from water quality collection can be found in Appendices A., B. and C.

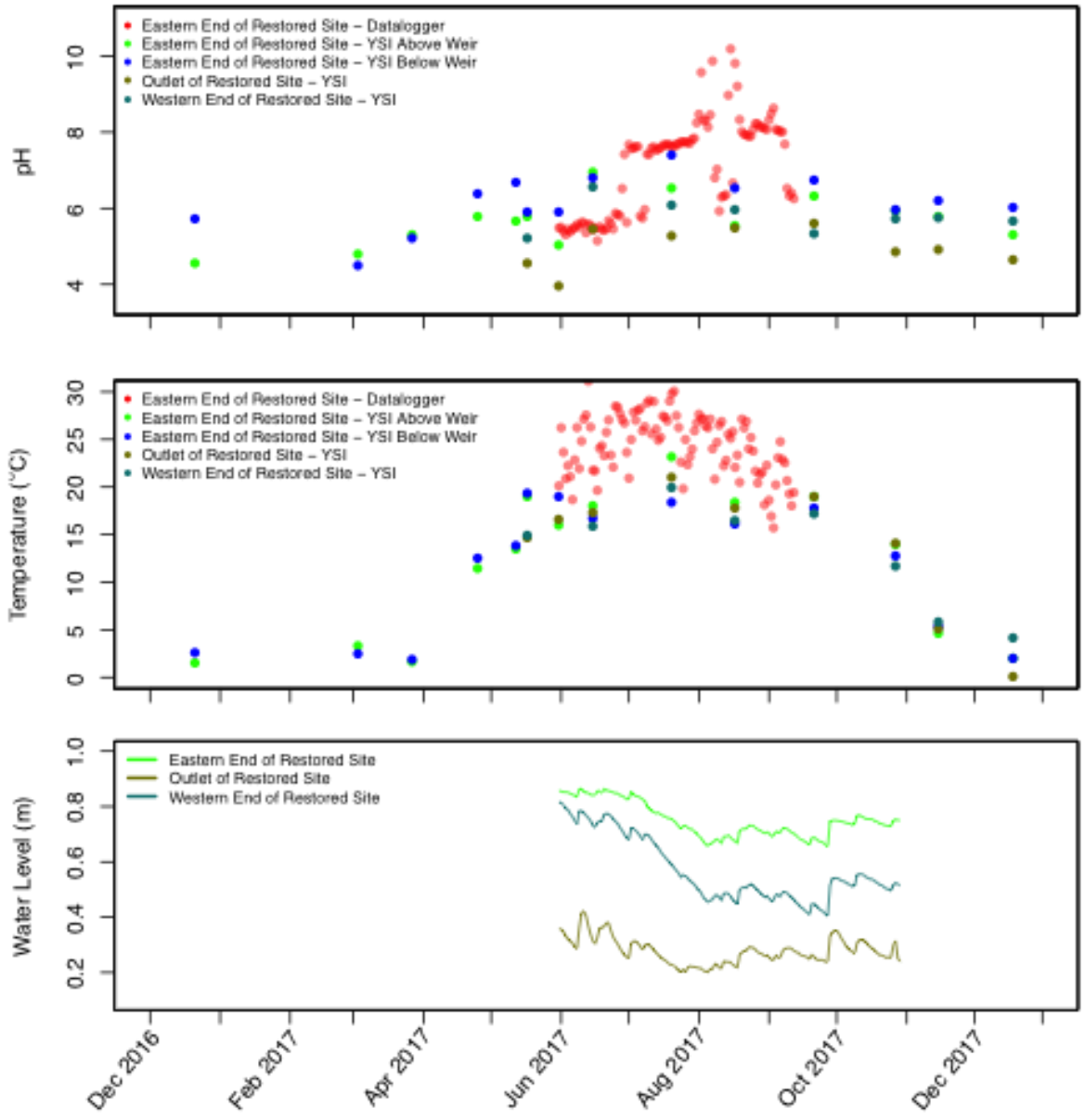

Figure 1: Top) pH data from YSIs located around the restored wetland from 2016-2017, and data from a datalogger located on the eastern side of the restored wetland; Middle) Temperature data from YSIs and a datalogger; Bottom) Maximum daily water level data from three dataloggers across the restored wetland in 2017.

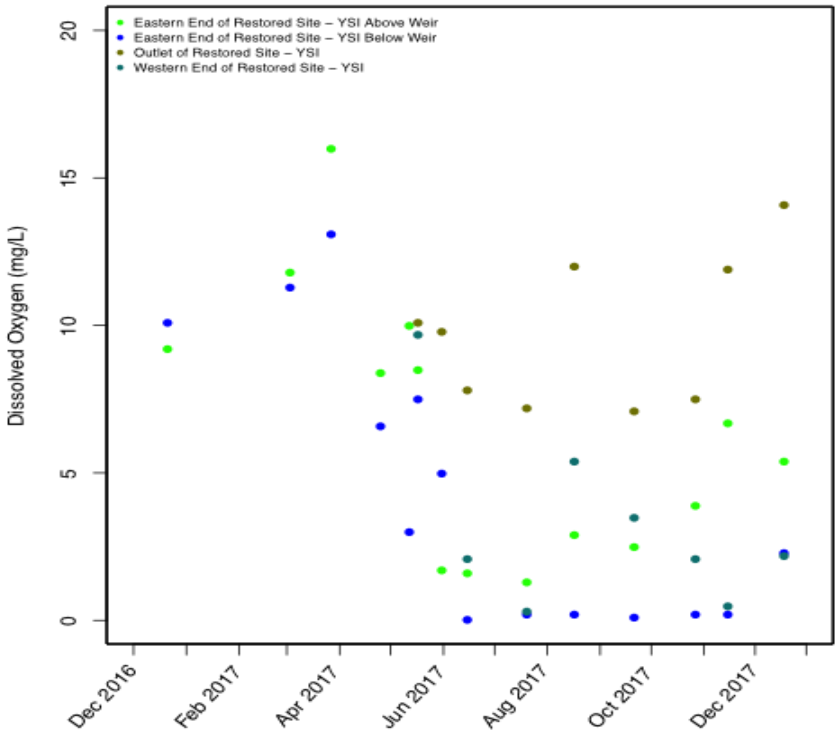

Figure 2: Dissolved oxygen measurements from four sites throughout the restored wetland from 2016 to 2017.

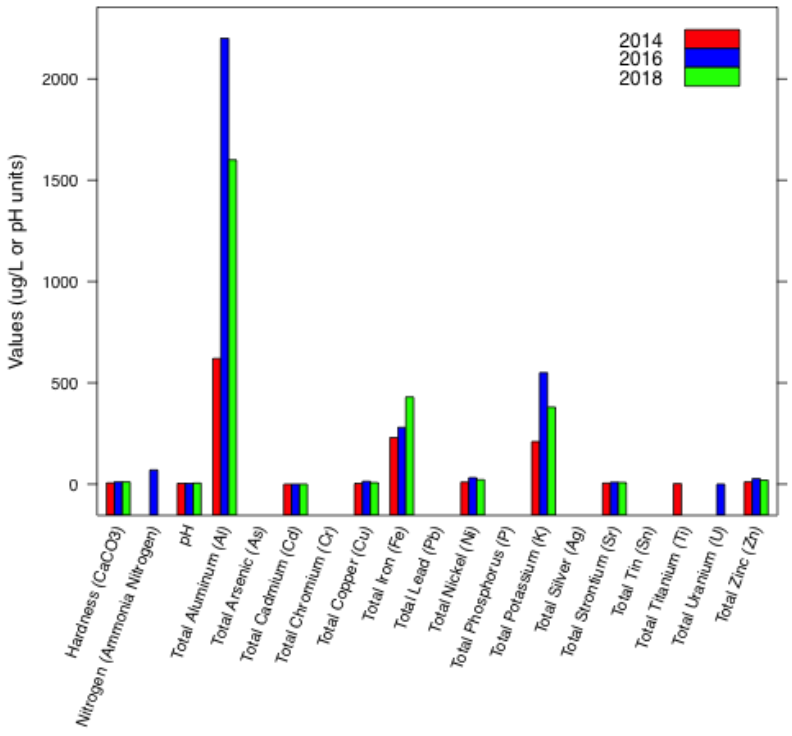

Figure 3: Chemical values from 2014, 2016, and 2018 water samples collected from the unrestored wetland.

