Weaselhead/
Glenmore Park
PRESERVATION SOCIETY

Weaselhead/Glenmore Park
SWCRR Impact Study
Environmental Monitoring Report 2016: baseline conditions

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INTRODUCTION

The South West Calgary Ring Road (SWCRR) construction phase started in fall 2016. This project's EIA (Environmental Impact Assessment) predicts alteration to habitats and impacts on the environment that will have an effect on the adjacent Weaselhead Natural Environment Park during the construction and later at the operational phase of the SWCRR. In this context, the Weaselhead/Glenmore Park Preservation Society initiated the SWCRR Impact Study, of which this report is a part. It details the results of the environmental monitoring component. The objective of this monitoring project is to assess the environmental impacts of the SWCRR, especially the section adjacent to the park that includes the Elbow River crossing, and establish whether or not they are within acceptable limits.

This first report (containing data collected in 2016) is of particular importance because it describes conditions in the study area prior to the landscape alterations that will take place during and following construction of the SWCRR. Together with data from surveys and environmental assessments carried out in the past, it will be used to represent the baseline environmental conditions in the Weaselhead prior to disturbance.

The intention of this monitoring effort is not to offer a comprehensive survey of habitats and ecosystem components in the park. This monitoring project is designed as a rapid environmental assessment tool, capable of giving early warning about changes in habitat quality and ecological processes in a timely manner and at a relatively low cost.

The continuation of this monitoring effort through the SWCRR construction phase and into the operational phase will provide the information necessary to evaluate objectively the environmental effects and the success of mitigation measures currently included in the design of the Elbow River Crossing. This information will allow the Society to base any requests for improved mitigation upon verifiable and scientific data.

1. TERRESTRIAL HABITATS

a. Breeding Bird Survey

The bird survey of June 2016 provides baseline information about the Weaselhead bird community. This will contribute to assessing the impact of the SWCRR on birds breeding in the area.

On June 26th 2016, three groups of volunteers surveyed the area, each group visiting different sites. Each group was lead by an expert in bird identification and practised in the method described below. Starting at 5:00am (daylight saving time: UTC-6:00) each group hiked to pre-determined stations located using GPS instruments. At these stations the group waited for 2 minutes in silence then recorded on datasheets the birds heard or seen less than 50m from the group, and from 50 to 100m distant for 10 minutes. Birds flushed when approaching the point, flying overhead, or flying through the area (under the canopy) were noted on the sheet, but not included in the total count of species.

The survey covered in total 28 stations in the Weaselhead area (including 4 stations just outside the boundary of the Weaselhead, two in North and two in South Glenmore Parks) (table 1). During the bird survey, 323 individuals and 45 species were identified (tables 2 and 3). The total Simpson's diversity index for the breeding bird survey was very high (1-S = 95.22%). The mean species density was 2.59 (±0.71) species per hectare (n=28).

Table 1: Station coordinates for the breeding bird survey and the noise pollution monitoring

Station	Latitude	Longitude
P1	50° 59.789′ N	114° 09.427′ W
P2	50° 59.772′ N	114° 09.221′ W
P3	50° 59.738′ N	114° 08.931′ W
P4	50°59.701′ N	114°09.347′ W
P5	50°59.647′ N	114°09.180′ W
P6	50°59.584′ N	114°09.359′ W
P7	50°59.446′ N	114°09.346′ W
P8	50°59.477′ N	114°09.128′ W
P9	50°59.324′ N	114°09.621′ W
P10	50°59.320′N	114° 09.355′ W
P11	50°59.320′N	114° 09.092′ W
P12	50°59.359′N	114° 08.815′ W
P13	50°59.560′N	114° 08.948′ W
P14	50°59.663′N	114° 08.757′ W
P15	50°59.513′N	114° 08.709′ W
P16	50°59.572′N	114° 08.470′ W
P17	50°59.431′N	114° 08.343′ W
P18	50°59.331′N	114° 08.072′ W
P19	50°59.200′N	114° 09.278′ W
P20	50°59.141′N	114° 09.435′ W
P21	50°59.189′N	114° 09.673′ W
P22	50°59.114′N	114° 09.097′ W
P23	50°59.119′N	114° 08.887′ W
P24	50°58.977′N	114° 08.894′ W
P25	50°58.963′N	114° 08.618′ W
P26	50°58.816′N	114° 08.506′ W
P27	50°58.875′N	114° 08.312′ W
P28	50°58.766′N	114° 08.018′ W

A significant linear regression slope ($p<0.05$) was found between the cumulative number of different species in the Weaselhead and the cumulative area investigated (figure 1). This regression follows the general function: $CS=0.41A+11.1$ ($R^2=0.9826$), where CS is the cumulative number of species and A is the cumulative area observed (ha). The slope value of this equation represents the expected increase in the cumulative number of species found with increased area of search (for the same period of the year). In this case an average of 0.41 "new" species were recorded with each additional hectare surveyed. The relationship between the recorded number of breeding bird species and the surveyed area behaves linearly for a search area up to the total area surveyed in 2016 (88ha). However it is expected if the surveyed area was increased beyond a certain value (greater than 88ha) the number of new species detected per each additional hectare would decline, and this linear relationship would level off to a horizontal asymptote. Assuming stable breeding bird populations and preserved habitats the results for subsequent years should be similar for the same period of the year when using the same methodology and during similar weather conditions (low wind and mostly, cloudy, temperature 13˚C-16˚C mostly with no precipitation).

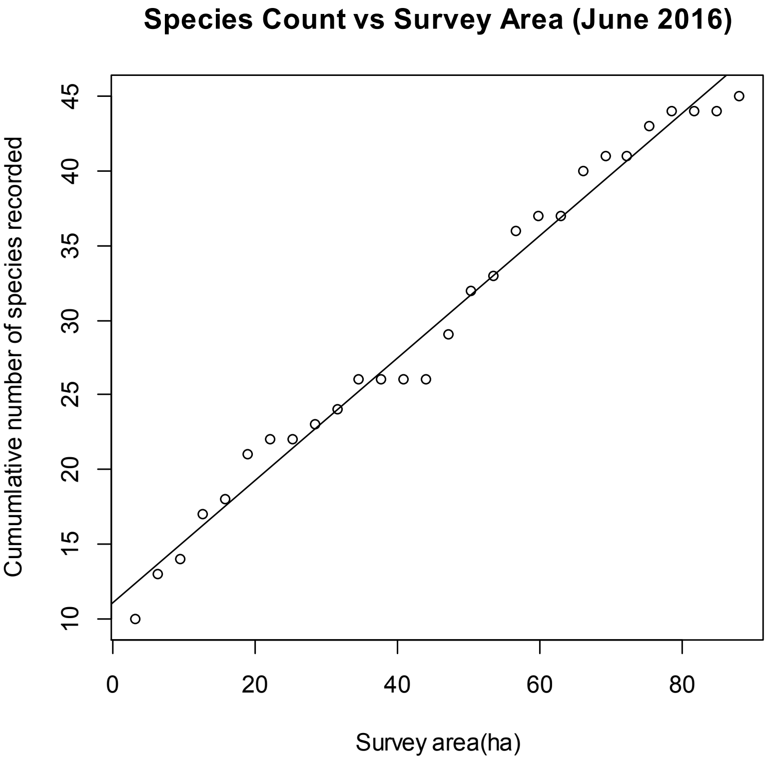

Figure 1: Regression model between cumulative number of species recorded and area, increasing in increments of 3.14ha (= area of 100m-radius circle around stations in which observations were made)

Table 2: Breeding bird survey species list (June 26th 2016), total individual counts and conservation status

Common Name	Species	Total Count	Status according to Alberta Environment and Parks		
			Status 2010	Status 2005	Status 2000
American Crow	*Corvus brachyrhynchos*	9	Secure	Secure	Secure
American Goldfinch	*Spinus tristis*	3	Secure		
American Robin	*Turdus migratorius*	20	Secure	Secure	Secure
Belted Kingfisher	*Megaceryle alcyon*	1	Secure		
Black-billed Magpie	*Pica hudsonia*	12	Secure	Secure	Secure
Black-capped Chickadee	*Poecile atricapillus*	22	Secure		
Boreal Chickadee	*Poecile hudsonicus*	1	Secure		
Brown Thrasher	*Toxostoma rufum*	1	Secure	Secure	Secure
Brown-headed Cowbird	*Molothrus ater*	15	Secure	Secure	Secure
Canada Goose	*Branta canadensis*	21	Secure	Secure	Secure
Cedar Waxwing	*Bombycilla cedrorum*	9	Secure	Secure	Secure
Chipping Sparrow	*Spizella passerina*	3	Secure	Secure	Secure
Clay-colored Sparrow	*Spizella pallida*	17	Secure	Secure	Secure
Common Raven	*Corvus corax*	1	Secure	Secure	Secure
Common Yellowthroat	*Geothlypis trichas*	1	Sensitive	Sensitive	Secure
Downy Woodpecker	*Picoides pubescens*	4	Secure	Secure	Secure
Gray Catbird	*Dumetella carolinensis*	8	Secure	Secure	Secure
Great Horned Owl	*Bubo virginianus*	1	Secure	Secure	Secure
Hairy Woodpecker	*Leuconotopicus villosus*	1	Secure	Secure	Secure
House Wren	*Troglodytes aedon*	16	Secure	Secure	Secure
Least Flycatcher	*Empidonax minimus*	12	Sensitive	Sensitive	Secure
Lincoln's Sparrow	*Melospiza lincolnii*	2	Secure	Secure	Secure
Mallard	*Anas platyrhynchos*	15	Secure	Secure	Secure
Northern Flicker	*Colaptes auratus*	3	Secure	Secure	Secure
Northern Waterthrush	*Parkesia noveboracensis*	2	Secure	Secure	Secure
Ovenbird	*Seiurus aurocapilla*	2	Secure		
Pileated Woodpecker	*Hylatomus pileatus*	2	Sensitive	Sensitive	Sensitive
Red-breasted Nuthatch	*Sitta canadensis*	9	Secure	Secure	Secure
Red-eyed Vireo	*Vireo olivaceus*	8	Secure	Secure	Secure
Red-necked Grebe	*Podiceps grisegena*	1	Secure	Secure	Secure
Red-winged Blackbird	*Agelaius phoeniceus*	10	Secure	Secure	Secure
Ring-necked Pheasant	*Phasianus colchicus*	1	Exotic	Exotic/Alien	Exotic/Alien
Song Sparrow	*Melospiza melodia*	9	Secure	Secure	Secure
Spotted Sandpiper	*Actitis macularius*	6	Secure		
Spotted Towhee	*Pipilo maculatus*	1	Secure	Secure	Secure
Veery	*Catharus fuscescens*	9	Secure	Secure	Secure
Warbling Vireo	*Vireo gilvus*	1	Secure	Secure	Secure

Western Wood-pewee	*Contopus sordidulus*	1	Sensitive	Secure	Secure
White-breasted Nuthatch	*Sitta carolinensis*	27	Secure	Secure	Secure
White-throated Sparrow	*Zonotrichia albicollis*	1	Secure	Secure	Secure
Wilson's Snipe	*Gallinago delicata*	1	Secure	Secure	Secure
Wilson's Warbler	*Cardellina pusilla*	1	Secure	Secure	Secure
Winter Wren	*Troglodytes hiemalis*	1	Secure	Secure	Secure
Yellow Warbler	*Setophaga petechia*	30	Secure	Secure	Secure
Yellow-bellied Sapsucker	*Sphyrapicus varius*	2	Secure	Secure	Secure
Other bird sights overhead or above 100m:					
American Widgeon	*Anas americana*	N/A	Secure	Secure	Secure
Bank Swallow	*Riparia riparia*	N/A	Secure	Secure	Secure
Cliff Swallow	*Petrochelidon pyrrhonota*	N/A	Secure	Secure	Secure
Common Merganser	*Mergus merganser*	N/A	Secure	Secure	Secure
Cooper's Hawk	*Accipiter cooperii*	N/A	Secure	Secure	Secure
Franklin Gull	*Leucophaeus pipixcan*	N/A	Secure		
Pine Siskin	*Carduelis pinus*	N/A		Secure	Secure
Sharp Shinned Hawk	*Accipiter striatus*	N/A	Secure	Secure	Secure
Swainson's Thrush	*Catharus ustulatus*	N/A	Secure	Secure	Secure
Tree Swallow	*Tachycineta bicolor*	N/A	Secure	Secure	Secure

In addition to the high bird species diversity found (the reason for the Weaselhead’s popularity amongst bird watchers) the area offers breeding habitat for a number of species of ‘sensitive’ status (Alberta Environment and Parks, 2016). During only one day of observation the above survey recorded four sensitive species: the Common Yellowthroat (*Geothlypis trichas*), the Least Flycatcher (*Empidonax minimus*), the Pileated Woodpecker (*Hylatomus pileatus*), and the Western Wood-pewee (*Contopus sordidulus*). These observations underscore the importance of the park for breeding birds.

