Weaselhead/Glenmore Park

SWCRR Impact Study 2016-2023

Environmental Monitoring Report 2017:

Part I – Noise, birds, vegetation, water quality and aquatic invertebrates

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INTRODUCTION

This report is divided into two parts. In this part, Part I, the results of the noise pollution survey, breeding bird survey, riparian vegetation community monitoring, water-quality monitoring and aquatic invertebrate assessment are presented. Part II will provide an update on a 5-year study into wildlife movement in the Park (a project being carried out by SAIT Dept. of Environmental Technology), results of amphibian monitoring and results of fish monitoring.

The South West Calgary Ring Road (SWCRR) construction phase started in fall 2016. The project's EIA (Environmental Impact Assessment) predicts alteration to habitats and impacts on the environment of the adjacent Weaselhead Natural Environment Park both during construction and later at the operational phase of the SWCRR. In this context, the Weaselhead/Glenmore Park Preservation Society initiated the SWCRR Impact Study to quantify impacts on biophysical components and on park users. The objective of the biophysical part of the Study is not to offer a comprehensive survey of habitats and ecosystem components in the park but to assess the environmental impacts of the SWCRR from 2016 to 2023 on selected environmental indicators, and compare these with those predicted in the EIA (carried out by AMEC[1] in 2006, updated in 2014).

The 2016 report described conditions in the study area prior to the landscape alterations that are taking place as a result of construction of the SWCRR.

This 2017 report presents the results collected in 2017 at the start of the construction phase. Figure 1 and figure 2 show satellite images of park taken Oct. 2017 and Sept. 2016 respectively. The habitat clearance, road-bed construction, and construction of the new channel to realign the Elbow River that took place during this interval can be seen to the left (west) in figure 1. (Note: the river was not moved to the new artificial channel until May 2018 to allow establishment of vegetation planted along its banks.) Figure 1 also shows an overview of the locations of data collected for the Study discussed in detail in the following sections.

When contrasted with the baseline conditions (data collected in 2016) the 2017 conditions offer insights into the potential effects of development of the SWCRR on the park's ecosystems. These are discussed in the final section of the report '*Final Considerations*'. Data from the long-term monitoring over the 7 years of the Study will provide the information necessary to evaluate objectively the environmental effects and the success of mitigation measures included in the SWCRR project. These data will allow the Society to base any requests for improved mitigation upon verifiable and scientific data. Data from the annual monitoring is also capable of giving early warning about changes in habitat quality and ecological processes in a timely manner and at a relatively low cost.

Figure 1: Overview of Study site and monitoring locations at start of construction. Weaselhead boundary shown by orange line; SWCRR construction site visible to west with new river channel visible, Glenmore Reservoir to east; blue pins show water quality/invertebrate sampling points; pink pins show locations of breeding bird point counts/noise survey; green pins/line show transect used for riparian vegetation monitoring; north is to top of image dated Oct. 2017 *(downloaded from GoogleEarth)*

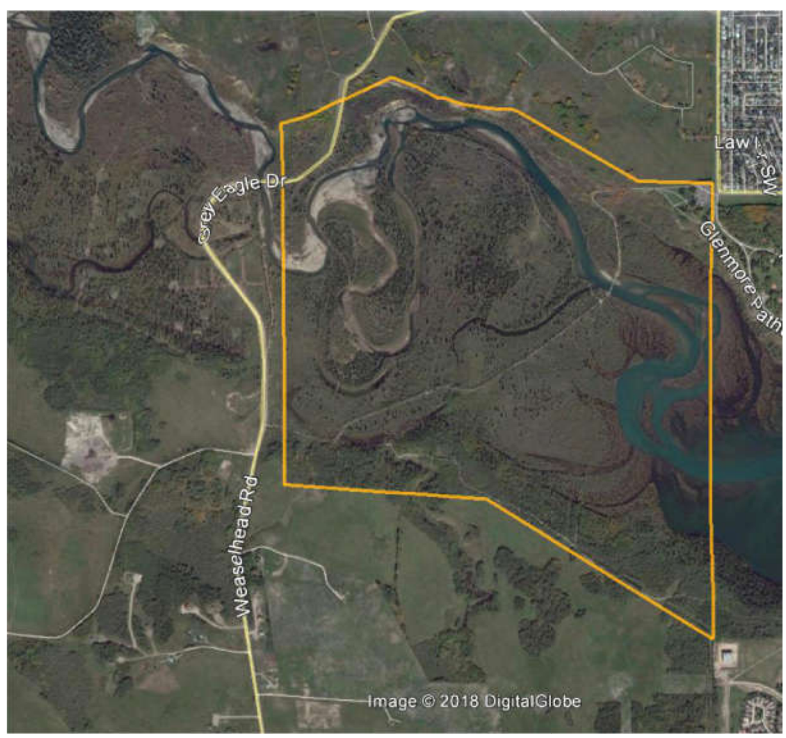

Figure 2: satellite image Sept. 2016 before major construction began *(downloaded from GoogleEarth);* orange line shows Weaselhead boundary

1. RESULTS: TERRESTRIAL HABITATS

a. Breeding Bird Survey

The 2017 breeding bird survey was conducted using the same protocol and study design as in 2016 and in the EIA[1]. In order to produce comparable results the timing of the survey, the locations of the bird counts and the time of day of observation were also kept constant. Similar weather conditions were recorded (low wind and mostly cloudy, temperature 13˚C-16˚C, little to no precipitation).

On July 2nd 2017, three groups of volunteers surveyed the area, each group visiting different points in the Weaselhead to record observations. Each group was led by an expert ornithologist and followed the method described below:

- Starting at 5:00am (daylight saving time: UTC-6:00) each group hiked to pre-determined stations (table 1) located with GPS.
- 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 point stations in the Weaselhead area (including 4 stations just outside the boundary of the Weaselhead, two in North and two in South Glenmore Park; figure 1 shows a satellite image of the park with the locations of these stations and table 1 give their coordinates).

Table 1: Station coordinates for breeding bird point counts and 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

During the 2017 bird survey, 453 individuals and 45 species were identified (tables 2 and 5). (Birds flying overhead or over 100m from survey point were recorded (table 3) but not included in the survey.) The total Simpson's diversity index for the breeding bird survey was very high (1-S = 94.47%). The mean species density was 3.06 (standard deviation = ±0.81, n=28) species per hectare, which is 18% greater than the species density measured in 2016 (paired t test, df = 27, $p<0.05$).

Similarly to 2016, the 2017 survey found a significant linear regression slope ($p<0.05$) between the cumulative number of different species and the cumulative area investigated (fig. 3). The 2017 survey species per area regression follows the general function: $CS=0.34A+15.9$ ($R^2=0.961$), 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 0.34 "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 and 2017 (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. Therefore, the slope of this species-area relationship also informs about how close the study sampling effort is to include every breeding bird species in the park, at that time of the year. From the linear regression results, both 2016 and 2017 surveys clearly were unable to include in the list every bird species in the park. The lower value of the 2017 slope (when compared to 2016) suggests that the total number of species recorded for that year (45) is closer to the total number of species present in 2017 compared with 2016.