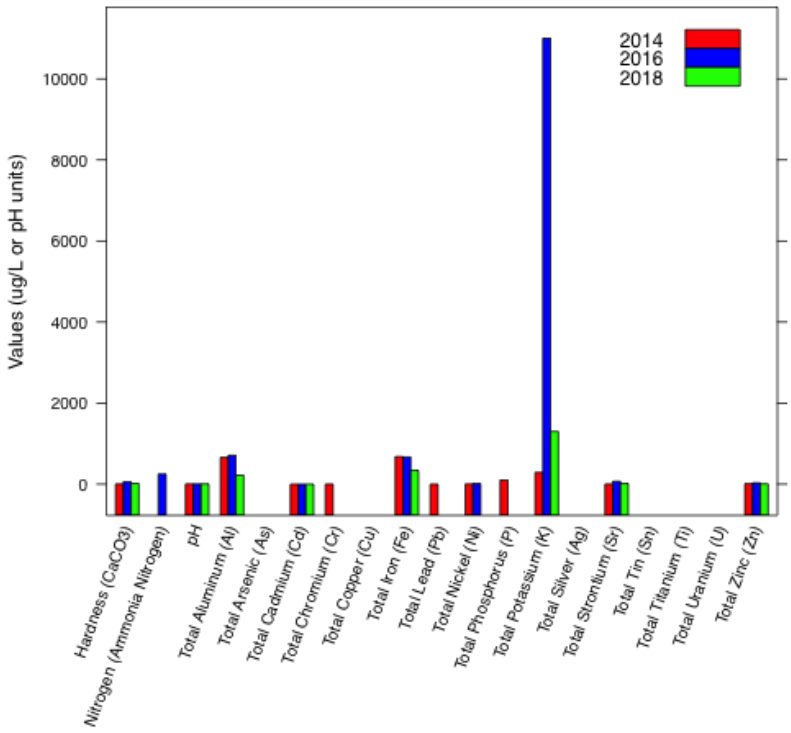

Figure 4: Chemical values from 2014, 2016, and 2018 water samples collected from the eastern end of the restored wetland.

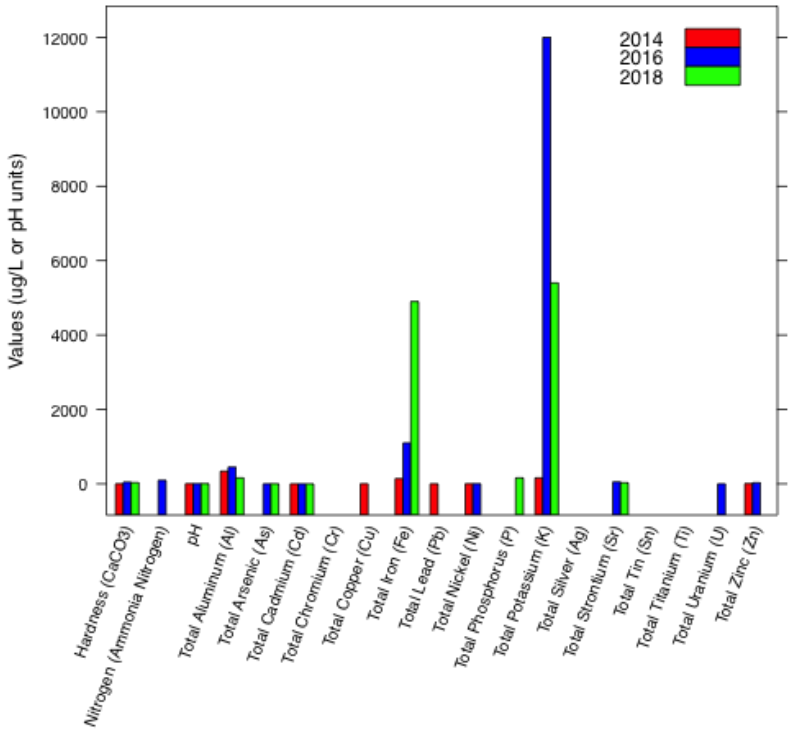

Figure 5: Chemical values from 2014, 2016, and 2018 water samples collected from the western end of the restored wetland.

Electrofishing Surveys

A summary of the results of type of fish caught, total count and total percentage over the three years of electrofishing surveys are shown in Table 1.

Table 1. Electrofishing results from 2013, 2015, and 2017.

Wildcat Brook Electrofishing Results				
Year Surveyed	2013	2015	2017	
Species Caught	Brook Trout	Chain Pickerel	Chain Pickerel	Brown Bullhead
Total Amounts	18	3	12	1
Total Percentage	53%	9%	35%	3%

Benthic Macroinvertebrates

Result summary of benthic macroinvertebrate sampling from 2015, 2016 and 2017 can be seen in Table 2 below.

Table 2. Benthic macroinvertebrate sample results from 2015, 2016 and 2017 in four locations along Wildcat Brook.

Sample site	WIL001			WIL002			WIL003			WIL004		
Location	Below Bridge			Immediately below restored site			Adjacent 7-hectare site			Upstream (reference)		
Year Sampled	2015	2016	2017	2015	2016	2017	2015	2016	2017	2015	2016	2017
Total Organism Count:	306	403	376	377	734	415	308	317	398	304	314	436
Total EPT %:	54	24	42	29	15	29	28	18	14	51	23	26
Richness:	27	27	23	24	29	27	26	28	24	25	29	28
Diversity:	2.2	2.23	2.07	2.46	1.6	2.10	2.09	2.33	1.23	2.13	1.82	1.57
Evenness:	0.67	0.68	0.66	0.77	0.48	0.63	0.64	0.70	0.38	0.66	0.54	0.47

Wildlife Observations

During Coastal Actions visits to the restoration site there were a total of 13 wildlife sightings and six recorded presence of wildlife. “Sightings” are documented when there is a physical visual seen of an animal and “presence of wildlife” would include animal tracks or scat found at site at the time of a visit. Appendix D shows a list of notes taken whenever the restoration site was visited by Coastal Action staff. Baseline results from wildlife surveys can also been seen in Appendix D.

Vegetation – Point Photos

The below photographs show the vegetation change at the restoration site through point photos at three main locations. Photographs shown are taken from the same location at the same time of year, but a year apart.

*Figure 6. Photographs taken at the Eastern end of the Wildcat Restoration site. The **left** photograph taken August 2016, and **right** photograph taken August 2017.*

*Figure 7. Photographs taken at the Western end of the Wildcat Restoration site. The **left** photograph taken May 2016, and the **right** photograph taken May 2017.*

*Figure 8. Photographs taken at the Northern end of the Wildcat Restoration site. The **left** photograph taken May 2016, and the **right** photograph taken May 2017.*

The comparison of the 2016 photographs to 2017 photographs show an clear increased amount of vegetation density and the diversity. Additional point photos and baseline vegetation surveys can be found in Appendix E.

Results Discussion

Water Quality

Large spikes in pH were recorded by the pH-data logger and confirmed with the monthly YSI samples (see Figure 1). The spikes do not correlate to changes in temperature or water level, Coastal Action hypothesizes that the spikes are due to contact between groundwater and a carbonaceous glacial till deposit located in the area. Future projects will include a ground-truthing of the surficial geology in the area, and track if there are any other parameters affecting the wetland's pH.

Even with alkaline spikes within the reclaimed wetland, chronic acidity remains a potential threat to organisms within the wetland. In the restored wetland, the eastern site is below the 6.5-pH threshold set by the Canadian Council of Ministers of the Environment (CCME) between 85.7 and 64.3% of samples (above and below the weir, respectively), while 100% of samples at the wetland's outlet were below 6.5-pH, and 55.6% below 5.0. In particular, the Atlantic whitefish are affected by the wetland's acidity, as egg survival decreases at pHs less than 5.0 (Cook et al., 2010).