Table 3: Breeding bird survey species list; total individual counts per station within 50m and 100m-radius from observer.

Breeding Bird Survey on Weaselhead Park - June 26th 2016																																																									
			Site																																																							
Common Name	**Scientific Name**	**Total Count**	**P1**		**P2**		**P3**		**P4**		**P5**		**P6**		**P7**		**P8**		**P9**		**P10**		**P11**		**P12**		**P13**		**P14**		**P15**		**P16**		**P17**		**P18**		**P19**		**P20**		**P21**		**P22**		**P23**		**P24**		**P25**		**P26**		**P27**		**P28**	
			50m	100m	50m	100m	50m	100m	50m	100m	50m	100m	50m	100m	50m	100m	50m	100m	50m	100m	50m	100m	50m	100m	50m	100m	50m	100m	50m	100m	50m	100m	50m	100m	50m	100m	50m	100m	50m	100m	50m	100m	50m	100m	50m	100m	50m	100m	50m	100m	50m	100m	50m	100m	50m	100m	50m	100m
American Crow	*Corvus brachyrhynchos*	*9*																																			8															1			
American Goldfinch	*Spinus tristis*	*3*		1									1						1																																				
American Robin	*Turdus migratorius*	*20*		2	1	1	1	1	1										1	1		1									1		1				1			1	1	1						1		1		1				1							
Belted Kingfisher	*Megaceryle alcyon*	*1*																													1																									
Black billed Magpie	*Pica hudsonia*	*12*																					1	1					1	1		3			3	1		1																				
Black-capped Chickadee	*Poecile atricapillus*	*22*		2						2		1	1						2							1							1												1	1	1				3							5					1				
Boreal Chickadee	*Poecile hudsonicus*	*1*											1																																											
Brown Thrasher	*Toxostoma rufum*	*1*																																1																								
Brown-headed Cowbird	*Molothrus ater*	*15*					1					1			1			1				1							1			2																		1						1	2				2							1	
Canada Goose	*Branta canadensis*	*21*																															20			1																							
Cedar Waxwing	*Bombycilla cedrorum*	*9*									1										1													1										1	2													1			2	
Chipping Sparrow	*Spizella passerina*	*3*																														1					1																			1				
Clay-colored Sparrow	*Spizella pallida*	*17*	1				2	2			1	1	1						1				1	1	1			1							1																1					1											1			
Common Raven	*Corvus corax*	*1*																																															1							
Common Yellowthroat	*Geothlypis trichas*	*1*																																								1														
Downy Woodpecker	*Picoides pubescens*	*4*								1												1																							1												1				
Gray Catbird	*Dumetella carolinensis*	*8*	1					2										1										1				1						1			1																								
Great Horned Owl	*Bubo virginianus*	*1*																																			1																					
Hairy Woodpecker	*Leuconotopicus villosus*	*1*																														1																										
House Wren	*Troglodytes aedon*	*16*				1	1		2	1		1					1								1	1						1	1				1												1					1				2									
Least Flycatcher	*Empidonax minimus*	*12*											1	1																										1			2				1				1	1			1			3						
Lincoln's Sparrow	*Melospiza lincolnii*	*2*																			1												1																										
Mallard	*Anas platyrhynchos*	*15*																				1																1						13																
Northern Flicker	*Colaptes auratus*	*3*				2															1																																						
Northern Waterthrush	*Parkesia noveboracensis*	*2*		1											1																																													
Ovenbird	*Seiurus aurocapilla*	*2*																												1																1													
Pileated Woodpecker	*Hylatomus pileatus*	*2*											1							1																																							
Red-breasted Nuthatch	*Sitta canadensis*	*9*						2			1																													2	1											1					1	1	
Red-eyed Vireo	*Vireo olivaceus*	*8*																																					1			2												1	2		1	1	
Red-necked Grebe	*Podiceps grisegena*	*1*																																																							1
Red-winged Blackbird	*Agelaius phoeniceus*	*10*																												1													9																
Ring-necked pheasant	*Phasianus colchicus*	*1*																																															1							
Song Sparrow	*Melospiza melodia*	*9*	1	1												1						1									1					1			1	1									1																
Spotted Sandpiper	*Actitis macularius*	*6*		1	2																														2																									1
Spotted Towhee	*Pipilo maculatus*	*1*																																		1																						
Veery	*Catharus fuscescens*	*9*																1	1																							1	2			2				1	1								
Warbling Vireo	*Vireo gilvus*	*1*																																										1														
Western Wood Peewee	*Contopus sordidulus*	*1*																																																1								
White Throated Sparrow	*Zonotrichia albicollis*	*27*	1												1	1	1					3	1	1	1	1					1	1	1	1	1			1					2			3	1				1			1									2					
White-breasted Nuthatch	*Sitta carolinensis*	*1*														1																																										
Wilson's Snipe	*Gallinago delicata*	*1*																																								1														
Wilson's Warbler	*Cardellina pusilla*	*1*																																								1														
Winter Wren	*Troglodytes hiemalis*	*1*					1																																																			
Yellow Warbler	*Setophaga petechia*	*30*		1	1	2					1	1						1					1	1		1			1						2				1			1			2								1	1		1			3	2				1				1			1	2	
Yellow-bellied Sapsucker	*Sphyrapicus varius*	*2*								1			1																																												

b. Noise pollution

Some bird species can be particularly vulnerable to the noise pollution such as that associated with the construction and operation of roads (McClure et al., 2013). In order to investigate if any possible changes in breeding bird richness, diversity and abundance observed before and after SWCRR construction may be correlated with changes in ambient noise the following data on pre-road construction noise levels were collected.

At the same stations as used in the breeding bird survey (table 1), a sound level meter (range 0 -100 dB LAS) was employed to monitor the noise pollution during the traffic peak hours on 7th and 8th July 2016. On each site, the sound level was measured for 2 minutes. The results are shown in table 4.

Table 4: Sound pressure measured in peak traffic hours (minimum, maximum, average and peak)

Site	Time UTC-6	Sound Pressure (dB)			
		Min	Max	Aver.	Peak
P1	16:05	32.9	64.0	51.5	74.5
P2	15:57	30.6	36.4	32.9	65.3
P3	8:53	34.4	63.1	46.0	84.9
P4	16:22	34.0	49.7	39.7	74.8
P5	16:33	34.4	48.9	40.2	71.9
P6	16:42	32.4	45.4	35.9	72.0
P7	16:52	31.7	48.6	39.0	76.9
P8	17:05	33.1	48.2	36.1	72.7
P9	17:31	30.7	44.7	35.5	74.3
P10	17:20	31.8	40.0	34.3	60.4
P11	18:20	31.4	47.0	39.1	71.3
P12	15:30	30.8	41.1	33.1	61.3
P13	15:44	32.5	46.2	34.5	71.1
P14	9:08	34.6	50.6	39.3	75.9
P15	9:23	32.4	43.5	36.0	70.9
P16	8:33	36.8	59.5	45.1	73.6
P17	8:17	36.5	44.4	39.5	74.6
P18	8:02	32.2	41.7	34.1	70.2
P19	18:02	36.5	45.9	38.7	76.4
P20	17:50	36.1	56.1	42.7	80.7
P21	17:40	29.8	53.5	44.0	75.8
P22	7:27	41.2	50.7	42.6	74.9
P23	7:16	40.9	57.8	50.8	73.7
P24	7:36	39.0	44.4	41.0	59.4
P25	7:01	42.8	54.0	48.0	73.9
P26	7:48	42.6	52.4	46.1	72.1
P27	6:52	42.9	48.5	44.7	65.4
P28	6:42	40.8	44.6	41.7	66.7
mean		35.2	49.0	40.4	72.0
sd		4.2	6.7	5.2	5.7

c. Beaver Pond riparian vegetation

Baseline information was collected in 2015 and 2016 to describe the riparian vegetation at the Beaver Pond in the Weaselhead in order to assess the effects of the SWCRR on this vegetation. This wetland was chosen as its upstream edge is bordered by the SWCRR and so represents habitat in immediate proximity to the SWCRR. The results for 2016 are detailed below. The same protocol and site were used in 2015.

A 50-metre transect parallel to the pond shoreline and oriented on the west-east azimuth (from 50˚59’11.29’’N; 114˚09’37.38’’W to 50˚59’11.29’’N; 114˚09’34.78’’W) was used as a reference line for 50 adjacent 2m x 2m quadrats. The quadrats were numbered from 1 to 50 from west to east (figure 1). The statistical package R$^{©}$ was used to create a random sample of 15 quadrats from the total of 50. These 15 quadrats represent samples from the Beaver Pond riparian vegetation and are the units of analysis used for the 2016 survey. On 9th and 10th September 2016, each selected quadrat was comprehensively screened, and the individual eudicot plants present were counted and identified to species level. The results are presented in table 1.

North

1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49
2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50

Pond Shoreline

Figure 2: Disposition of 50 quadrats (2m x 2m) on the west-east transect created on the Beaver Pond shoreline. From these, 15 randomly selected quadrats were included in the 2016 survey (quadrats number 8, 10, 12, 13, 17, 18, 21, 26, 29, 33, 35, 37, 41, 42, 44).

The results show a total taxa richness of 33 species of eudicot plants found in the total area surveyed, 60m^2 (15 quadrats x 4m^2 per quadrat). Prickly Rose (*Rosa acicularis*) was the dominant species in the area surveyed, comprising 27.7% of the total individuals counted (including all species). The area revealed an average richness of 3.23±0.88 eudicot species per square meter (n=15). The Simpson’s index (S) was calculated for each quadrat as follows:

$$S = \sum_{i=1}^{R} \left(\frac{n_i}{N}\right)^2$$

Where n_i is the total number of organisms of the i^{th} species, R is richness (total number of species in the study) and N is the total number of organisms of all species. The Simpson’s index is a diversity indicator. It measures the probability that two individuals selected from a sample will belong to the same species. The 1-Simpson’s index (1-S) indicates the probability that two individuals randomly selected from a sample will belong to different species. This index (1-S) has a range from zero (very low diversity) to 100% (very high diversity). The area investigated in this study showed a mean 1-Simpson's index for eudicot plants of 82.2%±5.1% per quadrat (2m x 2m) in 2016.

When compared with the results for the same area in September 2015 (1-S = 81.6%±4.8%, figure 3) no statistically significant difference was found in the logSimpson's Index per quadrat between the two years (ANOVA, df = (1, 28), $p>0.05$). The log10 transformation was necessary for meeting the residuals normality assumption of the ANOVA.