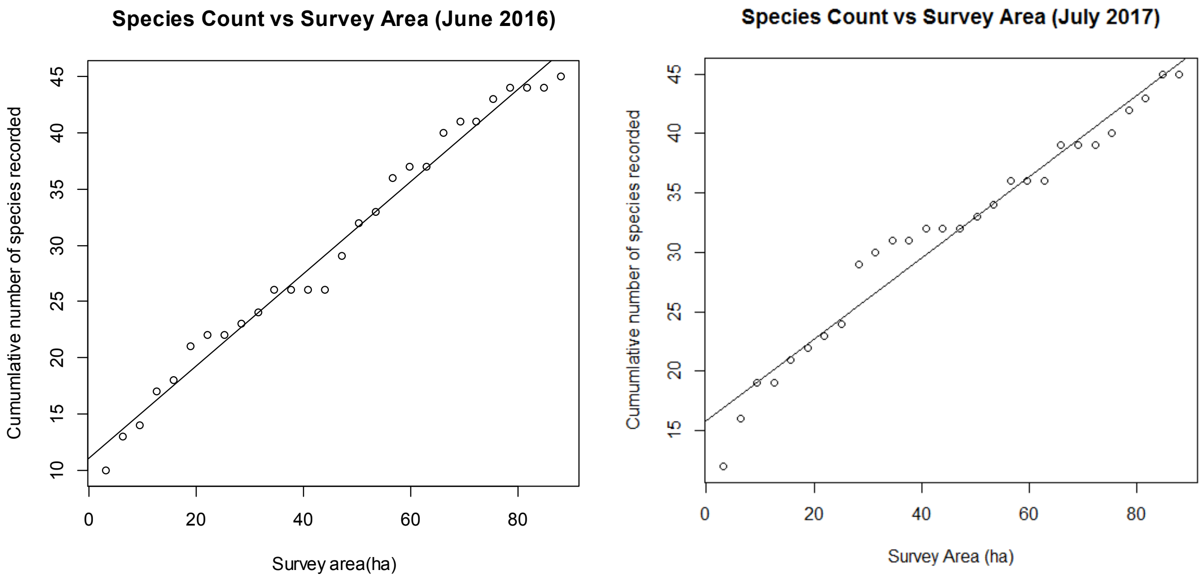

Figure 3: Regression model between cumulative number of species recorded and area, increasing in increments of 3.14ha (= area of 100m-radius circle around stations in which observations were made) .(2016: CS=0.41A+11.1 (R^2=0.9826), where CS is the cumulative number of species and A is the cumulative area observed (ha). 2017 CS=0.34A+15.9 (R^2=0.961

Table 2: Breeding bird survey species list (July 2nd 2017) with total individual counts

Common Name *(* birds listed as 'sensitive' in 2015 AEP[2])*	**Species**	**Total Count**
White Throated Sparrow	*Zonotrichia albicollis*	*42*
Black-capped Chickadee	*Poecile atricapillus*	*39*
Clay-colored Sparrow	*Spizella pallida*	*37*
Cedar Waxwing	*Bombycilla cedrorum*	*28*
American Robin	*Turdus migratorius*	*25*
Cliff Swallow	*Petrochelidon pyrrhonota*	*25*
Red-winged Blackbird	*Agelaius phoeniceus*	*23*
House Wren	*Troglodytes aedon*	*19*
Mallard	*Anas platyrhynchos*	*19*
Veery	*Catharus fuscescens*	*19*
American Crow	*Corvus brachyrhynchos*	*16*
Least Flycatcher*	*Empidonax minimus**	*12*
Red-breasted Nuthatch	*Sitta canadensis*	*12*
Song Sparrow	*Melospiza melodia*	*10*
Brown-headed Cowbird	*Molothrus ater*	*8*
Gray Catbird	*Dumetella carolinensis*	*8*
Red-eyed Vireo	*Vireo olivaceus*	*7*
Common Raven	*Corvus corax*	*6*
Gadwall	*Mareca strepera*	*6*
Pileated Woodpecker*	*Hylatomus pileatus**	*5*

American Goldfinch	*Spinus tristis*	*4*
Killdeer	*Charadrius vociferus*	*4*
Downy Woodpecker	*Picoides pubescens*	*3*
Pine Siskin	*Spinus pinus*	*3*
American Wigeon	*Mareca americana*	*2*
Brewer's Blackbird	*Euphagus cyanocephalus*	*2*
Spotted Sandpiper	*Actitis macularius*	*2*
Tree Swallow	*Tachycineta bicolor*	*2*
White-breasted Nuthatch	*Sitta carolinensis*	*2*
Baltimore Oriole*	*Icterus galbula**	*1*
Belted Kingfisher	*Megaceryle alcyon*	*1*
Black billed Magpie	*Pica hudsonia*	*1*
Chipping Sparrow	*Spizella passerina*	*1*
Hermit Thrush	*Catharus guttatus*	*1*
House Finch	*Haemorhous mexicanus*	*1*
Northern Flicker	*Colaptes auratus*	*1*
North. Rough-Winged Swallow	*Stelgidopteryx serripennis*	*1*
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	*1*
Ruby-crowned kinglet	*Regulus calendula*	*1*
Ruddy Duck	*Oxyura jamaicensis*	*1*
Savannah Sparrow	*Passerculus sandwichensis*	*1*
Sora*	*Porzana Carolina**	*1*
Western Wood Peewee*	*Contopus sordidulus*	*1*

Table 3: Breeding bird survey (July 2nd 2017) – birds observed flying overhead or further than 100m from survey points *(* birds listed as 'sensitive' by AEP[2] 2015)*

Common Goldeneye	*Bucephala clangula*
Loon	*Gavia sp.*
Merlin	*Falco columbarius*
Ring-billed Gull	*Larus delawarensis*
Franklyn's Gull	*Leucophaeus pipixcan*
Bank Swallow*	*Riparia riparia**
Northern rough-winged swallow	*Stelgidopteryx serripennis*
Nutting's Flycatcher	*Myiarchus nuttingi,*
Pine Grosbeak	*Pinicola enucleator*

Table 4: Breeding bird survey (July 2nd 2017) – change in species occurrence within 100m of survey points, 2017 compared with 2016 *(* birds listed as 'sensitive' by AEP[2] 2015)*

Family	new species recorded in 2017		species recorded in 2016 but not in 2017	
Anatidae	*Mareca american*	American Wigeon	*Branta canadensis*	Canada Goose
	Mareca strepera	Gadwall		
	Oxyura jamaicensis	Ruddy Duck		
Podicipedidae			*Podiceps grisegena*	Red-necked Grebe
Phasianidae			*Phasianus colchicus*	Ring-necked Pheasant
Rallidae	*Porzana Carolina**	Sora*		
Charadriidae	*Charadrius vociferus*	Killdeer		
Scolopacidae			*Gallinago delicata*	Wilson's Snipe
Strigidae			*Bubo virginianus*	Great-horned Owl
Picidae			*Leuconotopicus villosus*	Hairy Woodpecker
Vireonidae			*Vireo gilvus*	Warbling Vireo
Hirundinidae	*Tachycineta bicolor*	Tree Swallow		
	Petrochelidon pyrrhonota	Cliff Swallow		
	Stelgidopteryx serripennis	Northern Rough-winged Swallow		
Paridae			*Poecile hudsonicus*	Boreal Chickadee
Troglodytidae			*Troglodytes hiemalis*	Winter Wren
Regulidae	*Regulus calendula)*	Ruby-crowned Kinglet		
Turdidae	*Catharus guttatus*	Hermit Thrush		
Mimidae			*Toxostoma rufum*	Brown Thrasher
Fringillidae	*Pheucticus ludovicianus*	Rose-breasted Grosbeak		
	Haemorhous mexicanus	House Finch		
	Spinus pinus	Pine Siskin		
Passerellidae	*Passerculus sandwichensis*	Savannah Sparrow	*Pipilo maculatus)*	Spotted Towhee
			Melospiza lincolnii	Lincoln's Sparrow
Icteridae	*Euphagus cyanocephalus*	Brewer's Blackbird		
	*Icterus galbula**	Baltimore Oriole*		
Parulidae			*Seiurus aurocapilla*	Ovenbird
			Parkesia noveboracensis	Northern Waterthrush
			Cardellina pusilla	Wilson's Warbler
Parulidae			*Geothlypis trichas**	Common Yellowthroat*

In addition to the high bird species diversity found again in 2017, the area still offers breeding habitat for a number of species of 'sensitive' status ([2]Alberta Environment and Parks, 2015). The Least Flycatcher, Pileated Woodpecker, Western Wood-peewee were recorded in both 2016 and 2017, the Common Yellowthroat (*Geothlypis trichas*) only in 2016, and the Sora and Baltimore Oriole only in 2017 (Table 3 and 4).

ies list; total individual counts per station within 50m and 100m-radius from observer.