Between June and December 2017, dissolved oxygen (DO) in the wetland was below the aquatic threshold of 6.5 mg/L set by the CCME (see Figure 2). The outlet of the wetland has consistently high DO (>6.5 mg/L), indicating a suitable habitat for aquatic organisms. The low in the summer months for the wetland may be attributed to the growing season and increased DO demand – and therefore depletion – by plants and other organisms in the area.

The restored Wildcat wetland appears to be filtering metals out of the water. Total aluminum concentrations in the unrestored wetland were between 600-2300 ug/L from 2014 to 2018 (see Figure 3), while the eastern and western reclaimed wetland sampling locations had total aluminum concentrations less than 1000 ug/L for all three sampled years (see Figures 4 and 5, respectively). In comparison to the 2016 samples, aluminum concentrations at the eastern, western, and outlet sampling sites all fell, with concentrations below 300 ug/L. In addition, copper, titanium, and uranium concentrations were measurable during the 2018 sampling of the unrestored wetland; however, these metals were below detection limits for all other 2018 sampling sites.

Although the wetland restoration site appears to be filtering and precipitating metals out of the water, some metals are still above CCME guidelines. Total aluminum concentrations measured at all six sites in 2018 exceeded the 5 ug/L thresholds (based on the criteria that pH was below 6.5). Although the majority of 2018 iron concentrations have fallen from the concentrations measured in 2014, total iron exceeds the 300 ug/L thresholds for all 2018 sampling sites. The western restored site exceeded the 300 ug/L thresholds by more than 10 times (4900 ug/L). Although chromium exceeded the 1 ug/L threshold at the restored wetland outlet for ionized Chromium (6+), it is unclear if this threshold applies to our data, as the lab does not measure for specific ion concentrations.

Electrofishing Surveys

The electrofishing results (see Table 1) reveal another stressor on Wildcat Brook due to the composition of fish species found. The invasive chain pickerel (*Esox niger*) had at some point been introduced into the Wildcat Brook system. The introduction of this species may explain the depletion the native brook Trout (*Salvelinus fontinalis*) in the system, where other studies have shown the impacts of the invasive chain pickerel (*Esox niger*) on native species (Mitchell et al, 2016). However, the electrofishing results show that native fish species has been supported in the system in the past and would benefit from a reduction of acid rock drainage (Dennis & Chair, 2012).

Coastal Action is hopeful that future electrofishing surveys will show additional native aquatic species moving into the area. If water quality improves in Wildcat Brook, native fish such as trout and salmon, will be able to better compete against the invasive fish species, chain pickerel (*Esox niger*), and inhabit this area, effectively expanding available habitat that was previously lost due to the poor water quality conditions.

Benthic Macroinvertebrates

The overall results from the benthic macroinvertebrate sampling suggest that the habitat is moderately productive across the four sample sites in Wildcat Brook. The results (see Table 2) show there was an increase in both the Total Organism Count and Richness of the samples from 2015 to 2016 and from 2015 to 2017. The Total Organism Count is the raw total of organisms sampled from the field, and later counted and species Family classification identified. The taxonomic Richness is the measure of the number of different taxonomic families within the samples. The higher the number, the richer the sample is. Richness will generally increase or decrease depending on the quality of habitat.

All other measurements varied showing no clear trend. The usefulness of the other measurements seen in Table 2 are explained in the following paragraph:

The Total EPT% is the percentage of the Families Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddis fly) in each sample. The presence these Families is widely considered to be a good water quality indicator. The taxonomic Diversity numbers where calculated using the Shannon-Wiener Diversity index. This diversity measure not only takes in the simple count of different species found in the sample, but also of their relative abundance distributions. The larger the number, the more diverse the sample is. The taxonomic Evenness numbers where calculated using Pielou's Evenness measure. Evenness refers to how close in numbers each species Family is in the sample. The calculation uses the Diversity index by balancing by assigning equal probability of observation to any of the organism found in the sample. Low Evenness means majority of organisms are observed in a limited number of Families, and a high Evenness means similar numbers of organisms are observed in each Family found in the sample. The means that if the number is higher there is a more balanced diversity.

Coastal Action is hopeful that future benthic macroinvertebrate sampling results will show an increase in total counts, EPT%, richness, diversity and evenness.

Wildlife Observations

Wildlife observations have shown new types of animals starting to move into the restored wetland habitat such as mallard ducks and painted turtles. Coastal Action is confident that more detailed surveys in the 2018 field season will reveal a greater amount of wildlife sightings, presences and diversity of species compared to baseline wildlife survey.

Vegetation – Point Photos

Vegetation point photos show a clear increase in amount of vegetation and the diversity from 2016 to 2017. Vegetation has continued to grow exponentially in the restoration site. More in-depth surveys are planned for the 2018 field season, which will in involve density measurements and listing vegetation species. Results will then be compared to the baseline vegetation surveys taken prior to restoration work, and Coastal Action is confident there will be an increase in density and diversity of plant life.

This monitoring has taken place in the year one conclusion of the Wildcat Shale Pit Remediation & Wetland Expansion Project. Therefore, the results are still in the preliminary stage, and further monitoring

will need to be conducted to capture the desired long-term benefits of the restoration efforts. Although results are preliminary, they show promising long-term benefits for Wildcat Brook and the newly restored wetland habitat.

Future Work & Conclusion

There are two other larger shale pits in the surrounding area that Coastal Action would like to remediate in the future. Remediating these pits will ensure water quality improvements in the adjacent Wildcat Brook and will improve wildlife habitat. These remediation projects would be much larger in scale compared to the completed 1.10-hectare restoration site, with the largest pit being just over 7.0-hectares. This project would require significantly more organic soil to cover the exposed bedrock adequately. A baseline study and restoration plan were completed on the 7.0-hectare site in 2017.

Coastal Action has formed a partnership with the Bridgewater Public Service Commission (PSC). The PSC's interests lay in improving water quality of Wildcat Brook, which enters directly into Hebb Lake very close to the main intake for the Town of Bridgewater's drinking water source. They are onboard to assist Coastal Action financially in the restoration of future shale pits in the surrounding area as it would lower their treatment costs and improve overall water quality in their municipal water supply. Coastal Action also formed partnerships through this project resulting in an opportunity for the use of municipal compost for future restoration projects that wish to promote the growth of healthy vegetation. The restoration efforts completed at the 1.10-hectare shale pit successfully demonstrated the fertility of the municipal compost used on-site as part of the restoration efforts and will continue to be documented by point photos and vegetation surveys into the future. These new partnerships will assist Coastal Action in planning and development of potential future restoration projects in the area.

Long-term monitoring of the completed 1.10-hectare restoration site will help Coastal Action with determining future remediation plans in the area. Coastal Action is optimistic that this project will continue to be successful in improving the water quality conditions in the adjacent Wildcat Brook and the overall health of the surrounding environment. It is Coastal Actions hope that the outflow of the Wildcat Restoration site will assist to buffer the low pH readings from the Wildcat Brook over the long-term. Creating new and highly productive wetland habitat will attract additional wetland wildlife and native fish species into the area.

Acknowledgments

Bluenose Coastal Action Foundation's Wildcat Shale Pit Remediation & Wetland Expansion Project would not be possible without the generous support of our project partners, volunteers, and local community. Project monitoring activities in 2017-18 could not have been completed without the Coastal Action's dedicated field staff. Restoration efforts in 2015-16 could not have happened without project partners, East Coast Aquatic Inc., who have also advised in much of the monitoring efforts. Much gratitude and many thanks to our financial partners, without your support there would be no project.

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Appendix A. Water Quality Grab Samples

Water quality grab samples were taken at six sites in the fall of 2014, 2016 and again in the winter of 2018. All sites are taken within the Wildcat Brook drainage area and analyzed by certified lab, Maxxam Analytics, for general parameters, inorganics, and metals. Parameters exceeding relevant water quality objective (WQO) are highlighted red.