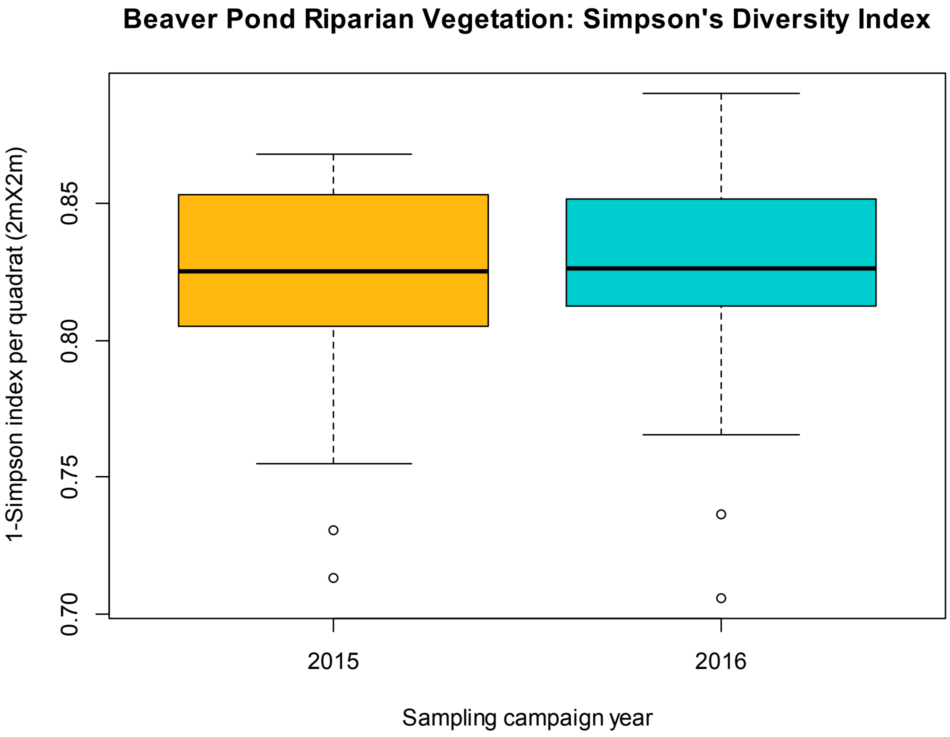

Figure 3: Simpson's diversity index (1-S) per quadrat for 2015 and 2016 sampling campaigns.

In September 2016 there was a mean of 3.2±0.88 eudicot species per square meter along the shore of the Beaver Pond (n=15). These results do not differ significantly (ANOVA, df = (1, 28), $p>0.05$) from the results obtained from the survey completed in 2015 (2.7±0.59 eudicot species m^2, figure 4).

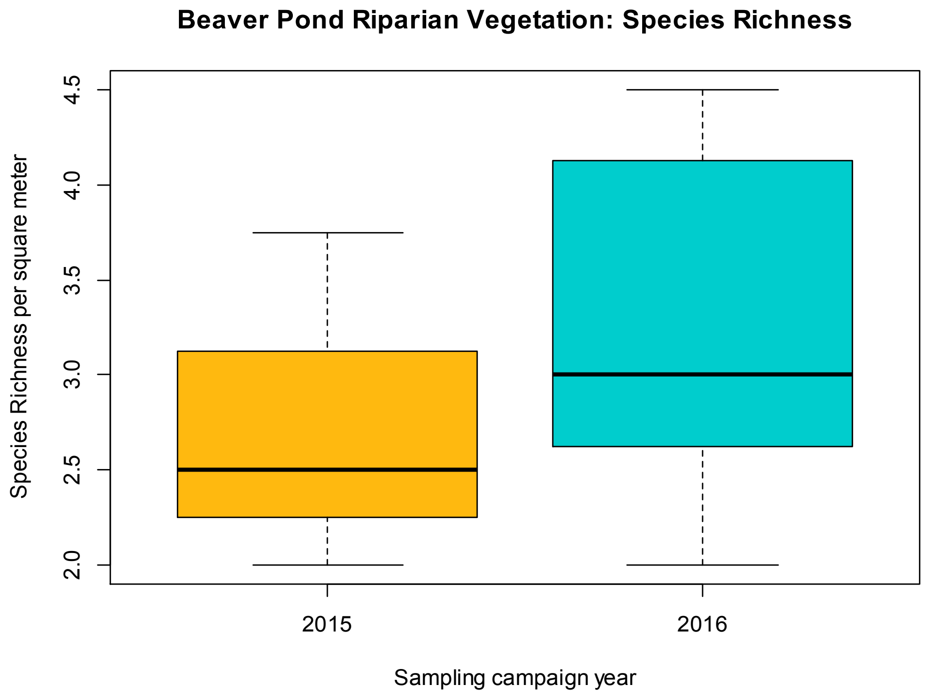

Figure 4: Eudicots species richness per square meter for 2015 and 2016 sampling campaigns.

Neither taxa richness per square meter or Simpson's diversity index per quadrat showed statistically significant differences ($p>0.05$) when comparing September 2015 with September 2016. These results are important in establishing the Beaver Pond's riparian vegetation community baseline conditions and natural variability range. Table 5 shows the species and number of individuals included in this vegetation survey. Most of the species are native, but invasive plants are also present. Any change to the relative abundance between native and invasive plants will be detected by future surveys in the area.

Table 5: Eudicots - Quadrats (2m x 2m) Individual counts - Sep 9th and 10th 2016

Species	**Common name**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Rosa acicularis	Prickly Rose	5	5	12	35	50	22	54	7	39	29	14	15	11	1	9
Cirsium arvense	Canada Thistle	6	11	8	7	10	7	4	5	8	6	14	8	3	5	3
Cornus stolonifera	Red-Osier Dogwood	0	0	0	0	4	0	2	4	3	2	0	0	2	0	1
Salix bebbiana	Bebb Willow	0	1	2	1	5	1	2	2	0	1	1	0	1	1	2
Euthamia graminifolia	Flat-top Goldenrod	0	0	1	1	0	1	1	0	0	0	0	0	1	5	0
Elaeagnus commutate	Silverberry	8	4	8	1	2	2	5	0	3	0	0	0	3	0	0
Polygonum persicaria	Spotted Lady's-thumb	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Sonchus arvensis	Field Sow Thistle	2	4	7	0	1	0	0	0	0	1	0	15	11	4	7
Viola Canadensis	Canada Violet	0	0	0	0	0	1	0	0	0	2	4	9	4	2	5
Lysimachia ciliate	Fringed Loosestrife	5	10	10	0	0	0	0	0	0	0	0	0	0	0	0
Mentha arvensis	Wild Mint	0	0	0	3	3	0	11	4	8	7	1	2	2	0	6
Dasiphora fruticose	Shrubby cinquefoil	0	0	0	4	2	0	2	0	0	1	0	0	1	0	0
Thalictrum venulosum	Veiny Meadow Rue	0	0	3	0	1	0	4	1	1	1	0	0	1	0	0
Solidago Canadensis	Canada Goldenrod	3	1	0	1	3	2	36	10	17	11	7	6	0	0	0
Vicia Americana	American Vetch	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Trifolium repens	White Clover	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anemone Canadensis	Canada Anemone	0	3	2	2	1	3	0	1	2	2	2	3	1	1	0
Galium boreale	Northern Bedstraw	0	0	1	0	1	0	2	0	0	1	0	0	0	0	0
Shepherdia Canadensis	Buffaloberry	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0
Rubus idaeus	Wild Red Raspberry	0	0	0	0	2	0	15	0	3	5	0	0	3	0	0
Fragaria virginiana	Wild Strawberry	0	0	0	60	10	5	33	15	22	5	0	0	1	0	0
Erigeron philadelphicus	Philadelphia fleabane	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Amelanchier alnifolia	Saskatoon	0	0	0	0	0	0	2	0	4	2	1	0	0	0	0

Arctostaphylos uva-ursi	Bearberry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Achillea millefolium	Common Yarrow	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0
Heracleum maximum	Cow Parsnip	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Betula occidentalis	Water Birch	0	0	0	0	0	0	0	0	0	0	1	0	5	0	0
Symphoricarpus occidentalis	Buckbrush	0	0	0	3	4	0	0	5	2	0	0	1	2	0	0
Salix peudomonticola	False-mountain Willow	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0
Pyrola asarifolia	Common Pink Wintergreen	6	6	4	7	10	2	5	9	3	15	3	0	4	0	3
Lonicera dioica	Twining Honeysuckle	0	0	0	0	0	0	0	0	0	3	1	0	0	0	0
Lonicera tartarica	Tartarian Honeysuckle	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Aster umbellatus	Flat-topped White Aster	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ranunculus pensylvanicus	Bristly buttercup	2	0	0	0	1	1	0	0	0	0	0	0	0	0	0
Geum macrophyllum	Largeleaf Avens	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0
Sorbus aucuparia	European Mountain Ash	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
Sanicula marilandica	Maryland Sanicle	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1

d. Mammal monitoring

The Weaselhead/Glenmore Park Preservation society is working in collaboration with SAIT (Southern Alberta Institute of Technology) to identify patterns of mammalian movement along the Elbow Valley in the Weaselhead area. Students from the Environmental Technology Program are collecting data in a multi-year project using remotely triggered cameras and winter tracking. Pre-disturbance data were collected in early 2016. A report on the results from this data is currently (March 2017) under development by SAIT students (personal communication: Pattison, 2017).

The SWCRR will create a barrier to wildlife movement between the Weaselhead and surrounding habitat. Although a wildlife passage has been included as part of the new Elbow River crossing it is uncertain as to which species will use it and with what frequency. This component of the project aims to identify potential changes in mammalian movement brought about by the SWCRR and to provide information on the use of the wildlife passage. It will also identify species that do not use the wildlife passage and allow consideration of alternative mitigation.

2. AQUATIC HABITATS

a. Water quality parameters

This section of the study provides baseline information on water quality in the Beaver Pond and Beaver Lagoon in the Weaselhead. These results will be compared with future surveys at the same sampling stations to assess the potential effects of the SWCRR on water quality.

Two sampling stations, representing different habitats, were initially defined, one in the Beaver Pond and one in the Beaver Lagoon, for assessing the water quality of each water body (figure 5). The Beaver Pond is in immediate proximity to the SWCRR and the Beaver Lagoon with which it is hydrologically connected is further downstream.

For each sampling station (habitat), three sampling sites were defined. An extra sampling site was also chosen at the Elbow River. Water sampling and in-situ assessments were performed in these habitats and sampling sites twice: on 26th August 2016 and on 19th October 2016 (figures 6 and 7, Table 6).

In October 2016, an additional sampling station (representing the Clearwater Pond habitat) was also assessed at three sampling sites. This last habitat is not located in the Weaselhead and is intended to represent a control site (figure 5, Table 6).

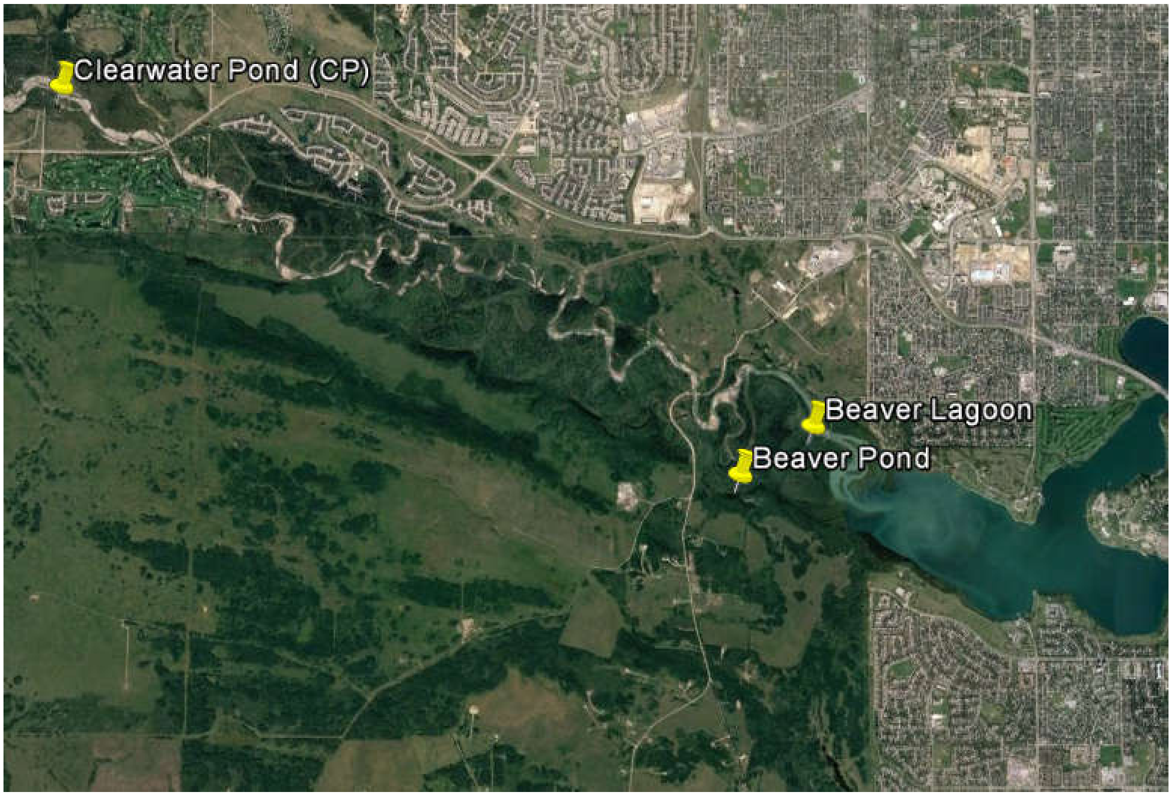

Figure 5: Location of aquatic habitats monitored for water quality.