Site																																																						
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	
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
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b. Noise pollution

Because some bird species can be particularly vulnerable to the noise pollution such as that associated with the construction and operation of roads ([3]McClure et al., 2013), the ambient noise in the Weaselhead has been monitored since 2016.

A sound level meter (range 0-100 dB LAS *(Slow, A-weighted Sound Level))* was employed to measure noise pollution during weekday traffic peak hours of 6:30 – 9:30 am and 3:30 – 6:30 pm) on 5th and 6th July 2017. Levels were measured at the same points (stations) as used in the breeding bird survey (table 1). On each site, the sound level was measured for 2 minutes. The results are shown in table 6. *(Note: 'maximum' and 'minimum' refer to levels calculated from the square root of the mean of the squares of the values within the time period; 'peak' is the instantaneous maximum value reached by the sound pressure wave.)*

Table 6: Sound pressure measured in peak traffic hours for 2017 ((minimum, maximum, average and peak)

Station	Time UTC-6	Sound Pressure (dB)			
		Minimum	Maximum	Average	Peak
P1	15:10	45.6	53.5	47.1	79.9
P2	15:00	45.7	60.8	48.7	94.2
P3	8:13	45.8	50.1	46.7	77.4
P4	15:22	46.0	55.8	48.5	93.5
P5	15:44	45.0	48.4	45.7	82.1
P6	15:55	45.6	49.6	46.9	81.1
P7	16:08	45.6	53.5	48.4	86.3
P8	9:13	45.2	53.8	46.9	90.8
P9	16:24	46.2	50.0	47.4	66.7
P10	9:25	45.7	53.2	46.9	90.7
P11	9:35	45.4	61.2	52.1	84.6
P12	8:46	45.1	54.4	46.9	92.5
P13	8:58	45.2	51.8	45.7	70.3
P14	8:22	45.6	61.8	49.8	96.5
P15	8:35	45.3	48.5	45.7	67.7
P16	7:55	48.5	54.5	51.5	71.1
P17	7:45	47.0	52.2	48.3	73.2
P18	7:25	36.3	52.7	40.8	83.5
P19	17:25	45.3	57.0	48.6	85.1
P20	17:00	49.5	59.8	51.6	92.4
P21	16:48	46.4	60.8	49.3	100.7
P22	17:36	35.2	52.5	41.3	74.2
P23	7:37	42.4	54.1	45.5	84.3
P24	7:50	44.2	47.2	45.4	63.4
P25	7:20	44.9	50.7	46.3	74.9
P26	8:05	40.0	54.2	46.4	84.9
P27	7:06	41.5	50.2	43.7	81.3
P28	6:49	45.6	51.1	47.1	65.8
mean		44.6	53.7	47.1	81.8
sd		3.1	4.1	2.6	10.1

All measures of ambient noise in the Weaselhead park became significantly higher during the SWCRR construction phase of 2017 compared with those measured in 2016 (figure 4: minimum, average, maximum and peak decibel levels; paired t tests, df= 27, p<0.05).

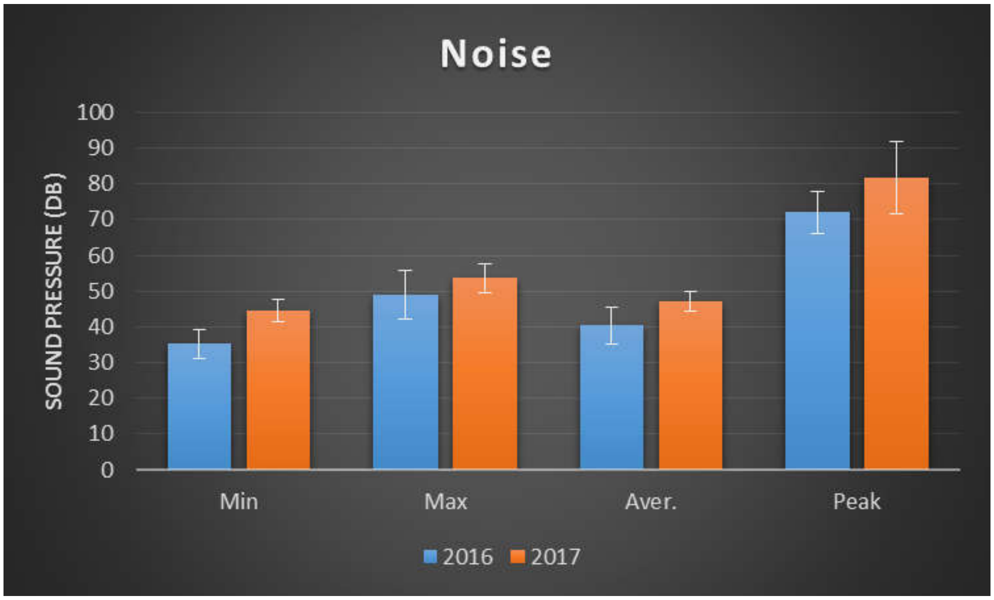

Figure 4: Sound levels measured in the Weaselhead park in July 2016 and July 2017 (n=28)

Figure 5: changes in sound level average recorded at sampling points in 2016 compared with 2017: small icons represent less than 6dB change, mid-sized icons represent over 6dB increase, large icons represent over 12dB increase (sampling period 2 minutes)

When average sound pressures recorded in 2017 are compared with those recorded in 2016, at 17 of the 28 sampling points the average has increased by 6dB or more, and at 5 of these point by more than 12dB. This equates to more than a doubling or tripling respectively of the sound level. In general sound levels have doubled along the north escarpment and north side of the floodplain, tripled on the south side of the floodplain, and remained the same along the south escarpment (see figure 5).

c. Beaver Pond riparian vegetation

Baseline information was collected in 2015 and 2016 to describe the riparian vegetation by the Beaver Pond in the Weaselhead. 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 2017 are detailed below. The same protocol and site were used in 2015 and 2016. The assessments included only flowering plants in the clade 'eudicots' i.e. did not include grasses and other monocots.

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 (figure 6).

Figure 6: green line shows location of 50m transect used for vegetation survey; orange line shows Weaselhead boundary

The quadrats were numbered from 1 to 50 from west to east (figure 7). 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 2017 survey. On 9th and 10th September 2017, 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 5. Table 7 shows species ordered by occurrence (the number of quadrats in which that particular species was present) and the species mean abundance in these quadrats. Two of the three most widely occurring herbaceous species were noxious weeds.

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 7: 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 2017 survey (quadrats number 8, 10, 12, 13, 17, 18, 21, 26, 29, 33, 35, 37, 41, 42, 44).

Table 7: Eudicots: occurrence (number of quadrats with one or more of the species) and abundance (mean count of the species in occupied quadrats)
**noxious weed ([4]Alberta Weed Control Act 19/2010); [nn]non-native species (unregulated)*

herbaceous species *(note – all are perennials)*	**common name**	**occurrence**	**abundance**	**USDA wetland classification[4]**
*Sonchus arvensis**	Field Sow Thistle	14	12	FAC
*Cirsium arvense**	Canada Thistle	14	6	FACU
Anemone canadensis	Canada Anemone	14	3	FACW
Viola canadensis	Canada Violet	13	10	FACU
Monarda fistulosa	Wild Bergamot	12	6	UPL
Persicaria amphibium	Swamp smartweed	12	3	OBL
Solidago canadensis	Canada Goldenrod	11	10	FACU
Thalictrum venulosum	Veiny Meadow Rue	11	7	FAC
Galium boreale	Northern Bedstraw	9	2	FACU
Lysimachia ciliata	Fringed Loosestrife	6	6	FACW
Pyrola asarifolia	Common Pink Wintergreen	6	2	FACU
Vicia americana	American Vetch	5	1	FACU
Symphyotrichum laeve	Smooth Blue Aster	5	1	FACU
Fragaria virginiana	Wild Strawberry	4	2	FACU
Symphyotrichum eatonii	Eaton’s Aster	3	5	FAC
Heracleum maximum	Cow Parsnip	3	2	FAC
Achillea millefolium	Common Yarrow	3	1	FACU
Stachys pilosa	Hairy Hedgenettle	3	1	FACW
Ranunculus macounii	Macoun’s Buttercup	2	1	OBL
Euthamia graminifolia	Flat-top Goldenrod	1	2	--
Scutellaria galericulata	Skullcap	1	2	OBL