Sample Locations:

WCB001 – Sampled in Wildcat Brook, approx. 20 m upstream from Lapland Road bridge (44°22'00.8" N,64°35'04.5" W)
WCB002 – Sampled at outlet of 1.1 ha restoration site (44°22'01.3" N, 64°35'07.2" W)
WCB003 – Sampled in 1.1 ha restoration site, eastern side (44°22'02.4" N, 64°35'08.2" W)
WCB004 – Sampled in 1.1 ha restoration site, western side (44°22'01.9" N, 64°35'14.7" W)
WCB005 – Sampled in 7.0 ha shale pit site in large pond in northern end (44°22'04.3 N, 64°35'29.3" W)
WCB006 – Sampled in Wildcat Brook upstream from shale pit sites (44°21'56.9" N, 64°35'53.4" W)

Appendix A. Table 1. Raw data from water quality grab samples taken in 2014, 2016 and 2018 for the Wildcat Brook Shale Pit Remediation & Wetland Expansion Project, Petite Rivière Watershed

Calculated Parameters (UNITS)	WCB001			WCB002			WCB003			WCB004			WCB005			WCB006			WQO	Reference
	2014	2016	2018	2014	2016	2018	2014	2016	2018	2014	2016	2018	2014	2016	2018	2014	2016	2018		
Anion Sum (me/L)	0.230	0.370	0.500	0.430	2.64	1.17	0.410	2.61	0.820	0.240	2.15	1.20	0.360	0.780	0.730	0.210	0.230	0.390		
Bicarb. Alkalinity (calc. as CaCO3) (mg/L)	ND	ND	ND	ND	ND	6.8	ND	ND	ND	ND	ND	22	ND	ND	ND	ND	ND	ND		
Calculated TDS (mg/L)	20	29	33	30	170	73	29	170	53	16	140	78	24	49	47	18	22	28		
Carb. Alkalinity (calc. as CaCO3) (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Cation Sum (me/L)	0.360	0.450	0.520	0.440	2.28	1.10	0.430	2.37	0.840	0.220	1.81	1.35	0.280	0.450	0.450	0.320	0.390	0.480		
Hardness (CaCO3) (mg/L)	5.2	8.4	8.3	4.6	61	26	4.9	63	16	2.3	47	33	6.0	11	11	4.4	6.7	7.4		

Ion Balance (% Difference)	22.0	9.76	1.96	1.15	7.32	3.08	2.38	4.82	1.20	4.35	8.59	5.88	12.5	26.8	23.7	20.8	25.8	10.3		
Langelier Index (@ 20C)	NC	NC	NC	NC	NC	-3.72	NC	NC	NC	NC	NC	-2.85	NC	NC	NC	NC	NC	NC		
Langelier Index (@ 4C)	NC	NC	NC	NC	NC	-3.97	NC	NC	NC	NC	NC	-3.10	NC	NC	NC	NC	NC	NC		
Nitrate (N) (mg/L)	0.084	0.054	ND	ND	0.62	0.17	ND	0.66	0.068	ND	ND	0.051	ND	ND	ND	0.066	ND	ND		
Saturation pH (@ 20C)	NC	NC	NC	NC	NC	9.65	NC	NC	NC	NC	NC	9.02	NC	NC	NC	NC	NC	NC		
Saturation pH (@ 4C)	NC	NC	NC	NC	NC	9.90	NC	NC	NC	NC	NC	9.27	NC	NC	NC	NC	NC	NC		
Inorganics																				
Acidity (mg/L)	6.4	6.4	8.8	14	11	14	14	12	17	6.2	14	41	11	24	26	10	11	10		
Total Alkalinity (Total as CaCO3) (mg/L)	ND	ND	ND	ND	ND	6.8	ND	ND	ND	ND	ND	22	ND	ND	ND	ND	ND	ND		
Carbonaceous BOD (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Dissolved Chloride (Cl) (mg/L)	8.0	9.4	16	11	26	21	9.8	26	20	4.9	19	17	3.6	3.3	7.7	7.2	8.0	14		
Colour (TCU)	120	180	58	80	17	14	70	16	9.4	6.0	13	190	ND	ND	ND	140	200	70		
Nitrate + Nitrite (N) (mg/L)	0.084	0.054	ND	ND	0.62	0.17	ND	0.66	0.068	ND	ND	0.051	ND	ND	ND	0.066	ND	ND		
Nitrite (N) (mg/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Nitrogen (Ammonia Nitrogen) (mg/L)	0.054	0.14	ND	0.082	0.26	0.11	ND	0.25	ND	ND	0.095	ND	ND	0.070	ND	ND	0.18	ND		
Dissolved Organic Carbon (C) (mg/L)	9.3	11	6.9	7.3	4.9	3.5	6.7	6.5	3.1	1.5	6.6	14	0.67	1.3	1.2	11	11	8.3		
Total Organic Carbon (C) (mg/L)	10	14	7.5	7.8	6.3	3.7	7.1	6.1	3.3	1.7	7.3	16	0.72	0.96	1.5	11	17	9.2		
Orthophosphate (P) (mg/L)	ND	0.012	ND	ND	ND	ND	ND	0.010	ND	ND	ND	ND	ND	0.010	ND	ND	0.011	ND		
pH	5.47	5.39	6.10	4.58	4.86	5.93	4.58	5.07	6.20	4.48	4.80	6.17	4.21	3.97	5.10	4.86	5.09	5.40	6.5-9	CCME*

Reactive Silica (SiO2) (mg/L)	4.2	5.3	4.1	3.4	2.9	2.5	3.9	2.6	2.9	1.8	3.7	3.1	3.5	5.6	5.3	3.6	5.4	4.4		
Dissolved Sulphate (SO4) (mg/L)	ND	4.8	2.2	6.4	89	21	6.5	88	12	4.8	77	13	12	33	25	ND	ND	ND		
Turbidity (NTU)	1.4	0.97	0.72	1.2	2.4	19	1.2	2.2	1.4	0.86	3.2	3.3	0.47	0.18	0.27	1.3	1.1	2.9		
Conductivity (uS/cm)	40	51	67	62	290	130	58	300	110	35	240	130	60	110	110	36	45	65		
Metals																				
Total Mercury (Hg) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	Not Tested	ND	ND	ND	ND	ND		
Dissolved Aluminum (Al) (ug/L)	190	240	130	690	560	140	610	620	190	280	410	170	590	2100	1700	200	240	120	5	CCME*
Total Aluminum (Al) (ug/L)	240	270	140	720	650	290	660	710	220	340	450	160	620	2200	1600	240	260	180	5	CCME*
Dissolved Antimony (Sb) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Total Antimony (Sb) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Dissolved Arsenic (As) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.6	ND	ND	ND	ND	ND	ND	5	CCME*
Total Arsenic (As) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.1	2.7	ND	ND	ND	ND	ND	ND	5	CCME*
Dissolved Barium (Ba) (ug/L)	2.9	4.1	4.1	4.8	18	7.8	4.1	19	5.7	3.8	29	11	4.6	8.8	7.2	3.9	3.5	3.7	1000	BC**
Total Barium (Ba) (ug/L)	3.0	4.6	4.3	4.7	19	8.0	4.4	20	5.9	3.7	31	10	4.6	9.1	6.9	2.7	3.7	3.6	1000	BC**
Dissolved Beryllium (Be) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Total Beryllium (Be) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Dissolved Bismuth (Bi) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Total Bismuth (Bi) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		