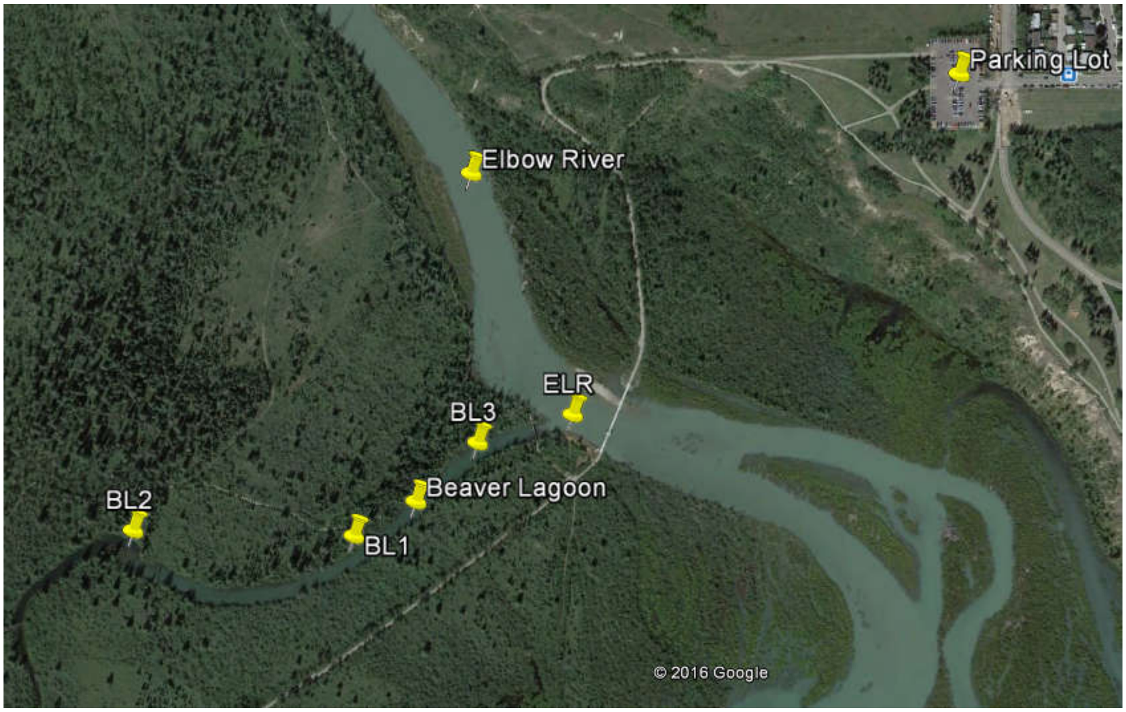

Figure 6: Location of sampling sites at the Beaver Lagoon and the Elbow River

Figure 7: Location of sampling sites at the Beaver Pond.

Table 6: Geographic coordinates and collection dates for water quality monitoring sampling sites

Habitat	Sampling Site	Latitude	Longitude	Sampling in 2016
Beaver Pond (BP)	BP1	50° 59.183’ N	114° 09.676’ W	Aug./Oct.
	BP2	50° 59.203’ N	114° 09.703’ W	Aug./Oct.
	BP3	50° 59.181’ N	114° 09.515’ W	Aug./Oct.
Beaver Lagoon (BL)	BL1	50°59.417’ N	114°09.025’ W	Aug./Oct.
	BL2	50°59.419’ N	114°09.217’ W	Aug./Oct.
	BL3	50°59.468’ N	114°08.918’ W	Aug./Oct.
Clearwater Pond (CP)	CP1	51°01.220’ N	114°15.323’ W	Oct.
	CP2	51°01.242’ N	114°15.320’ W	Oct.
	CP3	51°01.231’ N	114°15.379’ W	Oct.
Elbow River (ELR)	ELR	50°59.484’N	114° 08.836’ W	Aug./Oct.

On August and October 2016 a YSI® 556 / YSI® Pro Plus multimeter was used to measure in-situ the water temperature, conductivity, pH and dissolved oxygen at the stations. The water turbidity was also measured in-situ with an Orbeco® TM-2629 turbidity meter in August and with the YSI® Pro Plus multimeter in October, together with Total Dissolved Solids (TDS). A 100 mL water sample from each station was taken in a glass container for the determination of ortho-phosphate (method: Molybdenum Blue) and chloride (method: Silver Nitrate Turbidimetric) using Orbeco Mini-Analyst Model 942. The results for the water quality assessments for the habitats assessed in August and October 2016 are presented in the tables 7 and 8. Table 9 presents a statistical analysis comparing the results obtained for different habitats and sampling dates.

Some parameters chosen for monitoring:

C**onductivity** (figure 8) of the water is a key parameter for providing early warning of contamination by inorganic pollution (e.g.: salts) which can release ions in the water, increasing its electric conductivity (Sawyer *et al.*, 2003). Baseline information about of the natural range and fluctuations of the conductivity in the studied water body is necessary for distinguishing between natural and disturbed levels of conductivity. This can be achieved by continuous monitoring the electric conductivity of a water body.

The **chloride** is one of the important dissolved ions that increases the electric conductivity in water (Sawyer *et al.*, 2003). The measure of chloride (figure 9) may be complementary to the conductivity monitoring effort, by assessing the concentration of an ion that is released, among other sources, by the salts used on road de-icing.

Turbidity responds to the concentration of suspended and dissolved solids in the water column (Sawyer *et al.*, 2003), being a parameter that is sensitive to mechanical disturbances in the watershed such as erosion processes and sediment transport. Large increases in turbidity can also be linked to algal blooms.

The measure of **pH** responds to the chemical balance of the elements present in the water that determine its acidic, neutral or basic conditions (Sawyer *et al.*, 2003). The pH can be affected by various processes in an aquatic ecosystem, which in turn can affect its chemistry and biology, sometimes dramatically.

Phosphorus is one of the most important limiting nutrients in aquatic ecosystems (Sawyer *et al.*, 2003). The introduction of phosphorus in a water body like the Beaver Pond may lead to an exponential increase in algal and cyanobacterial productivity, accelerating the eutrophication rate. This often results in low levels of **dissolved oxygen** (DO, figure 10) that can cause fish and invertebrate mass mortality or decreased fertility.

Comparisons with control site:

The permutation test used for comparing conductivity values revealed that the conductivity of the Clearwater Pond (CP) was significantly ($p<0.05$) lower than in the other habitats sampled regardless date (table 9 and figure 8). Chloride, an important component of the total dissolved ions measured by the conductivity meter, is also significantly ($p<0.05$) lower in CP (table 9 and figure 9). This suggests that the CP water volume may be renewed at a higher rate (as a % of its total volume per unit of time) by the Elbow River than in the BP or BL. The Elbow River sampling station also showed consistently lower conductivity readings than BP and BL. These results seem to indicate a different hydrological regime in CP compared to BP and BL. This has conservation implications. If BP and BL do not have as much water exchange with the Elbow River as CP, this could potentially make BP and BL more sensitive to contaminants than CP: any pollutant entering the BP or BL systems would be expected to achieve higher concentrations due to a lower dilution rate by the Elbow River water. More investigations on these hydrological mechanisms are however necessary for a definitive conclusion.

Unusually low DO result:

A particularly low DO oxygen reading for the BP was recorded in August 2016 (mean=41.7% ± 12.7%). This value is significantly lower ($p<0.05$) than the mean DO reading for BL in the same date. This low DO concentration in BP may be linked to natural or cultural eutrophication processes. Some sensitive species of invertebrates or fish are affected at these levels; which are below water quality guidelines for dissolved oxygen in freshwater for the protection of aquatic life (CCREM 1987).

Table 7: Water quality parameters on August 26th 2016

field: August 26th 2016			**Habitat**				
	Beaver Pond			**Beaver Lagoon**			**Elbow River**
Parameters	**BP1**	**BP2**	**BP3**	**BL4**	**BL5**	**BL6**	**ELR**
Turbidity (NTU)	30.8	1.8	3.3	2.3	1.4	2.8	4.7
Temperature (°C)	11.9	10.9	12.2	13.6	13.1	13.5	12.1
pH	7.6	7.6	8.0	8.0	7.6	8.2	8.2
Conductivity (µS/cm)	470	493	469	344	458	317	290
DO (mg/L)	5.20	2.97	5.30	9.85	9.77	9.88	10.60
DO (%)	48%	27%	50%	95%	93%	95%	99%
Phosphate (mg/L)	0.00	0.07	0.16	0.05	0.06	0.08	0.05
Chloride (mg/L)	2.88	3.31	4.18	4.00	4.68	4.62	4.58

Table 8: Water quality parameters on October 19th 2016

					Water body / Site					
field: October 19th 2016	**Beaver Pond**			**Beaver Lagoon**			**Elbow River**	**Clearwater Pond**		
Parameters	**BP1**	**BP2**	**BP3**	**BL4**	**BL5**	**BL6**	**ELR**	**CP1**	**CP2**	**CP3**
Turbidity (NTU)	0.8	0.0	10.0	0.0	0.0	0.0	0.0	10.0	10.0	13.0
Temperature (°C)	4	4.5	4.1	5.4	6.4	4.7	6.2	7.6	6.9	6.9
pH	7.9	8.1	8.0	8.1	7.8	8.2	8.4	8.6	8.5	8.6
Conductivity - C (µS/cm)	444	468.1	449	341.6	444.8	331	279.1	220.3	213.7	211
DO (mg/L)	10.84	8.34	5.10	9.74	6.69	9.68	11.50	10.70	10.70	11.25
DO (%)	83%	64%	39%	77%	53%	75%	92%	90%	88%	92%
Phosphate (mg/L)	0.00	0.00	0.01	0.00	0.04	0.00	0.04	0.00	0.02	0.00
Chloride (mg/L)	5.26	5.86	5.85	5.34	5.86	6.20	4.82	2.03	2.21	2.13
TDS (mg/L)	483.50	498.50	485.60	354.30	447.10	350.30	283.10	214.30	210.60	210.00

Table 9: Results of statistical analysis and hypothesis testing water quality. The statistical package R® was used for comparing the habitats: between locations and between assessment dates. Means (±sd) of a given parameter followed by the same letter as a superscript do not differ significantly ($\alpha = 0.05$). Temperature, pH, DO, Phosphate and Chloride were analysed via ANOVA (df=5, 12). DO and phosphate data were transformed to meet ANOVA's residuals normality and homoscedasticity assumptions (x^2 and x^0.5 transformations respectively). Turbidity and Conductivity data were compared via a non-parametric test (Approximative K-Sample Fisher-Pitman Permutation Test with 100000 permutations).