Hedysarum alpinum	Alpine Sweetvetch	1	1	FACU
Sanicula marilandica	Maryland Sanicle	1	1	FACU
Argentina anserina	Silverweed	1	1	FACW
Geum rivale	Water Avens	1	1	FACW
Mentha arvensis	Wild Mint	1	1	FACW

woody species	common name	occurrence	abundance	USDA wetland classification[5]
Rosa acicularis	Prickly Rose	14	19	FACU
Salix bebbiana	Bebb Willow	12	1	FACW
Elaeagnus commutata	Silverberry	10	3	UPL
Cornus sericea	Red-Osier Dogwood	10	2	FACW``
Rubus strigosus	American Red Raspberry	9	7	--
Symphoricarpos occidentalis	Buckbrush	7	2	UPL
Dasiphora fruticosa	Shrubby cinquefoil	7	2	FACW
Amelanchier alnifolia	Saskatoon	7	1	FACU
Salix pseudomonticola	False Mountain Willow	6	1	FACW
Shepherdia canadensis	Buffaloberry	1	2	FACU
Lonicera dioica	Twining Honeysuckle	1	1	FACU
Viburnum trilobum	Highbush Cranberry	1	1	--
Cotoneaster lucidus[nn]	Shiny Cotoneaster	1	1	--
Rosa woodsii	Wood's Rose	1	1	FACU

OBL	Obligate Wetland	*Hydrophyte*	*Almost always occur in wetlands*
FACW	Facultative Wetland	*Hydrophyte*	*Usually occur in wetlands, but may occur in non-wetlands*
FAC	Facultative	*Hydrophyte*	*Occur in wetlands and non-wetlands*
FACU	Facultative Upland	*Nonhydrophyte*	*Usually occur in non-wetlands, but may occur in wetlands*
UPL	Obligate Upland	*Nonhydrophyte*	*Almost never occur in wetlands*

The 2017 results show a total taxa richness of 40 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 20.6% of the total individuals counted (including all species). The area revealed an average richness of 4.05±1.00 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 ith 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 83.1%±4.6% per quadrat (2m x 2m) in 2017.

When compared with the results for the same area in 2015 and 2016 no statistically significant difference was found in the Simpson's Diversity Index (figure 8) per quadrat between the three years (ANOVA, df = (1, 28), $p>0.05$). A log transformation was necessary for meeting the residuals normality assumption of the ANOVA.

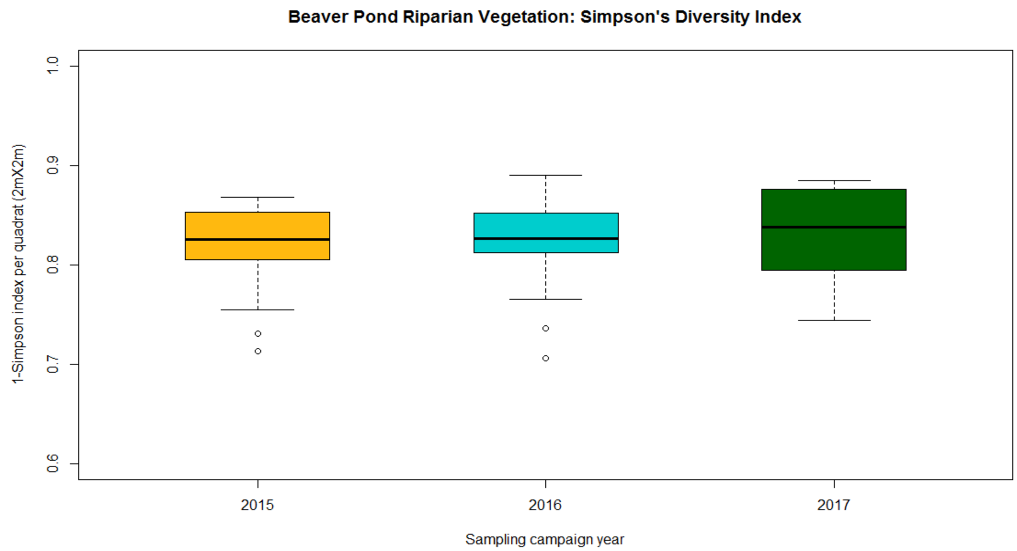

Figure 8: Simpson's Diversity Index (1-S) per quadrat for 2015, 2016 and 2017 sampling campaigns.

The measured mean of eudicot species per square meter (figure 9) along the shore of the Beaver Pond (4.1±1.00 species/m^2, n=15) is higher than the values recorded for 2016 and 2015 (ANOVA and Tukey's test, df = (1, 28), $p<0.05$).

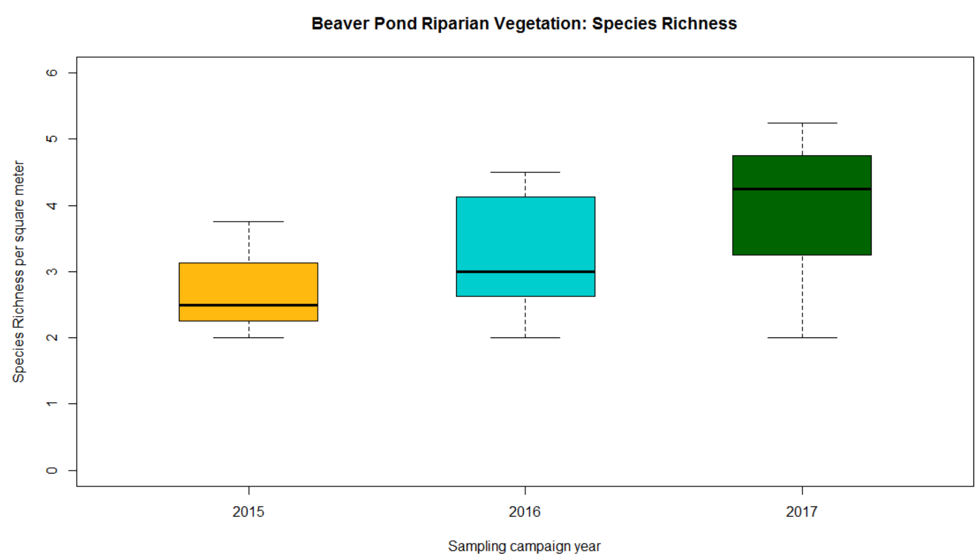

Figure 9: Eudicots species richness per square meter for 2015, 2016 and 2017 sampling campaigns

12 new species were found in 2017 when compared with results from surveys completed in 2015 and 2016, and 11 species found in 2015 and/or 2016 were not found again in the 2017 samples (table 8).