Dissolved Boron (B) (ug/L)	ND	ND	ND	ND	380	97	ND	380	51	ND	490	160	ND	ND	ND	ND	ND	ND		
Total Boron (B) (ug/L)	ND	ND	ND	ND	380	90	ND	400	51	ND	510	160	ND	ND	ND	ND	ND	ND		
Dissolved Cadmium (Cd) (ug/L)	0.015	0.022	0.028	0.027	0.23	0.028	0.024	0.25	0.030	0.016	0.23	0.010	0.042	0.12	0.11	0.030	0.022	0.029	0.09	CCME*
Total Cadmium (Cd) (ug/L)	0.019	0.020	0.029	0.032	0.24	0.036	0.032	0.26	0.030	0.021	0.24	0.032	0.052	0.14	0.092	0.019	0.021	0.025	0.09	CCME*
Dissolved Calcium (Ca) (ug/L)	1000	1700	1600	540	18000	7000	600	19000	3800	250	12000	9200	1100	2100	2000	860	1300	1400	4000 to 8000	BC**
Total Calcium (Ca) (ug/L)	1100	1800	1600	510	18000	6500	620	19000	3700	240	13000	8900	1100	2100	1800	790	1300	1300		
Dissolved Chromium (Cr) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.8	ND	ND	ND	52	ND	ND	1	CCME*
Total Chromium (Cr) (ug/L)	ND	ND	ND	3.6	ND	1.7	1.9	ND	ND	ND	ND	ND	ND	ND	ND	3.7	1.1	ND	1	CCME*
Dissolved Cobalt (Co) (ug/L)	0.43	0.67	0.63	2.2	8.8	1.4	1.9	9.1	1.2	2.5	6.2	1.6	5.1	15	12	ND	ND	0.46		
Total Cobalt (Co) (ug/L)	0.56	0.68	0.55	2.1	8.9	1.6	1.9	9.2	1.2	2.4	6.5	1.6	5.3	15	11	ND	ND	0.41		
Dissolved Copper (Cu) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.1	14	8.7	ND	ND	ND	2	CCME*
Total Copper (Cu) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.4	ND	ND	3.4	14	7.6	ND	ND	ND	2	CCME*
Dissolved Iron (Fe) (ug/L)	630	750	330	510	380	400	550	300	170	62	370	5000	200	260	430	590	820	350	300	CCME*
Total Iron (Fe) (ug/L)	850	920	390	620	890	1400	680	670	340	140	1100	4900	230	280	ND	760	900	560	300	CCME*
Dissolved Lead (Pb) (ug/L)	ND	ND	ND	0.62	ND	ND	0.51	ND	ND	0.87	ND	ND	ND	ND	ND	ND	ND	ND	1	CCME*
Total Lead (Pb) (ug/L)	ND	ND	ND	0.69	ND	ND	0.60	ND	ND	1.1	ND	ND	ND	ND	ND	ND	ND	ND	1	CCME*
Dissolved Magnesium (Mg) (ug/L)	650	990	1100	790	3900	1900	830	4100	1600	420	3900	2400	810	1300	1600	550	820	970		

Total Magnesium (Mg) (ug/L)	670	1100	1000	760	4200	1900	860	4300	1600	430	4300	2400	830	1500	1400	540	850	910		
Dissolved Manganese (Mn) (ug/L)	61	80	94	310	1100	390	360	1100	300	180	1300	690	310	560	520	42	59	76		
Total Manganese (Mn) (ug/L)	64	85	94	300	1200	430	380	1200	290	180	1400	670	320	600	480	44	61	74		
Dissolved Molybdenum (Mo) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	73	CCME*
Total Molybdenum (Mo) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	73	CCME*
Dissolved Nickel (Ni) (ug/L)	ND	2.4	ND	4.1	14	ND	3.6	15	ND	2.6	3.8	ND	10	32	24	ND	ND	ND	25	CCME*
Total Nickel (Ni) (ug/L)	ND	ND	ND	3.6	14	2.2	3.9	15	ND	2.8	3.9	ND	10	32	22	ND	ND	ND	25	CCME*
Dissolved Phosphorus (P) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Total Phosphorus (P) (ug/L)	110	ND	ND	ND	ND	ND	100	ND	ND	ND	ND	160	ND	ND	ND	ND	ND	ND		
Dissolved Potassium (K) (ug/L)	500	520	390	290	9200	2500	310	9700	1300	160	10000	5600	200	480	410	520	310	300	373000	BC**
Total Potassium (K) (ug/L)	570	540	390	290	11000	2100	290	11000	1300	160	12000	5400	210	550	380	430	340	250	373000	BC**
Dissolved Selenium (Se) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	CCME*
Total Selenium (Se) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	CCME*
Dissolved Silver (Ag) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1	CCME*
Total Silver (Ag) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1	CCME*

Dissolved Sodium (Na) (ug/L)	4800	5200	7700	6600	18000	12000	6400	19000	11000	3200	13000	8400	2100	2400	4500	4300	4500	7100		
Total Sodium (Na) (ug/L)	4900	5600	7700	6300	20000	11000	6600	21000	11000	3100	16000	8000	2100	2900	4300	4300	5100	6600		
Dissolved Strontium (Sr) (ug/L)	5.1	8.4	8.1	2.9	65	25	3.0	69	14	ND	48	31	4.6	8.6	8.2	4.7	7.3	8.1		
Total Strontium (Sr) (ug/L)	5.0	8.9	8.1	2.5	68	24	2.8	70	15	ND	52	30	5.0	9.3	8.0	4.7	7.7	7.6		
Dissolved Thallium (Tl) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Total Thallium (Tl) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Dissolved Tin (Sn) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Total Tin (Sn) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Dissolved Titanium (Ti) (ug/L)	2.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.4	ND	ND	2000	BC**
Total Titanium (Ti) (ug/L)	4.4	2.5	ND	2.9	ND	3.5	ND	ND	ND	ND	ND	ND	2.4	ND	ND	19	ND	2.9	2000	BC**
Dissolved Uranium (U) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.12	ND	ND	0.16	ND	ND	ND	ND		
Total Uranium (U) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.16	ND	ND	0.18	ND	ND	ND	ND		
Dissolved Vanadium (V) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Total Vanadium (V) (ug/L)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Dissolved Zinc (Zn) (ug/L)	ND	ND	6.0	9.7	29	7.6	9.9	32	7.8	7.1	28	ND	11	24	24	6.0	6.1	5.1	30	CCME*
Total Zinc (Zn) (ug/L)	5.6	5.3	ND	8.9	31	7.0	11	33	7.7	7.6	30	ND	11	27	20	ND	ND	ND	30	CCME*

*CCME – Canadian Council of Ministers of the Environment (2016)

**BC – British Columbia Water Quality Guidelines (2006)

Appendix B. Field Probe Water Quality Sampling Results

Appendix B. Table 1. Raw data from field probe water quality sampling in 2017 for the Wildcat Brook Shale Pit Remediation & Wetland Expansion Project, Petite Rivière Watershed.