						Parameters			
Water body	**Site**	**Assessment Date**	**Turbidity (NTU) n=3 ***	**Temperature (°C) n=3**	**pH n=3**	**Conductivity (µS/cm) n=3 ***	**DO (%) $*^{1}$ n=3**	**Phosphate PO_4 (mg/L) $*^{2}$ n=3**	**Chloride Cl^{-} (mg/L) n=3**
Beaver Pond	**BP**	**November 1st 2015**	4.3 (±1.3) ^{a}	3.3 (±0.51) ^{e}	7.7 (±0.25) ^{b}	426 (±6) ^{a}	81.3% (±10.1%) $^{a\ b}$	0.02 (±0.03) ^{a}	4.1 (±0.79) ^{b}
		August 26th 2016	12.0 (±16.3) ^{a}	11.7 (±0.68) ^{b}	7.7 (±0.23) ^{b}	477 (±14) ^{a}	41.7% (±12.7%) ^{c}	0.08 (±0.08) ^{a}	3.5 (±0.66) $^{b\ c}$
		October 19th 2016	3.6 (±5.6) ^{a}	4.2 (±0.26) $^{d\ e}$	8.0 (±0.10) $^{a\ b}$	454 (±13) ^{a}	62.0% (±22.1%) $^{b\ c}$	0.00 (±0.01) ^{a}	5.7 (±0.34) ^{a}
Beaver Lagoon	**BL**	**August 26th 2016**	2.2 (±0.7) ^{a}	13.4 (±0.26) ^{a}	7.9 (±0.31) ^{b}	373 (±75) ^{a}	94.3% (±1.2%) ^{a}	0.06 (±0.01) ^{a}	4.4 (±0.38) $^{a\ b}$
		October 19th 2016	0.0 (±0.0) ^{a}	5.5 (±0.85) ^{d}	8.0 (±0.21) $^{a\ b}$	373 (±63) ^{a}	68.3% (±13.3%) $^{a\ b\ c}$	0.01 (±0.02) ^{a}	5.8 (±0.43) ^{a}
Clearwater Pond	**CP**	**October 19th 2016**	11.0 (±1.7) ^{a}	7.1 (±0.40) ^{c}	8.6 (±0.06) ^{a}	215 (±5) ^{b}	90.0% (±20.0%) $^{a\ b}$	0.01 (±0.01) ^{a}	2.1 (±0.09) ^{c}

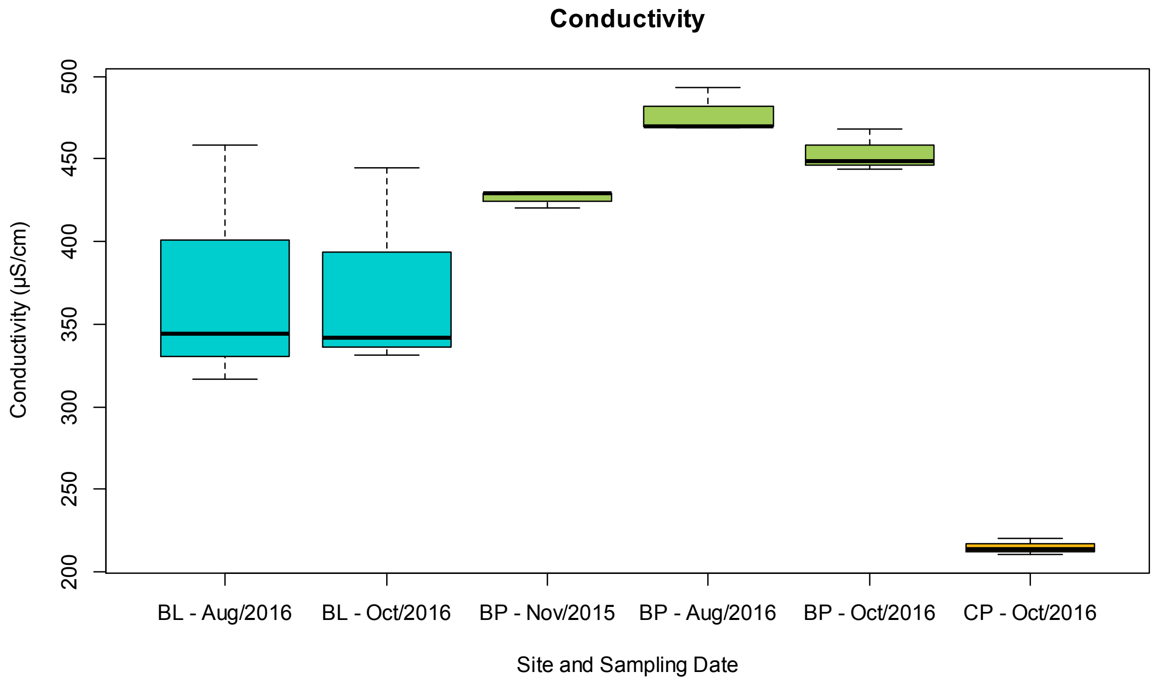

Figure 8: Conductivity recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) in 2015 and 2016.

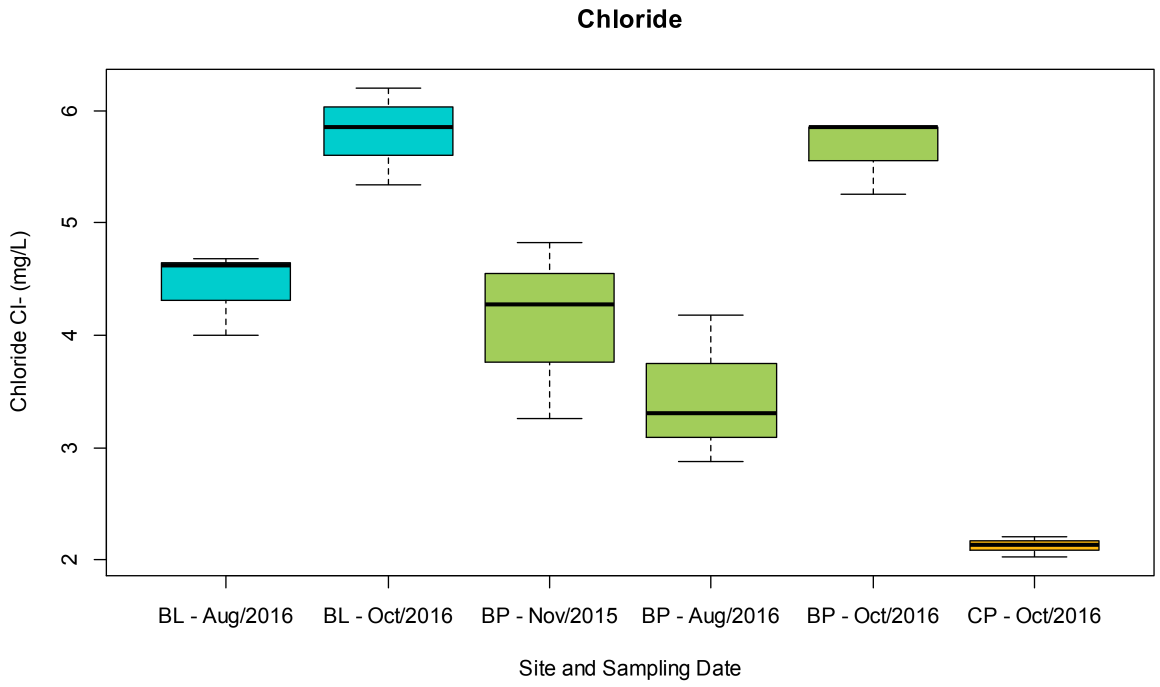

Figure 9: Chloride recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) in 2015 and 2016.

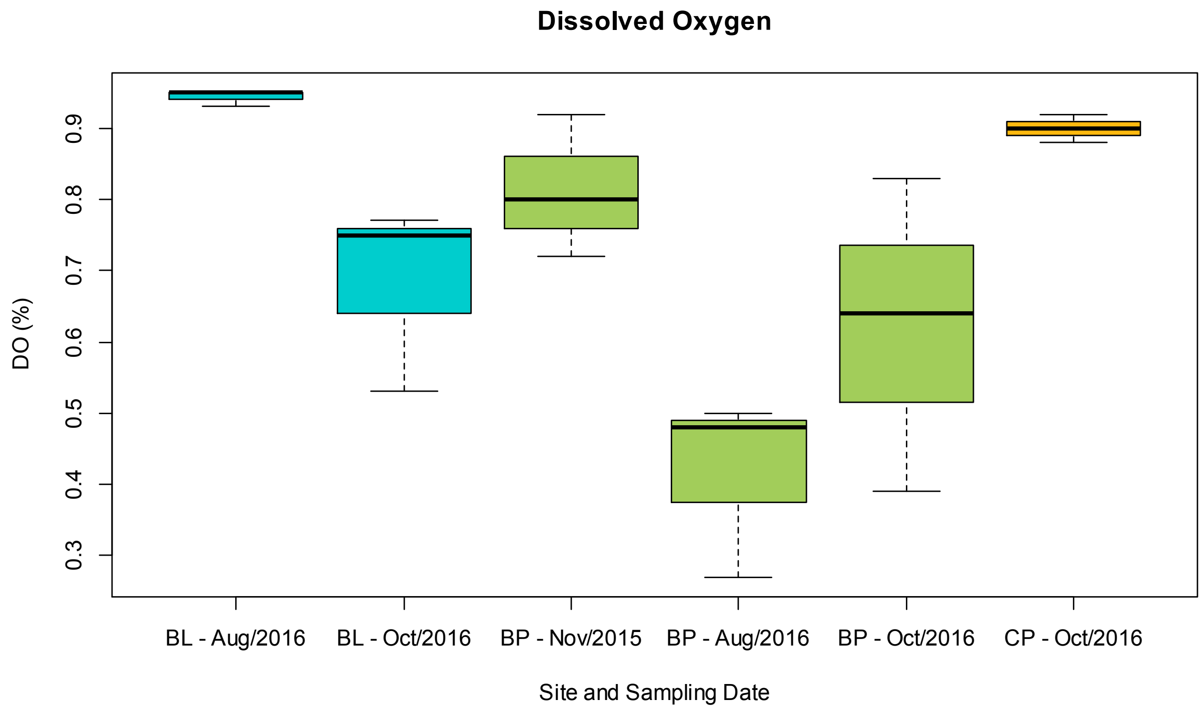

Figure 10: Dissolved oxygen (DO) recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) in 2015 and 2016.

b. Aquatic macroinvertebrates

Aquatic macroinvertebrates are considered good indicators of water quality. These organisms are made up of species that constitute a broad range of trophic levels and pollution tolerances, thus providing robust information for interpreting cumulative effects (EPA, 2017). By monitoring the macroinvertebrate community structure it is possible not only to assess the condition of this essential biotic component of the aquatic ecosystem, but also to make inferences about the suitability of physical and chemical parameters of the water to support aquatic life.

There is a long list of substances and physicochemical parameters that may affect invertebrate communities. Direct analysis of these substances and parameters is often costly and depends on specialized laboratory equipment. Macroinvertebrate sampling integrates the effects of short-term environmental variations (EPA, 2017).

The invertebrate communities are therefore a valuable early indicator of physical and chemical environmental changes to their habitats and may respond with appreciable sensitivity to the cumulative effects of potential environmental impacts.

Macroinvertebrate monitoring was undertaken in 2016 to describe baseline conditions in the aquatic habitats at the Weaselhead prior to construction of the SWCRR. During 2016 in three different habitats were sampled (Beaver Pond (BP), Beaver Lagoon (BL) and Clearwater Pond (CP). Three sampling sites were chosen at each habitat, i.e. a total of nine sampling sites (table 10). The sampling sites were selected based on how well they represented local aquatic habitats and for their accessibility.

The BL and BP habitats were sampled in 26th August and 19th October 2016. The CP habitat was only sampled in the later date. CP is the only one not located in the Weaselhead. This habitat is located in the Elbow River floodplain, approximately 8 km upstream from the Weaselhead, and has natural features similar to the aquatic habitats in the Weaselhead. Its greater distance and upstream location from SWCRR construction make the CP habitat potentially a good control site for the monitoring campaign.

Table 10: Geographic coordinates and collection dates for macroinvertebrates sampling sites.

Habitat	Sampling Site	Latitude	Longitude	Sampling in 2016
Beaver Pond (BP)	BP1	50° 59.183’ N	114° 09.676’ W	Aug./Oct.
	BP2	50° 59.203’ N	114° 09.703’ W	Aug./Oct.
	BP3	50° 59.181’ N	114° 09.515’ W	Aug./Oct.
Beaver Lagoon (BL)	BL1	50°59.417’ N	114°09.025’ W	Aug./Oct.
	BL2	50°59.419’ N	114°09.217’ W	Aug./Oct.
	BL3	50°59.468’ N	114°08.918’ W	Aug./Oct.
Clearwater Pond	CP1	51°01.220’ N	114°15.323’ W	Oct.
	CP2	51°01.242’ N	114°15.320’ W	Oct.
	CP3	51°01.231’ N	114°15.379’ W	Oct.

During the sampling campaigns composite samples of 3 subsamples were collected at each site. Each subsample consisted of a one net (15.5cm x 13cm hand-held net with 1mm openings) jab against the pond bed substrate and aquatic vegetation. Diverse substrate types were looked for and sampled if present (e.g. aquatic plants, underwater logs, sand, mud, etc). The contents of the net were immediately transferred into a white plastic tray. After accumulating 3 subsamples (i.e. one composite sample) from the same site in the tray the excess vegetation and other debris was removed, taking care to retain the invertebrates. The remaining contents were then poured through the net to remove excess water. The net contents were transferred into a glass container and preserved with 70% isopropyl alcohol solution. The invertebrates present were later identified under a dissection microscope to the greatest possible taxonomic resolution given the available resources. Specimens were placed in containers (preserved in 70% isopropyl alcohol solution) and separated by taxon.