Table 8: change in species occurrence, 2017 compared with 2015 and 2015 (*^{nn}non-native species)*

new species recorded in 2017			**species recorded in 2015 and/or 2016 but not in 2017**		
Herbaceous species	**Common name**	**WC***	**Herbaceous species**	**Common name**	**WC***
Ranunculus macounii	Macoun's Buttercup	OBL	Doellingeria umbellata	Flat-topped White Aster	OBL
Scutellaria galericulata	Skullcap	OBL			
Persicaria amphibium	Swamp smartweed	OBL			
Argentina anserina	Silverweed	FACW	*Geum macrophyllum*	Largeleaf Avens	FACW
Stachys pilosa	Hairy Hedgenettle	FACW	*Polygonum persicaria*	Spotted Lady's-thumb	FACW
				Bristly buttercup	FACW
Symphyotrichum eatonii	Eaton's Aster	FAC	*Erigeron philadelphicus*	Philadelpea fleabane	FAC
Symphyotrichum laeve	Smooth Blue Aster	FACU	*Trifolium repens*^{nn}	White clover^{nn}	FACU
Hedysarum alpinum	Alpine Sweetvetch	FACU			
Monarda fistulosa	Wild Bergamot	UPL			
Woody species	**Common name**	WC*	**Woody species**	**Common name**	**WC***
Cotoneaster lucidus^{nn}	Shiny Cotoneaster^{nn}	--	*Betula occidentalis*	Water Birch	FACW
		FACU	*Lonicera tatarica*^{nn}	Tartarian Honeysuckle^{nn}	FACU
Rosa woodsii	Wood's Rose		Arctostaphylos uva-ursi	*Bearberry*	*UPL*
		--	*Salix boothii*	Booth's willow	--
Viburnum trilobum	Highbush Cranberry		*Sorbus aucuparia*^{nn}	European Mountain Ash^{nn}	--

*Wetland classification (USDA[5]):

OBL	Obligate Wetland	*Hydrophyte*	*Almost always occur in wetlands*
FACW	Facultative Wetland	*Hydrophyte*	*Usually occur in wetlands, but may occur in non-wetlands*
FAC	Facultative	*Hydrophyte*	*Occur in wetlands and non-wetlands*
FACU	Facultative Upland	*Nonhydrophyte*	*Usually occur in non-wetlands, but may occur in wetlands*
UPL	Obligate Upland	*Nonhydrophyte*	*Almost never occur in wetlands*

Table 9: Eudicots - Quadrats (2m x 2m) Individual counts - Sep 9th and 10th 2017
**noxious weed ([4]Alberta Weed Control Act 19/2010); [nn]non-native species (unregulated)*

Herbaceous species *(note – all are perennials)*	**Common name**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	*total*
*Sonchus arvensis**	Field Sow Thistle	11	35	18	1	0	2	1	1	0	8	19	14	43	12	6	*171*
Viola canadensis	Canada Violet	3	15	5	6	15	12	2	3	2	33	4	15	13	0	0	*128*
Solidago canadensis	Canada Goldenrod	2	5	4	8	2	6	55	7	14	11	0	0	1	0	0	*115*
*Cirsium arvense**	Canada Thistle	8	15	5	7	8	7	0	8	3	10	2	3	7	1	6	*90*
Thalictrum venulosum	Veiny Meadow Rue	4	6	10	4	0	1	11	11	14	14	1	0	2	0	0	*78*
Monarda fistulosa	Wild Bergamot	2	8	5	7	1	0	8	2	0	6	19	3	2	0	9	*72*
Anemone canadensis	Canada Anemone	2	12	6	1	3	1	0	2	1	3	2	2	1	3	3	*42*
Lysimachia ciliata	Fringed Loosestrife	3	5	23	1	0	1	0	0	0	0	0	0	0	0	3	*36*
Persicaria amphibia	Swamp smartweed	0	3	4	1	2	1	0	1	1	0	6	1	1	1	11	*33*
Galium boreale	Northern Bedstraw	3	1	3	3	0	0	2	2	1	2	0	0	2	0	0	*19*
Symphyotrichum eatonii	Eaton’s Aster	0	0	0	0	0	0	0	0	0	0	0	4	4	8	0	*16*
Pyrola asarifolia	Common Pink Wintergreen	0	0	0	0	3	3	0	0	0	2	0	0	1	3	1	*13*
Fragaria virginiana	Wild Strawberry	0	2	0	0	1	0	1	0	0	2	0	0	0	0	0	*6*
Heracleum maximum	Cow Parsnip	0	0	2	2	0	0	2	0	0	0	0	0	0	0	0	*6*
Vicia americana	American Vetch	0	0	1	1	1	0	0	1	1	0	0	0	0	0	0	*5*
Symphyotrichum laeve	Smooth Blue Aster	0	0	0	0	1	1	1	0	0	1	0	0	0	1	0	*5*
Achillea millefolium	Common Yarrow	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	*3*
Stachys pilosa	Hairy Hedgenettle	1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	*3*
Euthamia graminifolia	Flat-top Goldenrod	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*2*
Ranunculus macounii	Macoun’s Buttercup	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	*2*
Scutellaria galericulata	Skullcap	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	*2*
Hedysarum alpinum	Alpine Sweetvetch	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	*1*
Sanicula marilandica	Maryland Sanicle	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	*1*
Argentina anserina	Silverweed	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	*1*
Geum rivale	Water Avens	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	*1*

Mentha arvensis	Wild Mint	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	*1*
Woody species	**Common name**																
Rosa acicularis	Prickly Rose	22	29	15	40	26	16	32	3	7	47	8	5	14	0	5	*269*
Rubus strigosus	American Red Raspberry	4	0	0	2	1	1	26	16	1	5	0	0	4	0	0	*60*
Elaeagnus commutata	Silverberry	2	8	2	1	0	3	6	3	4	2	0	0	3	0	0	*34*
Cornus sericea	Red-Osier Dogwood	6	2	0	0	0	0	1	3	1	1	2	1	2	0	4	*23*
Salix bebbiana	Bebb Willow	0	1	1	1	2	1	4	1	1	1	0	1	0	1	2	*17*
Symphoricarpus occidentalis	Buckbrush	0	0	2	2	0	1	1	1	6	3	0	0	0	0	0	*16*
Dasiphora fruticosa	Shrubby cinquefoil	1	2	1	5	0	0	2	0	0	2	0	0	1	0	0	*14*
Amelanchier alnifolia	Saskatoon	2	1	0	0	0	2	1	0	1	0	1	0	1	0	0	*9*
Salix pseudomonticola	False Mountain Willow	1	0	0	0	0	0	0	0	1	1	0	1	3	0	1	*8*
Shepherdia canadensis	Buffaloberry	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	*2*
Lonicera dioica	Twining Honeysuckle	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	*1*
Viburnum trilobum	Highbush Cranberry	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	*1*
Cotoneaster lucidus[nn]	Shiny Cotoneaster	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	*1*
Rosa woodsii	Wood's Rose	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	*1*

2. RESULTS: AQUATIC HABITATS

a. Water quality parameters

This section of the study provides information on water quality in two wetlands in the Weaselhead, the Beaver Pond and Beaver Lagoon. Water quality in an additional wetland, Clearwater Pond, was also assessed. This last habitat is in the Elbow Valley but is upstream of the SWCRR construction zone and not located in the Weaselhead. It is intended to represent a reference site (figure 10).

Two sampling stations representing different habitats were defined, one in the Beaver Pond and one in the Beaver Lagoon, to assess the water quality of each water body (figure 11). The Beaver Pond is in immediate proximity to the SWCRR and the Beaver Lagoon with which it is hydrologically connected is further downstream. Surface flow to these wetlands will be maintained during and post SWCRR construction as per the drainage plan proposed by the SWCRR contractor, KGL (figure 13).

For each 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 on 26th August 2017 and on 21st October 2017 (figures 12 and 13, Table 10).