Wildcat Brook Shale Pit Remediation & Wetland Expansion Project, Petite Rivière Watershed **Water Quality from YSI Field Probe Readings:**									
Site:	Western pond in the western end of Wildcat Restoration site.								
Date (dd-mm-yy)	**Time (24h)**	**Temp (C)**	**Pressure (mmHg)**	**DO (%)**	**DO (mg/L)**	**SPC (mS/cm)**	**TDS (mg/L)**	**Sal (ppt)**	**pH**
17-05-17	14:19	15	751.7	96	9.7	0.132	85.8	0.06	5.23
15-06-17	10:33	15.9	758.8	22	2.1	0.131	85.15	0.06	6.57
20-07-17	9:44	20	752.9	4	0.3	0.107	69.55	0.05	6.1
17-08-17	12:45	16.5	751	55	5.4	0.098	63.7	0.05	5.98
21-09-17	12:36	17.3	757.1	36	3.5	0.093	60.45	0.04	5.36
27-10-17	8:55	11.8	752.1	20	2.1	0.132	85.8	0.06	5.75
15-11-17	13:15	5.9	760.5	4	0.5	0.131	85.15	0.06	5.78
18-12-17	13:17	4.2	757.8	18	2.2	0.087	56.55	0.04	5.69
Site:	Eastern pond in the eastern end of Wildcat Restoration site – Located above weir								
Date (dd-mm-yy)	**Time (24h)**	**Temp (C)**	**Pressure (mmHg)**	**DO (%)**	**DO (mg/L)**	**SPC (mS/cm)**	**TDS (mg/L)**	**Sal (ppt)**	**pH**
03-03-17		3.4	752.5	89	11.8	0.192	125.45	0.09	4.8
27-03-17	13:10	1.7	764.9	115	16	0.114	74.1	0.05	5.32
25-04-17	12:14	11.5	767.7	77	8.4	0.116	75.4	0.05	5.8
12-05-17	13:54	13.6	754.4	96	10	0.11	71.5	0.05	5.67
17-05-17	14:04	19.1	751.9	92	8.5	0.116	74.75	0.05	5.8
31-05-17	12:56	16	759.7	17	1.7	0.124	80.6	0.06	5.06
15-06-17	10:41	18.1	758.9	17	1.6	0.13	84.5	0.06	6.97
20-07-17	9:30	23.2	752.9	15	1.3	0.167	108.55	0.08	6.55
17-08-17	12:32	18.4	751.2	29	2.9	0.118	76.7	0.06	5.56
21-09-17	12:46	19	757.2	27	2.5	0.134	87.1	0.06	6.33
27-10-17	8:46	14	752	38	3.9	0.16	104	0.08	5.94
15-11-17	13:22	4.7	760.5	52	6.7	0.165	107.25	0.08	5.81
18-12-17	13:09	2	758	39	5.4	0.124	80.6	0.06	5.31
Site:	Outlet of Wildcat Restoration site in the eastern end – Located below weir								
Date (dd-mm-yy)	**Time (24h)**	**Temp (C)**	**Pressure (mmHg)**	**DO (%)**	**DO (mg/L)**	**SPC (mS/cm)**	**TDS (mg/L)**	**Sal (ppt)**	**pH**
03-03-17		2.5	752.5	83	11.3	0.133	86.45	0.06	4.51
27-03-17	13:16	1.9	765	95	13.1	0.11	71.5	0.05	5.23
25-04-17	12:17	12.6	767.7	63	6.6	0.139	90.35	0.07	6.39
12-05-17	13:57	13.9	754.5	30	3	0.192	124	0.09	6.69

17-05-17	14:10	19.4	751.8	82	7.5	0.11	71.5	0.05	5.93
31-05-17	13:16	19.1	759.7	54	5	0.166	107.25	0.08	5.93
15-06-17	10:44	16.8	758.9	4	0.04	0.202	131.3	0.01	6.83
20-07-17	9:35	18.5	752.8	2	0.2	0.396	257.4	0.19	7.42
17-08-17	12:39	16.2	751.1	2	0.2	0.3	195	0.14	6.56
21-09-17	12:51	17.8	757.3	1	0.1	0.256	166.4	0.12	6.77
27-10-17	8:51	12.8	752.2	2	0.2	0.212	137.8	0.1	5.99
15-11-17	13:30	5.4	760.5	2	0.2	0.229	148.86	0.11	6.23
18-12-17	13:04	2.1	758.1	17	2.3	0.187	121.55	0.09	6.03
Site:	Wildcat Brook at Lapland Road crossing								
Date (dd-mm-yy)	**Time (24h)**	**Temp (C)**	**Pressure (mmHg)**	**DO (%)**	**DO (mg/L)**	**SPC (mS/cm)**	**TDS (mg/L)**	**Sal (ppt)**	**pH**
17-05-17	14:32	14.7	751.4	99	10.1	0.04	26	0.02	4.56
31-05-17	15:51	16.6	759.2	101	9.8	0.038	24.7	0.02	3.98
15-06-17	10:52	17.4	758.7	82	7.8	0.038	24.7	0.02	5.48
20-07-17	9:56	21.1	752.8	81	7.2	0.041	26.65	0.02	5.3
17-08-17	12:58	17.9	750.8	125	12	0.042	27.3	0.02	5.51
21-09-17	12:58	19	757.3	76	7.1	0.048	31.2	0.02	5.63
27-10-17	8:38	14.2	751.9	73	7.5	0.055	35.75	0.02	4.88
15-11-17	13:41	5.2	760.2	94	11.9	0.054	35.1	0.02	4.93
18-12-17	12:56	0.1	758.2	99	14.1	0.053	33.8	0.02	4.66

Appendix C. Water Quality Data Loggers Results

Appendix C. Table 1. Raw data statistics for water level and pH data loggers (measured every 15-minutes in 2017) for the Wildcat Brook Shale Pit Remediation & Wetland Expansion Project, Petite Rivière Watershed.

	Wildcat Brook	Eastern End	Western End		Eastern End - pH
Variable				Variable	
X	Min.: 1	Min.: 1	Min.: 1	X	Min.: 1
X	1st Qu.: 5425	1st Qu.: 5422	1st Qu.: 5422	X	1st Qu.: 2501
X	Median: 10850	Median: 10842	Median: 10842	X	Median: 5000
X	Mean: 10850	Mean: 10842	Mean: 10842	X	Mean: 5000
X	3rd Qu.: 16274	3rd Qu.: 16262	3rd Qu.: 16263	X	3rd Qu.: 7500
X	Max.: 21698	Max.: 21683	Max.: 21684	X	Max.: 10000
X	#N/A	#N/A	#N/A	Date	Min.: 2017-05-31
Date	Min.: 2017-05-31	Min.: 2017-05-31	Min.: 2017-05-31	Date	1st Qu.: 2017-06-26
Date	1st Qu.: 2017-07-08	1st Qu.: 2017-07-08	1st Qu.: 2017-07-08	Date	Median: 2017-07-22
Date	Median: 2017-08-14	Median: 2017-08-14	Median: 2017-08-14	Date	Mean: 2017-07-22
Date	Mean: 2017-08-14	Mean: 2017-08-14	Mean: 2017-08-14	Date	3rd Qu.: 2017-08-17
Date	3rd Qu.: 2017-09-21	3rd Qu.: 2017-09-21	3rd Qu.: 2017-09-21	Date	Max.: 2017-09-12
Date	Max.: 2017-10-29	Max.: 2017-10-29	Max.: 2017-10-29	Temperature	Min.: 12.79
Date	#N/A	#N/A	#N/A	Temperature	1st Qu.: 18.99
Abs.Pres	Min.: 99.22	Min.: 103.3	Min.: 100.0	Temperature	Median: 21.43
Abs.Pres	1st Qu.: 101.18	1st Qu.: 104.8	1st Qu.: 102.0	Temperature	Mean: 21.37
Abs.Pres	Median: 101.61	Median: 105.4	Median: 102.7	Temperature	3rd Qu.: 23.68
Abs.Pres	Mean: 101.66	Mean: 105.4	Mean: 102.9	Temperature	Max.: 31.12

Abs.Pres	3rd Qu.: 102.08	3rd Qu.: 106.0	3rd Qu.: 104.0	pH	Min.: 5.034
Abs.Pres	Max.: 104.30	Max.: 107.6	Max.: 106.0	pH	1st Qu.: 5.482
Abs.Pres	NA's: 15	NA's: 3	NA's: 1	pH	Median: 7.115
Temp	Min.: 3.155	Min.: 6.877	Min.: 7.582	pH	Mean: 6.696
Temp	1st Qu.: 15.282	1st Qu.: 15.569	1st Qu.: 14.613	pH	3rd Qu.: 7.673
Temp	Median: 17.665	Median: 18.236	Median: 17.379	pH	Max.: 10.188
Temp	Mean: 17.283	Mean: 17.163	Mean: 16.650	Redox.mV.	Min.: 29.9
Temp	3rd Qu.: 19.662	3rd Qu.: 19.662	3rd Qu.: 18.996	Redox.mV.	1st Qu.: 290.4
Temp	Max.: 26.488	Max.: 23.196	Max.: 23.100	Redox.mV.	Median: 380.8
Temp	NA's: 15	NA's: 3	NA's: 1	Redox.mV.	Mean: 377.0
Abs.Pres.Barom	Min.: 97.58	Min.: 97.58	Min.: 97.58	Redox.mV.	3rd Qu.: 488.6
Abs.Pres.Barom	1st Qu.: 100.29	1st Qu.: 100.29	1st Qu.: 100.29	Redox.mV.	Max.: 530.8
Abs.Pres.Barom	Median: 100.72	Median: 100.72	Median: 100.72		
Abs.Pres.Barom	Mean: 100.74	Mean: 100.74	Mean: 100.74		
Abs.Pres.Barom	3rd Qu.: 101.16	3rd Qu.: 101.16	3rd Qu.: 101.16		
Abs.Pres.Barom	Max.: 102.94	Max.: 102.94	Max.: 102.94		
Abs.Pres.Barom	NA's: 22	NA's: 7	NA's: 8		
Water.Level	Min.: 0.1290	Min.: 0.6430	Min.: 0.395		
Water.Level	1st Qu.: 0.2370	1st Qu.: 0.6940	1st Qu.: 0.470		
Water.Level	Median: 0.2620	Median: 0.7310	Median: 0.518		
Water.Level	Mean: 0.2678	Mean: 0.7439	Mean: 0.561		
Water.Level	3rd Qu.: 0.2950	3rd Qu.: 0.8090	3rd Qu.: 0.679		
Water.Level	Max.: 0.4220	Max.: 0.8640	Max.: 0.815		
Water.Level	NA's: 37	NA's: 8	NA's: 9		