Results

In 2016 a total of 735 specimens were identified to 34 taxa for the habitats studied (BP, BL and CP). The 34 taxa identified represent the greatest taxonomic resolution achieved, consisting of 28 groups identified to genus/species levels and 6 groups identified to family/subfamily/ superfamily levels (tables 14 and 15). In the overall survey the Coleoptera was the richest Order in number of taxa (comprising 7 different genus/species).

i. <u>Taxa Richness</u>

The habitats monitored (BP, BL and CP) did not differ significantly between location and over time (i.e. comparing August and October 2016 sampling) in the mean number of captured macroinvertebrate taxa per site (ANOVA, df=4,10, p>0.05) (table 11 and figure 11). These results do not represent anywhere near a comprehensive list of macroinvertebrate taxa living in the sampled habitats. Instead they provide a metric, or a way of measuring the expected taxa richness to be obtained from applying the same techniques and sampling effort as described above. This metric can therefore be compared between years and provides a valuable indicator of change in habitat quality.

High taxa richness is associated with good water quality (EPA, 2017). 2016 baseline data from the habitats monitored give an estimate of the invertebrate richness expected in future August and October sampling if nothing changes. Furthermore invertebrate richness at the different sites and on the different dates of collection did not differ significantly in 2016, which increases the ability of this statistical approach to detect future changes to this ecological metric.

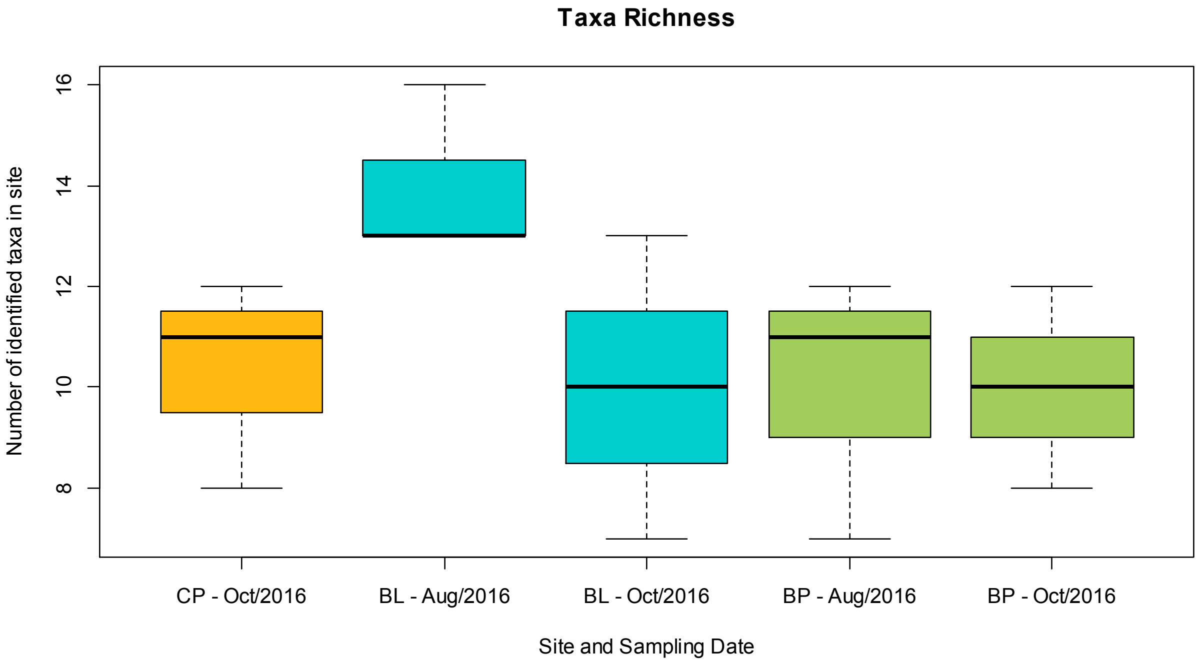

Figure 11: Taxa richness for the Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP) on August and October 2016

Table 11: Taxa richness for the Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP) on August and October 2016. Means (±sd) followed by the same superscript letter do not differ significantly (p>0.05).

Taxa Richness per sample for each habitat		
Habitat	**Aug. 2016 Mean number of taxa per site (±sd) n=3**	**Oct. 2016 Mean number of taxa per site (±sd) n=3**
Beaver Pond	10 (±2.6)^{a}	10 (±2.0)^{a}
Beaver Lagoon	14 (±1.7)^{a}	10 (±3.0)^{a}
Clearwater Pond	n.a.	10±2.1^{a}

ii. Simpson's Diversity Index

The Simpson's diversity index takes into account not only the number of taxa present in a given site, but also the relative abundance of individuals per taxa. It estimates the probability that two individuals randomly taken from a sample will belong to the same taxa (S). Its inverse proportion (1-S) estimates the probability that two randomly selected individuals in a sample will belong to different taxa (from zero to 100%). The Simpson's index (S) is calculated as follows:

$$S = \sum_{i=1}^{R} \left(\frac{n_i}{N}\right)^2$$

Where n_i is the total number of organisms of the i^{th} species, R is richness (total number of species in the study) and N is the total number of organisms of all species.

The Clearwater Pond (CP) had a significantly lower macroinvertebrate taxa diversity (using Simpson's Diversity Index) when compared with the results for the other habitats (BL and BP) in August and October (Tukey's HSD test, p<0.05). The Beaver Pond (BP) and the Beaver Lagoon (BL) did not differ significantly (ANOVA, df=4,10, p>0.05) between location and over time (for August and October 2016 sampling) in the Simpson's Diversity Index (figure 12 and table 12). High taxa diversity is commonly associated with good water quality (EPA, 2017).

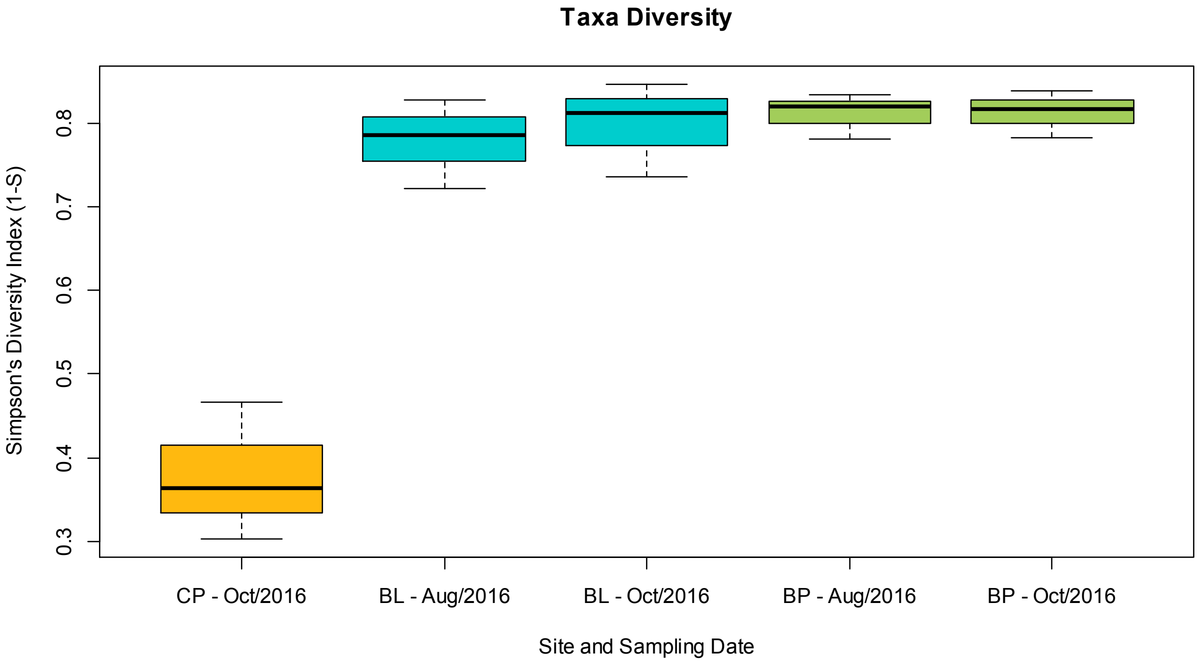

Figure 12: Simpson's Diversity Index (1-S) for the Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP) on August and October 2016.

Table 12: Simpson's Diversity Index (1-S) for the Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP) on August and October 2016. Means (±sd) followed by the same letter do not differ significantly (p>0.05).

Simpson's Diversity Index per sample for each habitat		
Habitat	**Aug. 2016** **1-S (±sd)** **n=3**	**Oct. 2016** **1-S (±sd)** **n=3**
Beaver Pond	81.2% (±2.79%) [a]	81.4% (±2.82%) [a]
Beaver Lagoon	77.9% (±5.39%) [a]	79.9% (±5.69%) [a]
Clearwater Pond	n.a.	37.8% (±8.23%) [b]

The diversity of macroinvertebrate taxa found in the different habitats is shown in terms of relative abundance of classes in figures 13, 14 and 15. These figures show seasonal changes in the community structure, with Insecta becoming the most represented (in number of individuals) class of invertebrates in October 2016 for both the Beaver Pond and Beaver Lagoon (figures 13 and 14). On the other hand, Gastropoda is the most abundant class of invertebrates in the Clearwater Pond for October 2016 (figure 15).

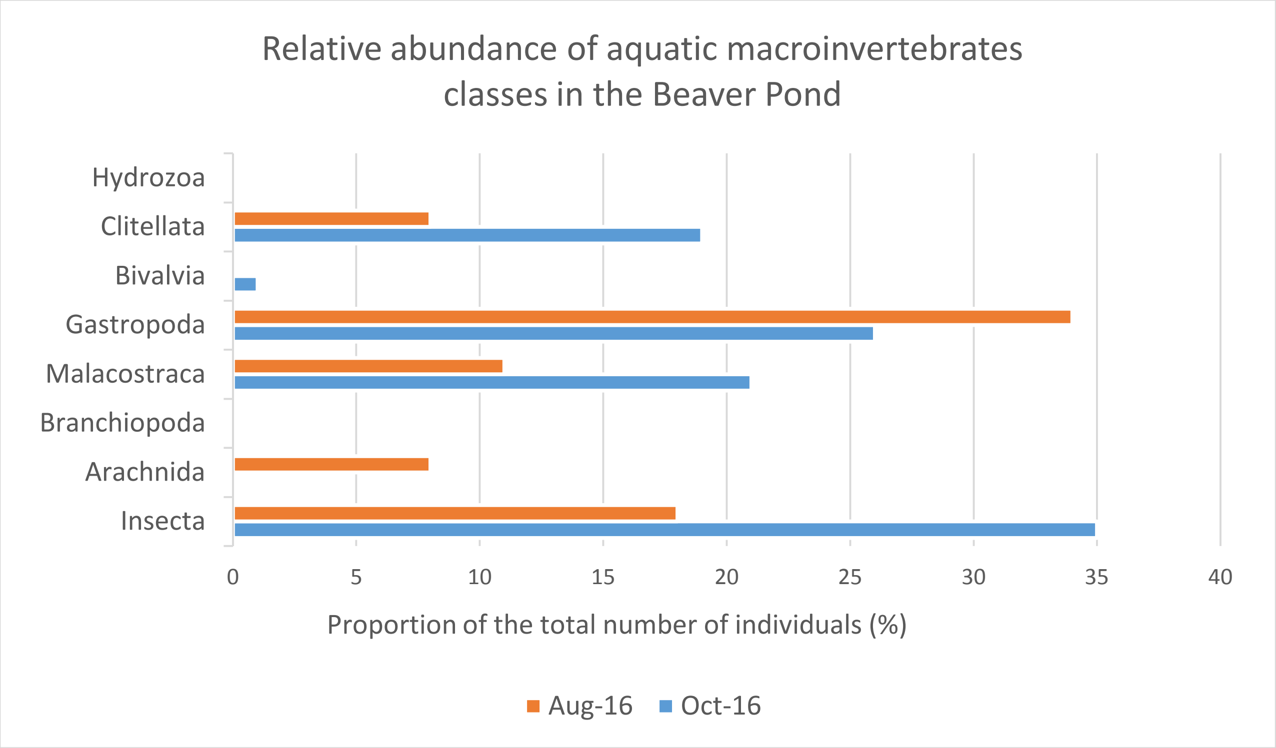

Figure 13: Relative abundance of macroinvertebrates classes in the Beaver Pond samples samples in October and August 2016.