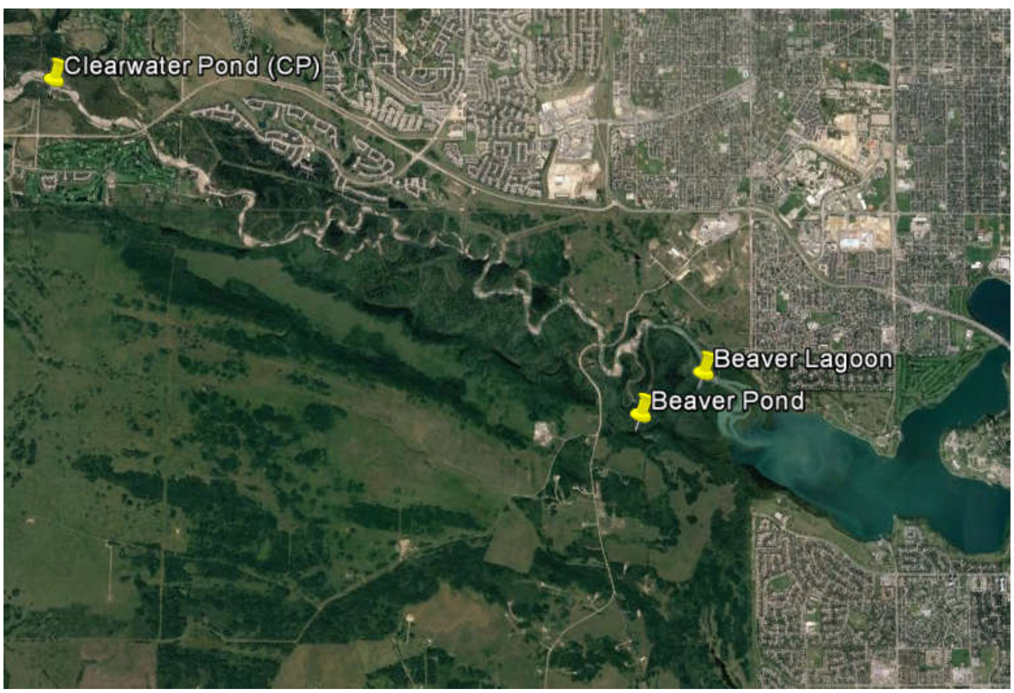

Figure 10: Location of aquatic habitats monitored for water quality.

Figure 11: Location of sampling sites at the Beaver Pond, Beaver Lagoon and Elbow River

Figure 12: Location of sampling sites at Clearwater Pond

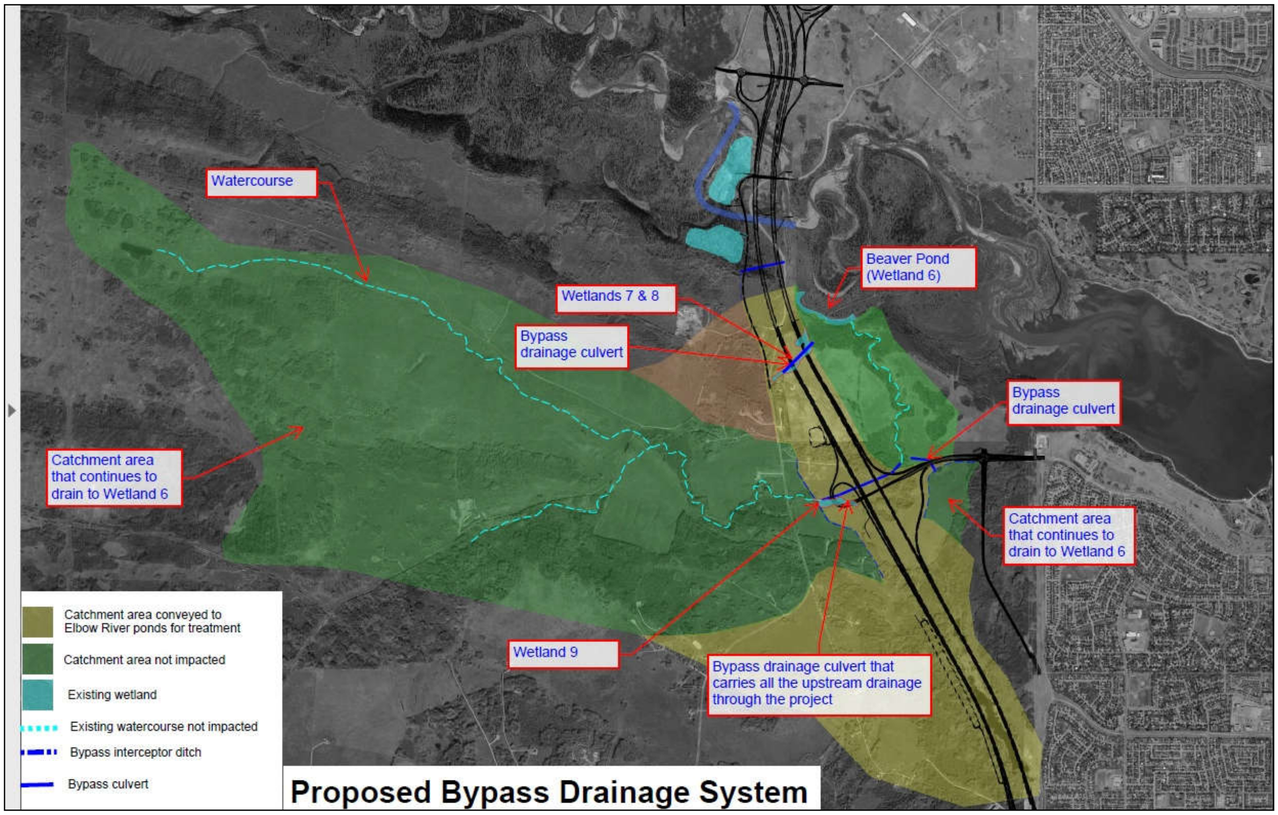

Figure 13: Proposed bypass drainage to maintain surface flow across the Transportation Utility Corridor (TUC) into Beaver Pond, Sept. 2017 (courtesy KGL – construction company SWCRR)

Table 10: Geographic coordinates of water quality monitoring sampling sites

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

On August and October 2017 a YSI® ProDSS multimeter was used to measure in-situ water temperature, conductivity, pH, dissolved oxygen and turbidity at sampling sites. A 100 mL water sample was collected 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. Results are presented in tables 11 and 12. Table 13 presents the sampling campaign summary statistics.

Table 11: Water quality parameters on August 26th 2017

	Water body / Site									
field: August 26th 2017	Beaver Pond			Beaver Lagoon			Elbow River	Clearwater Pond		
Parameters	**BP1**	**BP2**	**BP3**	**BL1**	**BL2**	**BL3**	**ELR**	**CP1**	**CP2**	**CP3**
Turbidity (NTU)	20	1.4	36	0.1	0	0.1	0	42.9	21.1	1.1
Temperature (°C)	14.6	11.4	10.7	16.2	14.2	15.8	12.4	22.4	22	20.7
pH	7.53	7.68	7.95	8.06	7.53	8.07	8.19	10.13	9.95	10.2
Conductivity - C (μS/cm)	589	535	523	346	446	346	332	236	236	238
DO (mg/L)	2.03	2.62	2.65	9.60	10.3	9.22	9.45	12.73	13.91	14.4
DO (%)	20	24.2	24.5	97.6	99.6	93.3	88.6	147	159	160
Phosphate (mg/L)	0.01	0.01	0	0.02	0.06	0.04	0.05	0.04	0	0.03
Chloride (mg/L)	3.68	3.32	7.70	3.26	4.90	3.26	3.99	1.06	0.95	0.96

Table 12: Water quality parameters on October 21st 2017

	Water body / Site									
field: October 21st 2017	Beaver Pond			Beaver Lagoon			Elbow River	Clearwater Pond		
Parameters	**BP1**	**BP2**	**BP3**	**BL1**	**BL2**	**BL3**	**ELR**	**CP1**	**CP2**	**CP3**
Turbidity (NTU)	18.7	30	19.6	0	0	0	0	15	11	22.1
Temperature (°C)	4.2	2.6	2.4	4.6	3.9	4.4	4.5	4.9	6.9	7.1
pH	8.07	8.21	8.15	8.16	7.84	8.17	8.16	8.14	8.06	8.16
Conductivity - C (μS/cm)	500	444	491	296	425	285	270	246	267	266
DO (mg/L)	9.12	10.2	9.99	10.4	10.6	10.6	11.4	10.6	10.4	10.9
DO (%)	70.1	75.2	73.5	80.1	80.1	81.4	88	82.6	86	89.6
Phosphate (mg/L)	0.01	0.03	0	0	0.01	0.02	0.04	0	0.03	0
Chloride (mg/L)	5.25	6.86	6.32	4.68	7.12	5.25	5.22	2.84	2.31	2.75

Table 13: Water quality parameters in 2017. Each value represents the average (±SEM) of three replicates (n=3).