Appendix D. Wildcat Restoration Site Visits and Wildlife Observations & Surveys

Appendix D. Table 1. Notes of wildlife and other observations for the Wildcat Brook Shale Pit Remediation & Wetland Expansion Project, Petite Rivière Watershed.

Date Visited	Notes:
21-Dec-16	Water quality samples taken at Wildcat Brook site and eastern end of restoration site. Had to break through ice. Bird tracks observed in snow.
03-Mar-17	Water quality samples taken at Wildcat Brook site and eastern end of restoration site. Hare tracks observed on trail into eastern end of site. Lots of water flowing over weir
27-Mar-17	Water quality samples taken at Wildcat Brook site and eastern end of restoration site. Overcast day. Surface of water muddy at eastern end. Mallard ducks present at eastern end.
17-May-17	Water quality samples taken at Wildcat Brook, eastern end and western end of restoration site. Quite a bit of algae growth observed in water. pH readings reading higher than normal. Chickadee sightings in eastern end. Painted turtle sighting in western end.
25-May-17	Water quality samples taken at Wildcat Brook, eastern end and western end of restoration site. Mallard ducks present in eastern end.
15-Jun-17	Water quality samples taken at Wildcat Brook, eastern end and western end of restoration site. Decrease water levels noticed, but water is still moving over weir. Mallard ducks present at eastern end.
20-Jul-17	Water quality samples taken at Wildcat Brook, eastern end and western end of restoration site. Low water, no water movement over weir. Water beetles sighting on the surface of water in site.
17-Aug-17	Water quality samples taken at Wildcat Brook, eastern end and western end of restoration site. Water is not moving over weir. Mallard ducks present, Dragon fly, and frog's sightings.
21-Sep-17	Water quality samples taken at Wildcat Brook, eastern end and western end of restoration site. Red tailed hawk sightings.
27-Oct-17	Water quality samples taken at Wildcat Brook, eastern end and western end of restoration site. Beautiful day. Raccoon tracks observed. Date logger probes in the Wildcat Brook taken out.
15-Nov-17	Water quality samples taken at Wildcat Brook, eastern end and western end of restoration site. Data logger probes taken out.
18-Dec-17	Water quality samples taken at Wildcat Brook, eastern end and western end of restoration site. Deer tracks and canine tracks seen on snow.
27-Jan-18	Water quality samples taken at Wildcat Brook, eastern end and western end of restoration site.

31-Jan-18	Water quality samples taken at Wildcat Brook, eastern end and western end of restoration site. Clear and windy weather, snow and ice on ground and water, bald eagle sighting.
27-Feb-18	Water quality samples taken at Wildcat Brook, eastern end and western end of restoration site. One red tail hawk, two bald eagles, mallard ducks present, and the remains of a dead bird – eaten by something.

Appendix D. Table 2. Ground-Truthing and Wildlife Survey completed at the Wildcat Brook Shale Pit Remediation & Wetland Expansion Project, Petite Rivière Watershed, prior to restoration work.

Ground-Truthing & Wildlife Survey	
Team:	Coastal Action Staff: Emma Kinley, Sam Reeves, Shauna Barry, Melissa Rafuse, & Alisha Kelly Volunteers: Reg Newell (DNR Wildlife Biologist) and Elijah Sawler (NSCC Natural Resources & Environmental Technology Program)
Purpose:	• Develop a comprehensive site description of the Wildcat Shale Pit Remediation site prior to proposed restoration work. • Gather information on existing wildlife in the site area of the 1.10-hectare shale pit.
Current land use:	Abandoned shale pit mining site – abandoned approximately 20 years ago
Details on Site:	
Current landscape features Pit area consists of bare rock with very minimal amount of soil and sparse shrub vegetation. Lower lying areas, that likely have been excavated in the past, pool with rain water. Pools all read low acidity and lack aquatic vegetation growth within them which duck species rely on for shelter when young and for food. Surrounding the pit area is a mixture of softwood and hardwood forest varying in age but majority of growth around 20-30 years old. Shale pit site is adjacent to nearby Wildcat Brook. Standing mixed wood forest consisted of eastern white pine, red maple, eastern hemlock, white birch, grey birch, black spruce, balsam fir, and tamarack. Ground vegetation consisted of wild raisin, speckled and green alders, lambkill, leather leaf, bog cranberry, reindeer moss, straw berry, and dew berry. Regeneration vegetation consisted of balsam fir, red spruce, oak, and eastern white pine.	
Habitat types present Mixed wood forest (surrounding pit); riparian zone habitat (edge of stream); bare rock (within pit area) – snakes, turtles, and insects like to draw heat from; wet marsh/wetland habitat (edge of pit); old trees – cavities used for wildlife nests/downfall for cover/great for insects; and pond habitat – lacking vegetation but sightings of tad poles and frog eggs.	
List Wildlife present/sightings • Black Capped Chickadee – sighting • Pileated Woodpecker hole • Mallard duck – sighting • Beaver stump • Tad poles – sighting • Hare scat • Mustelidae family tracks and scat (scat found in larger pit) • Racoon tracks	

- Fish bones
- Coyote scat and tracts (found in larger pit)
- Deer tracks (found in larger pit)
- Unknown yellow bird – sighting
- Bird egg lining
- Insect damage on some old trees

List Other Possible Species

- The large white pine serves as good habitat for red-tailed hawk nesting and other raptor nesting, as well as barred owls, possibly great horned owl, and saw-whet owl.
- Smaller mammal species: shrews, red back moles included
- Bobcat, coyote, fox (likely not fox if coyotes are present)
- Pine grosbeak could be present during winter
- Deer could be present during winter, not the best feeding habitat during summer (little shrub vegetation to feed on)
- Warblers (like mixed forest)
- Grosbeak
- Woody, downy, and pileated woodpeckers
- Wood ducks
- Kinglets
- Goshawks
- Porcupines
- Fisher (possible tracks spotted in pit)
- Snakes
- Dragonflies
- Short tailed shrew (poisonous)

Appendix E. Point Photos & Vegetation Surveys

Appendix E. Table 1. Sample of point photos taken for the Wildcat Brook Shale Pit Remediation & Wetland Expansion Project, Petite Rivière Watershed.

Point Photos at 1.10-hectare Wildcat Restoration Site			
Point One:	Eastern end of the Wildcat Restoration site.		
			
23-November-2015	12-August-2016	08-September-2016	21-August-2017
Point Two:	Central of the Wildcat Restoration site looking at the eastern end.		
			
02-September-2015	22-April-2016	07-August-2016	17-May-2017
Point Three:	Western end of the Wildcat Restoration site.		
			
03-September-2015	03-May-2016	12-August-2016	17-May-2017
Point Four:	Northern end of the Wildcat Restoration site.		
			
03-May-2016	12-August-2016	07-October-2016	17-May-2017

Appendix E. Table 2. Density Measurements taken for the Wildcat Brook Shale Pit Remediation & Wetland Expansion Project, Petite Rivière Watershed, prior to restoration efforts. The Wildcat Restoration site was split into four sections (1-lower right, 2-upper right, 3-upper left, and 4-lower left) and each section sampled five times using a 1x1 square grid to measure randomized locations for presence of vegetation.