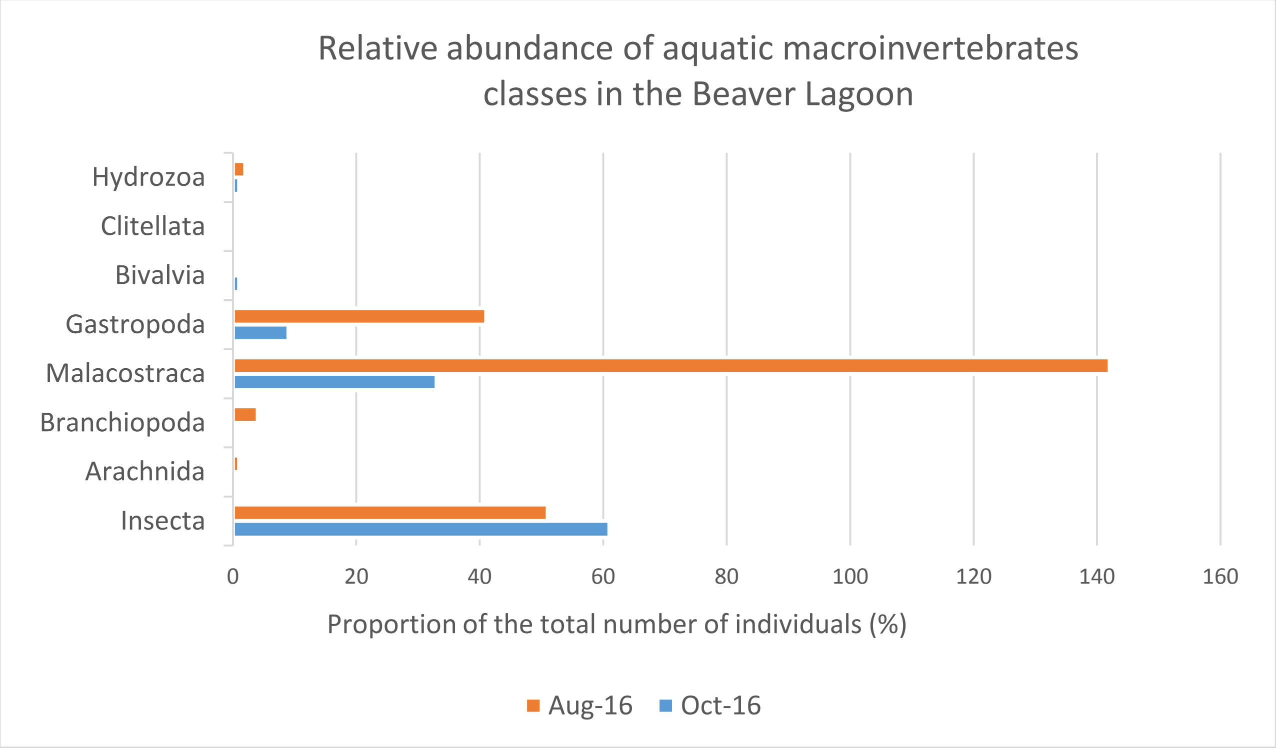

Figure 14: Relative abundance of macroinvertebrates classes in the Beaver Lagoon samples in October and August 2016.

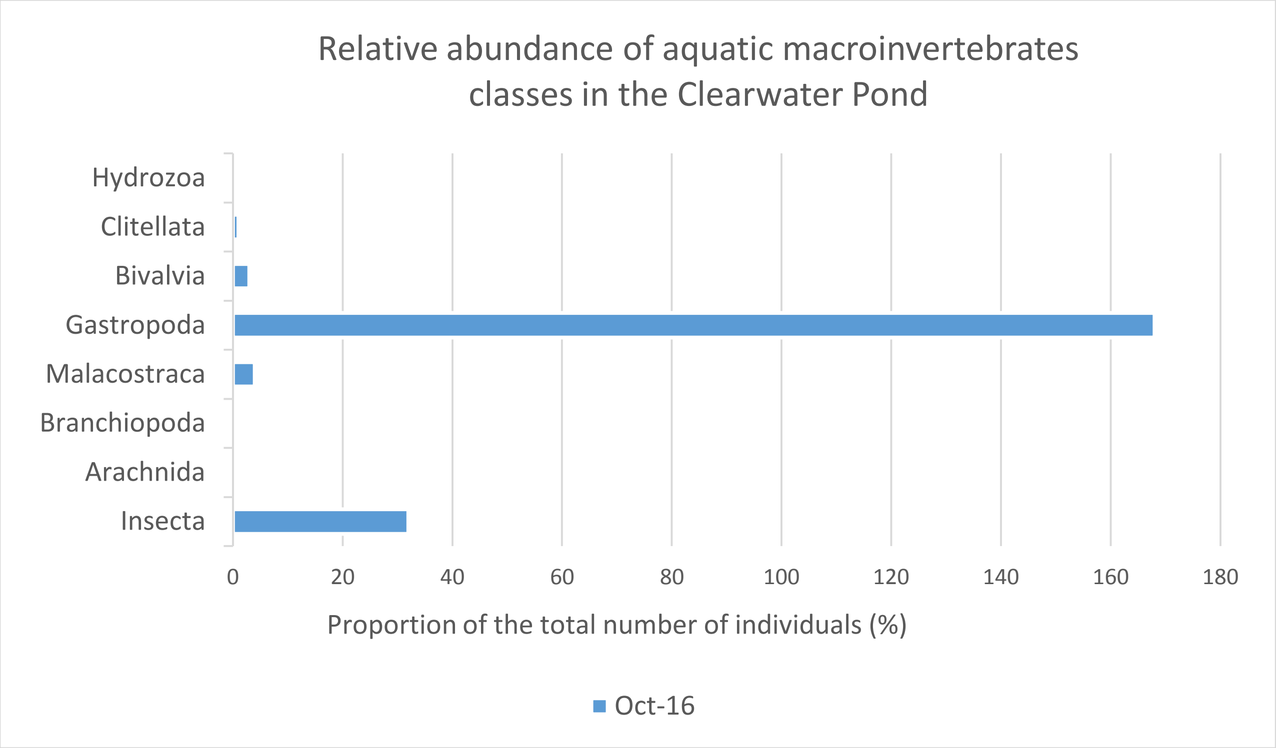

Figure 15: Relative abundance of macroinvertebrates classes in the Clearwater Pond sample (October 2016).

iii. <u>EPT taxa %</u>

The proportion of number of taxa from pollution-sensitive groups relative to total number of taxa is often used as a bioindicator parameter. The number of taxa from **E**phemeroptera (mayflies), **P**lecoptera (stoneflies) and **T**richoptera (caddisflies) relative to the total number of taxa, known as % **EPT** as taxa richness, is an example of such a parameter. The EPT group contain a relatively high proportion of species intolerant to water pollution.

The habitats being monitored (BP, BL and CP) did not differ significantly (ANOVA, df=4,10, $p>0.05$) between location and over time (August and October 2016) in the mean of EPT taxa % per site (figure 16 and table 13). As with the total richness results, the fact that this parameter did not differ significantly in 2016 between sites and dates of collection supports its ability to detect future changes in this ecological metric.

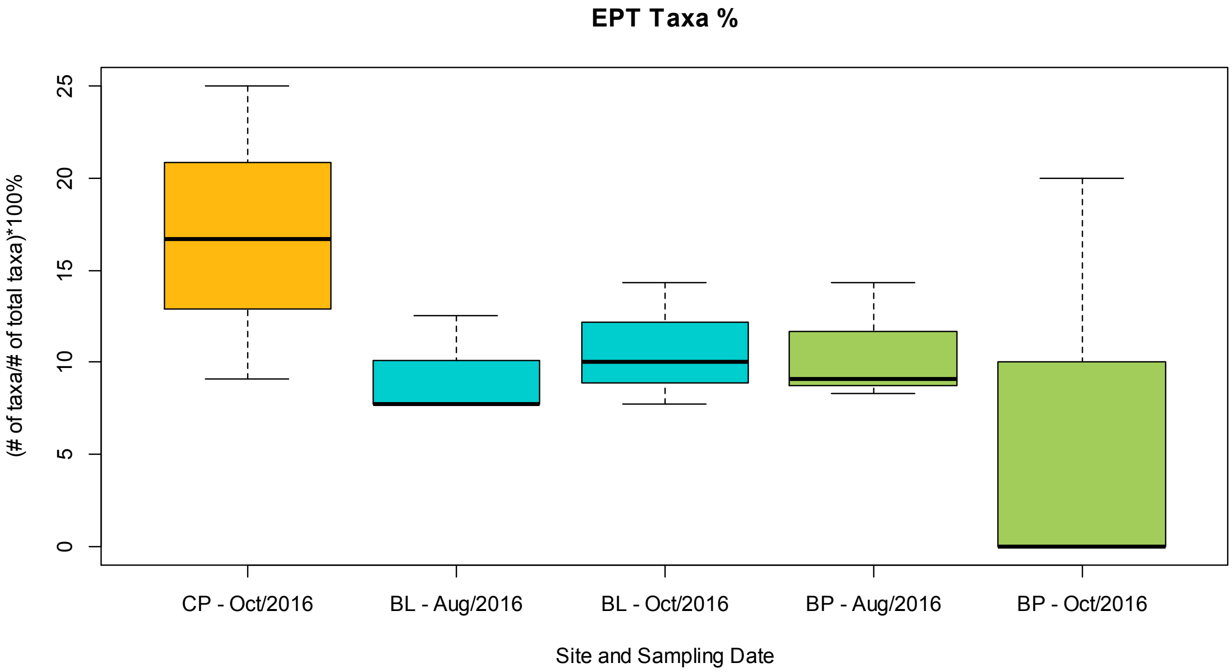

Figure 16: EPT taxa % for the Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP) on August and October 2016.

Table 13: EPT taxa % for the Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP) on August and October 2016. Means (±sd) followed by the same superscript letter do not differ significantly (p>0.05).