Water body	Site	Assessment Date	Parameters Turbidity (NTU)	Temperature (°C)	pH	Conductivity (μS/cm)	DO (%) *[1]	Phosphate PO_4 (mg/L) *[2]	Chloride Cl^- (mg/L)
Beaver Pond	BP	Aug. 26th 2017	19.1 (±10.0)	12.2 (±1.2)	7.72(±0.12)	549 (±20)	23 (±2)	0.01(±0.00)	4.9 (±1.4)
		Oct. 21st 2017	22.8 (±3.6)	3.1(±0.6)	8.14(±0.04)	478 (±17)	73 (±2)	0.01(±0.01)	6.1 (±0.5)
Beaver Lagoon	BL	Aug. 26th 2017	0.1 (±0.0)	15.4 (±0.6)	7.89(±0.18)	379 (±34)	97 (±2)	0.04(±0.01)	3.8 (±0.5)
		Oct. 21st 2017	0.0 (±0.0)	4.3 (±0.2)	8.06(±0.11)	335 (±45)	80 (±0)	0.01(±0.01)	5.7 (±0.7)
Clearwater Pond	CP	Aug. 26th 2017	21.7 (±12.0)	21.7 (±0.5)	10.09(±0.07)	237 (±1)	157 (±3)	0.02(±0.01)	0.99(±0.04)
		Oct. 21st 2017	16.0 (±3.0)	6.3 (±0.7)	8.12(±0.03)	259 (±7)	86 (±2)	0.01(±0.01)	2.63(±0.06)

Parameters Discussions:

i) **Conductivity** (figure 14) of 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 ([6]Sawyer *et al.*, 2003). Baseline information on the natural range and fluctuations of the conductivity in the studied water body is necessary for distinguishing between natural and disturbed levels of conductivity.

When the conductivity levels before and after the start of the SWCRR construction (2016-2017) are contrasted no significant changes were detected for the Beaver Lagoon station ($p>0.05$). However, for the Beaver Pond and the Clearwater Pond, the conductivity measured in 2017 increased significantly when compared to the recorded values in 2016 for the same sites and at the same time of the year (paired t test, $df=2$, $p<0.05$).

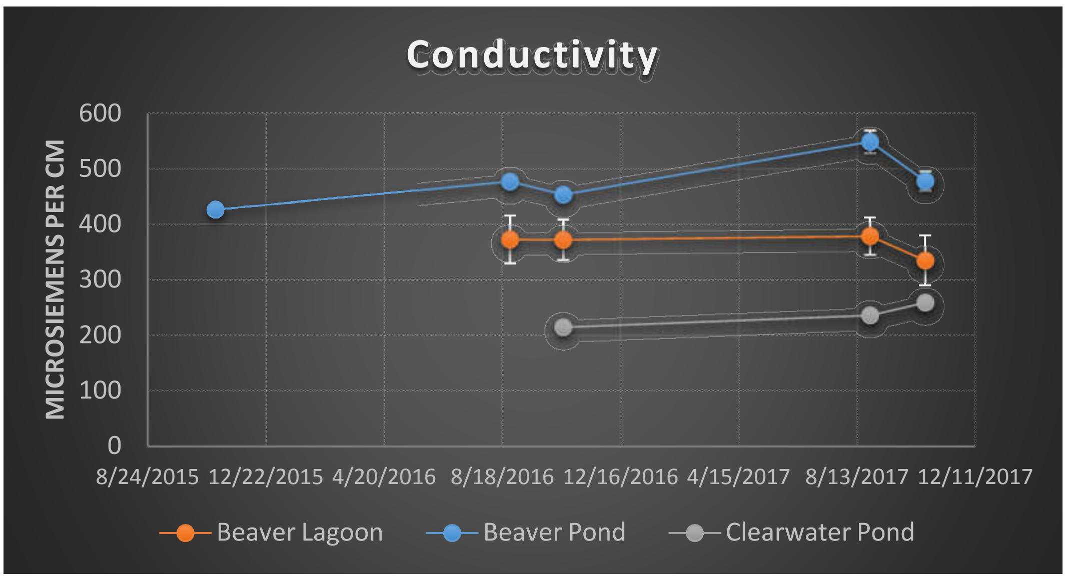

Figure 14: Conductivity recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) in 2015, 2016 and 2017.

ii) **Chloride** is one of the dissolved ions that increase the electric conductivity in water ([6]Sawyer *et al.*, 2003). Chloride (figure 15) is released from sources that include salts used in road de-icing so is an important ion to monitor as levels may be increased once the SWCRR is in use. No significant changes were detected ($p>0.05$) in the chloride levels at the monitoring stations before and after the start of the SWCRR construction (2016-2017).

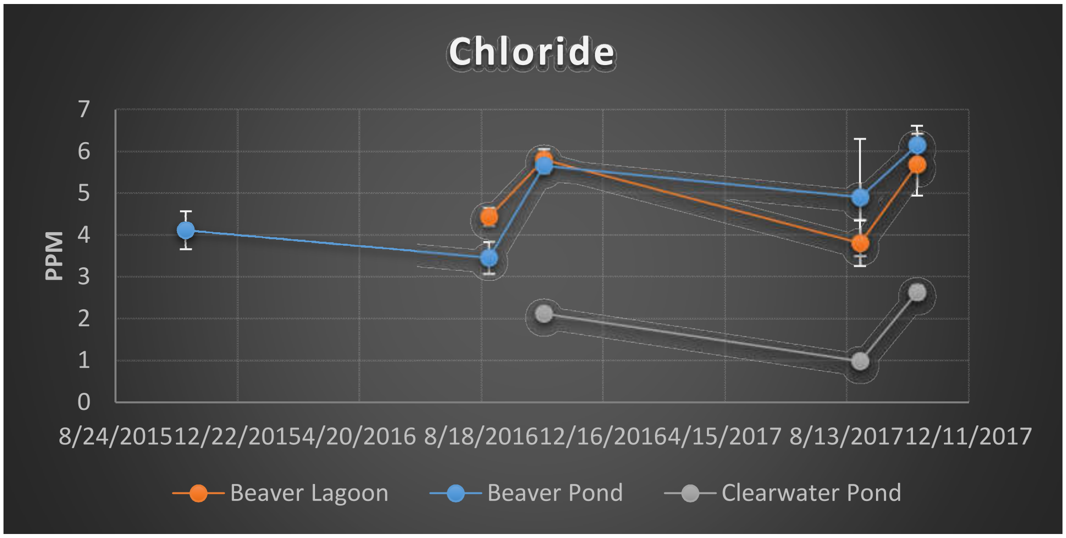

Figure 15: Chloride recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) in 2015, 2016 and 2017.

iii) **Turbidity** responds to the concentration of suspended and dissolved solids in the water column ([6]Sawyer *et al.*, 2003). It 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. This parameter is highly variable and sensitive to localized disturbances. No significant changes were detected ($p>0.05$) at the monitoring stations before and after the start of the SWCRR construction (2016-2017; figure 16).