Section:	Quadrate:	1	2	3	4	5	Vegetation Averages:
1	Q1	0	30	15	5	3	8.50%
	Q2	0	20	10	5	1	
	Q3	0	25	15	3	3	
	Q4	1	20	10	3	1	
2	Q1	2	15	75	5	3	15.60%
	Q2	1	7	60	3	2	
	Q3	1	10	20	1	2	
	Q4	2	5	75	20	3	
3	Q1	50	85	15	10	0	31.58%
	Q2	75	30	35	10	0	
	Q3	55	65	10	10	0.5	
	Q4	80	70	20	10	1	
4	Q1	5	10	80	95	60	43.55%
	Q2	5	5	65	75	70	
	Q3	2	7	50	80	50	
	Q4	2	10	50	80	70	
Total Average: 24.80%							

Appendix E. Table 3. Vascular Plant List completed for the Wildcat Brook Shale Pit Remediation & Wetland Expansion Project, Petite Rivière Watershed, prior to restoration efforts.

	Latin Name	Common Name	Nova Scotia General Status Rank
1	Abies balsamea	Balsam Fir	4 Secure
2	Acer rubrum	Red Maple	4 Secure
3	Agrostis scabra	Rough Bent Grass	4 Secure
4	Anaphalis margaritacea	Pearly Everlasting	4 Secure
5	Anthoxantum odoratum	Sweet Vernal Grass	7 Exotic
6	Anus incana ssp. rugosa	Speckled Alder	4 Secure
7	Symphyotrichum lateriflorum	Calico Aster	4 Secure
8	Betula populifolia	Grey Birch	4 Secure
9	Bidens frondosa	Devil's Beggarticks	4 Secure
10	Brasenia screberi	Water Shield	4 Secure
11	Calopogon pulchellus	Grass Pink	
12	Carex canescens	Hoary Sedge	4 Secure
13	Carex lurida	Shining Sedge	4 Secure
14	Carex scoparia	Broom Sedge	4 Secure
15	Centaurea nigra	Knapweed	

16	Chamaedaphne calyculata	Leatherleaf	4 Secure
17	Comptonia peregrina	Sweet Fern	4 Secure
18	Cypripedium acaule	Pink Lady's-slipper	4 Secure
19	Danthonia compressa	Flattened Oat Grass	4 Secure
20	Danthonia spicata	Poverty Oat Grass	4 Secure
21	Dennstaedtia punctilobula	Hay-scented Fern	4 Secure
22	Drosera intermedia	Spoon-leaved Sundew	4 Secure
23	Drosera rotundifolia	Round-leaved Sundew	4 Secure
24	Dulichium arundinacium	Three-way Sedge	4 Secure
25	Eleocharis acicularis	Needle Spikerush	4 Secure
26	Eleocharis tenuis	Slender Spikerush	4 Secure
27	Epigaea repens	Mayflower	4 Secure
28	Epilobium ciliatum	Northern Willowherb	4 Secure
29	Erechtites hieraciifolia	Fireweed	4 Secure
30	Erigeron strigosus	Rough Fleabane	4 Secure
31	Eriophorum virginicum	Tawny Cottongrass	4 Secure
32	Euthamia graminifolia	Narrow-leaved Goldenrod	4 Secure
33	Fragaria virgininana	Wild Strawberry	4 Secure
34	Gaultheria hispidula	Creeping Snowberry	4 Secure
35	Gaultheria procumbens	Teaberry	4 Secure
36	Gaylussacia baccata	Huckleberry	4 Secure
37	Glyceria obtusa	Atlantic Manna Grass	4 Secure
38	Hieracium kalmii	Kalm's Hawkweed	5 Undetermined
39	Hieracium sp.	A hawkweed	7 Exotic
40	Hypericum canadense	Canada St. John's-wort	4 Secure
41	Hypericum perforatum	Common St. John's-wort	7 Exotic
42	Iris versicolor	Blue Flag	4 Secure
43	Juncus brevicaudatus	Narrow-panicled Rush	4 Secure
44	Juncus canadensis	Canada Rush	4 Secure
45	Juncus militaris	Bayonet Rush	4 Secure
46	Juncus pelocarpus	Brown-fruited Rush	4 Secure
47	Juncus effusus	Soft Rush	4 Secure
48	Juncus tenuis	Slender Rush	4 Secure
49	Kalmia angustifolia	Sheep Laurel	4 Secure
50	Kalmia polifolia	Bog Laurel	4 Secure
51	Larix laricina	Larch	4 Secure
52	Lechea intermedia	Pinweed	4 Secure
53	Ledum groendandicum	Labrador-tea	4 Secure
54	Leontodon autumnalis	Fall dandelion	7 Exotic
55	Lobelia inflata	Indian Tobacco	4 Secure
56	Lycopodiella inundata	Northern Bog Clubmoss	4 Secure
57	Lysimachia terrestris	Swamp Candle	4 Secure
58	Melampyrum lineare	Cow wheat	4 Secure
59	Muhlenbergia uniflora	Bog Muhly Grass	4 Secure
60	Myrica gale	Sweet Gale	4 Secure
61	Nuphar variegata	Cow Lily	4 Secure
62	Nymphaea cordata	Water Lily	4 Secure
63	Oenothera biennis	Common Evening Primrose	4 Secure

64	Oenothera perennis	Perennial Evening Primrose	4 Secure
65	Oxalis dillenii	Slender Yellow Wood Sorrel	7 Exotic
67	Dichanthelium depauperatum	Starved Panic Grass	4 Secure
68	Panicum lanuginosum	Woolly Panic Grass	4 Secure
69	Phalaris arundinacea	Reed Canary Grass	4 Secure
70	Picea mariana	Black Spruce	4 Secure
71	Picea rubens	Red Spruce	4 Secure
72	Pinus strobus	White Pine	4 Secure
73	Plantago major	Common Plantain	7 Exotic
74	Poa compressa	Canada Blue Grass	7 Exotic
75	Poa pratensis	Kentucky Blue Grass	4 Secure
76	Pogonia ophioglossoides	Rose Pogonia	4 Secure
77	Pontederia cordata	Pickerelweed	4 Secure
78	Potamogeton confervoides	Alga Pondweed	4 Secure
79	Potentilla sp.	a cinquefoil	4 Secure
80	Prenanthes trifoliolata	Three-leaved Rattlesnakeroot	4 Secure
81	Prunella vulgaris	Heal-all	7 Exotic
82	Pteridium aquilinum	Bracken Fern	4 Secure
83	Quercus rubra	Red Oak	4 Secure
84	Rhododendron canadense	Rhodora	4 Secure
85	Rhynchospora alba	White Beakrush	4 Secure
86	Rubus hispidus	Bristley Dewberry	4 secure
87	Sarracenia purpurea	Pitcher Plant	4 Secure
88	Scirpus atrocinctus	Black-girdled Woolsedge	4 Secure
89	Scirpus cyperinus	Common Woolsedge	4 Secure
90	Solidago juncea	Early Goldenrod	4 Secure
91	Solidago puberula	Downy Goldenrod	4 Secure
92	Solidago rugosa	Rough Goldenrod	4 Secure
93	Sparganium americanum	American Burreed	4 Secure
94	Spiraea alba var. latifolia	Meadowsweet	4 Secure
95	Spiraea tomentosa	Steeplebush	4 Secure
96	Spiranthes sp. (in bud; possibly S. ochroleuca)	a ladies-tresses	4 Secure
97	Triadenum fraseri	Fraser's Marsh St. John's-wort	4 Secure
98	Trifolium arvensis	Rabbit's-foot Clover	7 Exotic
99	Tsuga canadensis	Hemlock	4 Secure
100	Vaccinium macrocarpon	Large Cranberry	4 Secure
101	Veronica officinalis	Common Speedwell	7 Exotic
102	Viburnum cassinoides	Witherod	4 Secure
103	Viola lanceolata	Lance-leaved Violet	4 Secure