	EPT taxa %	
Habitat	**Aug. 2016** **# EPT taxa/# total taxa (±sd)** **n=3**	**Oct. 2016** **# EPT taxa/# total taxa (±sd)** **n=3**
Beaver Pond	11%±3.2% ^{a}	6.7%±11% ^{a}
Beaver Lagoon	9.3%±2.8% ^{a}	11%±3.3% ^{a}
Clearwater Pond	n.a.	17%±8.0% ^{a}

Table 14: Taxonomic classification for the aquatic macroinvertebrates sampled on August 26th 2016.

		sampled in August 26th 2016											
		Taxa						**Beaver Pond**			**Beaver Lagoon**		
Phylum	**Subphylum**	**Class**	**Subclass**	**Order**	**Suborder**	**Family/Group**	**Greatest Taxonomic Resolution Obtained**	**BP1**	**BP2**	**BP3**	**BL1**	**BL2**	**BL3**
Arthropoda		**Insecta**		Ephemeroptera		Caenidae	*Caenis* sp. Stephens, 1835	0	0	0	0	0	1
						Baetidae	*Centroptilum* sp. Eaton 1869	0	3	0	11	3	4
				Trichoptera		Limnephilidae	*Limnephilus* sp. Leach in Brewster, 1815	2	0	1	0	0	0
				Odonata	Zygoptera	Coenagrionidae	*Ischnura* sp. Charpentier, 1840	0	0	0	1	0	0
							Enallagma sp. Charpentier, 1840	2	0	0	0	0	0
				Diptera		Chironomidae	Orthocladiinae	0	0	0	0	2	3
						Culicidae	*Anopheles earlei* Vargas, 1943	0	0	0	1	1	1
				Coleoptera		Dytiscidae	*Laccophilus* sp. Leach, 1815	0	0	0	1	0	1
							Graphoderus occidentalis Horn, 1883	1	1	0	0	0	0
							Potamonectes sp. Zimmermann, 1921	0	0	0	0	0	1
							Ilybius sp. Erichson, 1832	1	0	0	0	0	1
							Coptotomus sp. Say, 1830	0	0	0	0	0	1
						Haliplidae	*Haliplus* sp. Latreille, 1802	2	1	0	2	7	1
				Hemiptera	Heteroptera	Corixidae	Corixidae	0	1	1	2	1	3
						Notonectidae	*Notonecta* sp. Linnaeus, 1758	1	1	0	1	0	1
		Arachnida	**Acari**	Trombidiformes	Prostigmata	Hydrachnidia	Hydrachnidia	1	7	0	0	0	1
	Crustacea	**Branchiopoda**		Diplostraca		Sididae	*Diaphanosoma* sp. Fischer, 1850	0	0	0	0	1	0
						Chydoridae	Chydoridae	0	0	0	1	2	0
		Malacostraca		Amphipoda		Gammaridae	*Gammarus lacustris* G.O. Sars, 1864	0	0	3	10	2	47
						Hyalellidae	*Hyalella azteca* (Saussure, 1858)	5	1	2	27	15	41
Mollusca		**Gastropoda**				Physidae	*Physa* sp. Draparnaud, 1801	3	1	6	4	2	3
						Lymnaidae	*Stagnicola* sp. Jeffreys, 1830	0	1	1	8	11	11
						Hydrobiidae	*Probythinella lacustris* (F. C. Baker, 1928)	0	1	0	0	0	0
						Planorbidae	*Planorbula campestris* (Dawson, 1875)	0	1	0	0	0	0
							Promenetus umbilicatellus (Cockerell, 1887)	10	8	2	1	1	0
Annelida		**Clitellata**	**Oligochaeta**			Naididae	Naididae	8	0	0	0	0	0
Cnidaria		**Hydrozoa**		Anthomedusae		Hydridae	*Hydra* sp. Linnaeus, 1758	0	0	0	0	2	0

Table 15: Taxonomic classification for the aquatic macroinvertebrates sampled on October 19th 2016.

		sampled in October 19th 2016														
						Taxa			**Beaver Pond**			**Beaver Lagoon**			**Clear Water Pond - Control**	
Phylum	**Subphylum**	**Class**	**Subclass**	**Order**	**Suborder**	**Family/Group**	**Greatest Taxonomic Resolution Obtained**	**BP1**	**BP2**	**BP3**	**BL1**	**BL2**	**BL3**	**CP1**	**CP2**	**CP3**
Arthropoda		**Insecta**		Ephemeroptera		Caenidae	*Caenis* sp. Stephens, 1835	0	1	0	0	0	0	1	1	0
						Baetidae	*Centroptilum* sp. Eaton 1869	0	2	0	10	13	1	0	0	2
				Trichoptera		Limnephilidae	*Limnephilus* sp. Leach in Brewster, 1815	0	0	0	0	0	0	0	2	1
				Odonata	Zygoptera	Coenagrionidae	*Ischnura* sp. Charpentier, 1840	0	0	0	0	1	0	0	1	0
							Enallagma sp. Charpentier, 1840	0	0	1	1	0	0	1	0	0
					Anisoptera	Aeshnidae	*Aeshna* sp. Fabricius, 1775	0	0	2	0	0	0	1	0	0
				Diptera		Chironomidae	Orthocladiinae	15	1	5	4	9	0	3	2	5
							Tanypodinae	0	0	0	0	1	0	0	0	0
						Culicidae	*Anopheles earlei* Vargas, 1943	0	0	0	0	0	0	0	0	0
						Tabanidae	*Tabanus* sp. Linnaeus, 1758	0	0	1	0	0	0	0	0	0
				Coleoptera		Dytiscidae	*Laccophilus* sp. Leach, 1815	0	0	0	0	0	0	0	0	0
							Graphoderus occidentalis Horn, 1883	0	0	0	0	0	0	0	0	0
							Potamonectes sp. Zimmermann, 1921	0	0	0	0	1	4	0	0	0
							Ilybius sp. Erichson, 1832	0	0	0	0	0	0	0	0	0
							Agabus sp. Leach, 1817	0	0	0	0	1	0	0	0	0
							Coptotomus sp. Say, 1830	0	0	0	0	0	0	0	0	0
						Haliplidae	*Haliplus* sp. Latreille, 1802	0	0	0	1	5	0	0	1	1
				Hemiptera	Heteroptera	Corixidae	Corixidae	0	1	1	2	5	1	2	3	1
						Notonectidae	*Notonecta* sp. Linnaeus, 1758	4	1	0	0	1	0	2	1	0
						Belostomatidae	*Lethocerus americanus* (Leidy, 1847)	0	0	0	0	0	0	0	1	0
		Arachnida	**Acari**	Trombidiformes	Prostigmata	Hydrachnidia	Hydrachnidia	0	0	0	0	0	0	0	0	0
	Crustacea	**Branchiopoda**		Diplostraca		Sididae	*Diaphanosoma* sp. Fischer, 1850	0	0	0	0	0	0	0	0	0
						Chydoridae	Chydoridae	0	0	0	0	0	0	0	0	0
		Malacostraca		Amphipoda		Gammaridae	*Gammarus lacustris* G.O. Sars, 1864	1	0	0	2	0	8	0	0	0
						Hyalellidae	*Hyalella azteca* (Saussure, 1858)	7	1	12	5	9	9	1	1	2
Mollusca		**Gastropoda**				Physidae	*Physa* sp. Draparnaud, 1801	2	1	2	1	1	1	0	1	1
						Lymnaeidae	*Stagnicola* sp. Jeffreys, 1830	0	2	0	1	0	0	0	0	0
							Fossaria (Bakerilymnaea) bulimoides (I. Lea, 1841)	0	0	1	0	0	0	1	1	0
						Hydrobiidae	*Probythinella lacustris* (F. C. Baker, 1928)	0	0	0	0	0	0	0	0	0
						Planorbidae	*Planorbula campestris* (Dawson, 1875)	1	0	1	0	0	0	0	0	0
							Promenetus umbilicatellus (Cockerell, 1887)	4	5	7	2	3	0	42	58	64
		Bivalvia		Veneroidea		Sphaeriidae	*Pisidium* sp. Pfeiffer, 1821	0	0	1	0	1	0	3	0	0
Annelida		**Clitellata**	**Oligochaeta**	Haplotaxida		Naididae	Naididae	12	5	2	0	0	0	1	0	0
Cnidaria		**Hydrozoa**		Anthomedusae		Hydridae	*Hydra* sp. Linnaeus, 1758	0	0	0	0	0	1	0	0	0

The results obtained from the 2016 macroinvertebrates sampling campaign will be compared with future surveys at the same sites. For this comparison to be effective and sensitive to potential environmental effects of the SWCRR, it is important to maintain the constancy of the sampling effort and the taxonomic resolution for the taxa already identified. It is also important to plan the sampling to be performed at the same time of year in order to isolate any phenology effects (seasonal variation in the invertebrate's communities).

The Clearwater Pond habitat is potentially a good control site for the 2 out of the 3 metrics used here. The CP habitat did not differ significantly from the BP and BL sites in taxa richness and EPT taxa %, making it useful to monitor these metrics and compare them with those from BP and BL in the future. A hypothetical pronounced loss of taxa richness or EPT taxa % at BP and/or BL that is not followed by a same pattern of change at CP could signal environmental impacts at a local scale in the Weaselhead.

The metrics used in this report (Taxa Richness, Simpson's Diversity Index and EPT taxa %) are not the only ones available for indicating habitat quality based on aquatic macroinvertebrates communities. Other calculations can be applied to the existing data, which may new reveal new patterns.

c. Periphyton

Periphyton is a term that applies to microbiota (including algae, protozoans and bacteria) living attached to any substrate underwater (Wetzel, 2001). Algae commonly have rapid reproduction rates and short life cycles, making them valuable indicators of short-term environmental impacts (EPA, 2017). Sampling is easy, inexpensive, and creates minimal impact to resident biota. Furthermore algal assemblages are sensitive to some pollutants which may not visibly affect other aquatic assemblages, or may only affect other organisms at higher concentrations (i.e., herbicides; EPA, 2017). Periphyton monitoring was not carried out in 2016 but is planned for 2017. The method is described by the EPA (2017) and is available on line as follows:

1. Establish the reach for multihabitat sampling as per the macroinvertebrate protocols (…). In most cases, the reach required for periphyton sampling will be the same size as the reach required for macroinvertebrate or fish sampling (30-40 stream widths) so that as many algal habitats can be sampled as is practical.
2. Before sampling, complete the physical/chemical field sheet (…) and the periphyton field data sheet (…). Visual estimates or quantitative transect-based assessments can be used to determine the percent coverage of each substrate type and the estimated relative abundance of macrophytes, macroscopic filamentous algae, diatoms and other microscopic algal accumulations (periphyton), and other biota (…).
3. Collect algae from all available substrates and habitats. The objective is to collect a single composite sample that is representative of the periphyton assemblage present in the reach. Sample all substrates (…) and habitats (riffles, runs, shallow pools, nearshore areas) roughly in proportion to their areal coverage in the reach. Within a stream reach,

light, depth, substrate, and current velocity can affect species composition of periphyton assemblages. Changes in species composition of algae among habitats are often evident as changes in color and texture of the periphyton. Small amounts (about 5 mL or less) of subsample from each habitat are usually sufficient. Pick specimens of macroalgae by hand in proportion to their relative abundance in the reach. Combine all samples into a common container.

4. Place all samples into a single water-tight, unbreakable, wide-mouth container. (…) Add recommended amount of Lugol's (IKI) solution, "M3" fixative, buffered 4% formalin, 2% glutaraldehyde, or other preservative (…).
5. Place a permanent label on the outside of the sample container with the following information: waterbody name, location, station number, date, name of collector, and type of preservative. Record this information and relevant ecological information in a field notebook or on the periphyton field data sheet (…). Place another label with the same information inside the sample container. (Caution! Lugol's solution and other iodine-based preservatives will turn paper labels black.)
6. After sampling, review the recorded information on all labels and forms for accuracy and completeness.
7. Examine all brushing and scraping tools for residues. Rub them clean and rinse them in distilled water before sampling the next site and before putting them away.
8. Transport samples back to the laboratory in a cooler with ice (keep them cold and dark) and store preserved samples in the dark until they are processed. Be sure to stow samples in a way so that transport and shifting does not allow samples to leak. When preserved, check preservative every few weeks and replenish as necessary until taxonomic evaluation is completed.
9. Log in all incoming samples (…). At a minimum, record sample identification code, date, stream name, sampling location, collector's name, sampling method, and area sampled (if it was determined).

d. Fish

Starting in 2017, the habitats currently under study will include fish surveys as an indicator of aquatic habitat health. Fish are very good indicators of long-term (several years) effects and broad habitat conditions because they are relatively long-lived and mobile (Karr et al. 1986 *in* EPA, 2017). This group include a range of species that represent a variety of trophic levels (omnivores, herbivores, insectivores, planktivores, piscivores). They also tend to integrate changes in lower trophic levels and hence integrated environmental health (EPA, 2017).

Additional advantages of using fish as bioindicators for rapid assessment of aquatic environments are (EPA, 2017):

- Some fish species are at the top of the aquatic food web and are consumed by humans, making them important for assessing contamination.
- Most specimens can be identified in the field by experienced fisheries biologists, and then released unharmed.
- Environmental requirements of most fish are comparatively well known, including information on life history and distributions.

The methods to be used in 2017 fish survey will consist of electrofishing, field identification and release of the fish unharmed. Electrofishing is recommended for most fish field surveys because of its greater applicability and efficiency (EPA, 2017).

FINAL CONSIDERATIONS

The "*Environmental Monitoring Report: baseline data"* represents an important step in gaining a deeper understanding of target aquatic and terrestrial ecosystem components in the Weaselhead. It provides an essential source of information on the baseline environmental condition of the area prior to construction of the SWCRR. This report will allow the Society to take informed decisions about environmental changes in the area through comparing results of future surveys (employing the same sampling and analytical methods) with the results presented here. The success of this monitoring effort depends on the continuation of this project over the construction phase and into the operational phase of the SWCRR.

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