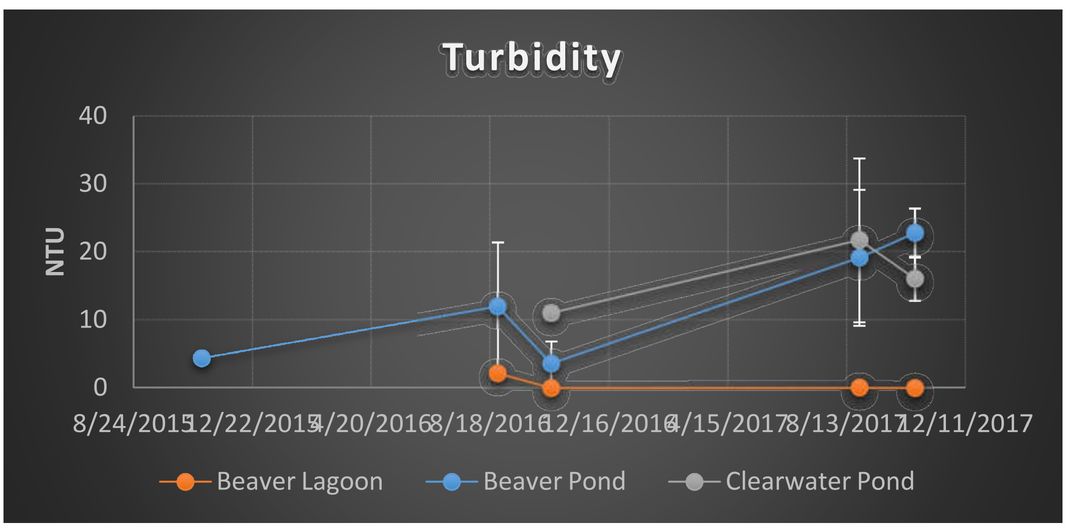

Figure 16: Turbidity recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) in 2015, 2016 and 2017.

iv) The measure of **pH** responds to the chemical balance of the elements present in the water that determine its acidic, neutral or basic conditions ([6]Sawyer *et al.*, 2003). The pH can be affected by various processes in an aquatic ecosystem. Changes in pH can in turn affect the chemistry and biology of the wetland, sometimes dramatically. When the pH is compared before and after the start of the SWCRR construction (2016-2017), no significant changes were detected for the Beaver Pond or Beaver Lagoon station (p>0.05). However there is a dramatic increase (figure 17) in the pH recorded for the Clearwater Pond in August 2017 (p<0.05).

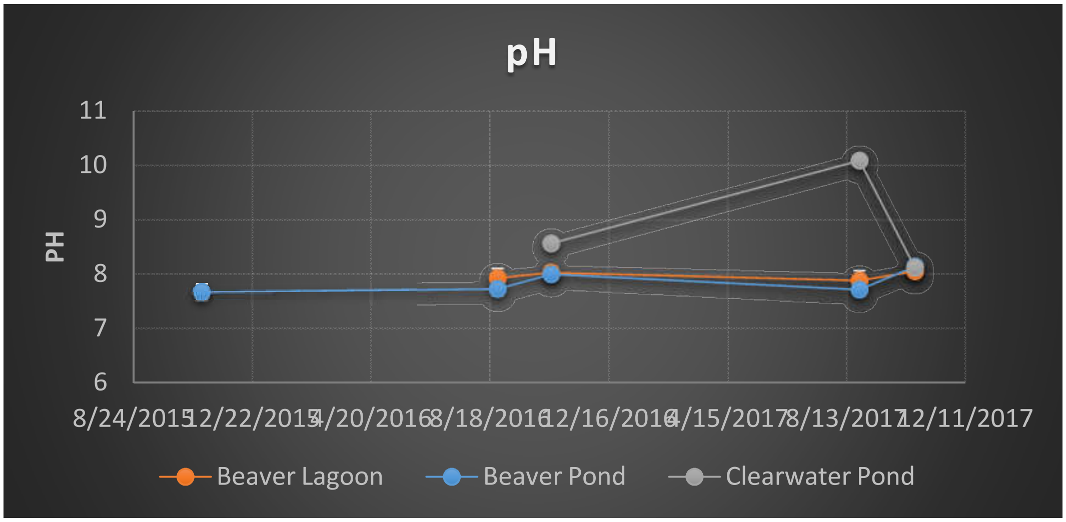

Figure 17: pH recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) in 2015, 2016 and 2017.

v) Phosphorus (fig 18) is one of the most important limiting nutrients in aquatic ecosystems ([6]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 that can cause fish and invertebrate mass mortality or decreased fertility.

No significant changes were detected (p>0.05) in the phosphate concentration or at the monitoring stations before and after the start of the SWCRR construction (2016-2017).

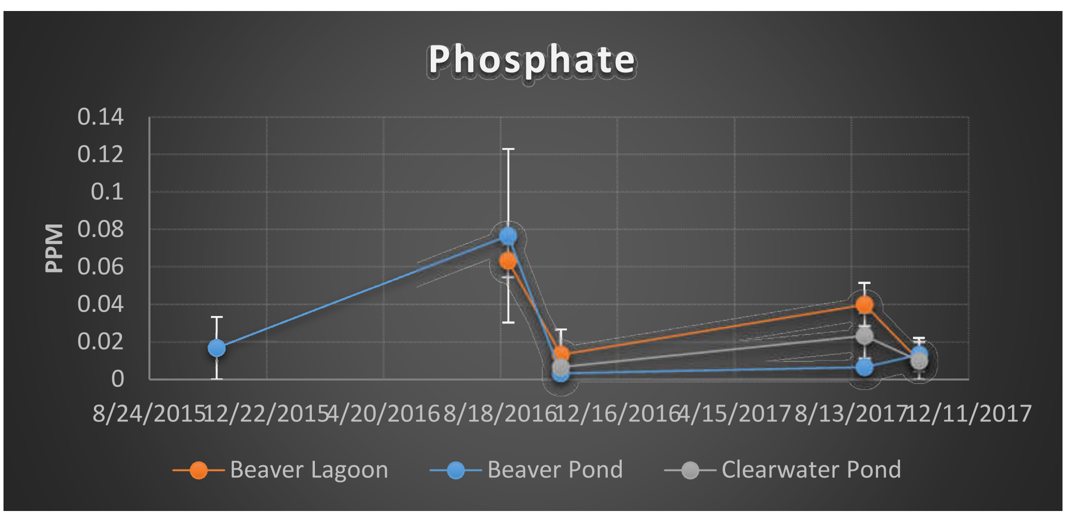

Figure 18: pH recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) in 2015, 2016 and 2017.

vi) No significant changes were detected (p>0.05) in **dissolved oxygen** saturation (figure 19) or **temperature** (figure 20) at the monitoring stations before and after the start of the SWCRR construction (2016-2017). However, a very low saturation of dissolved oxygen (23±2%) was recorded in the Beaver Pond in August 2017.

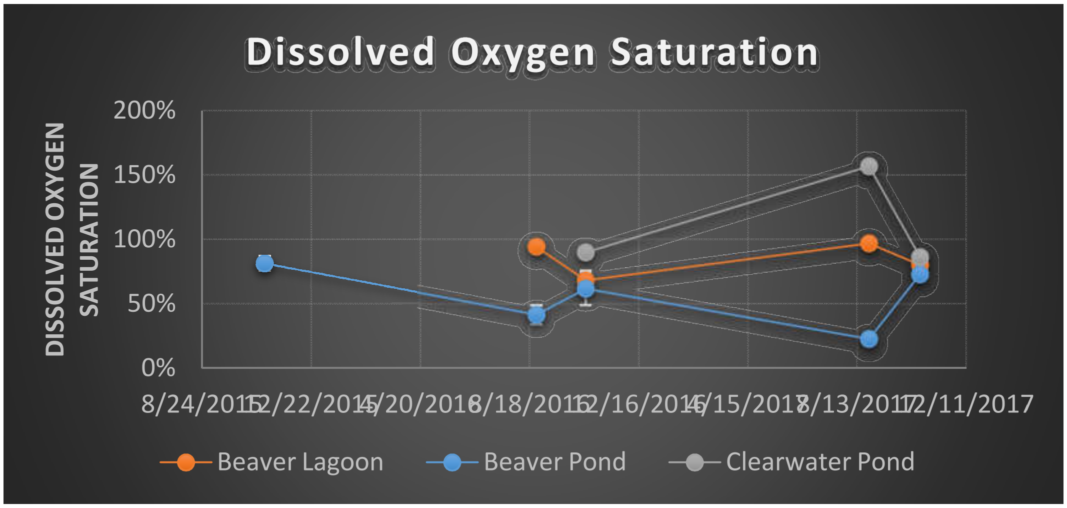

Figure 19: Dissolved oxygen (DO) recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) in 2015, 2016 and 2017.

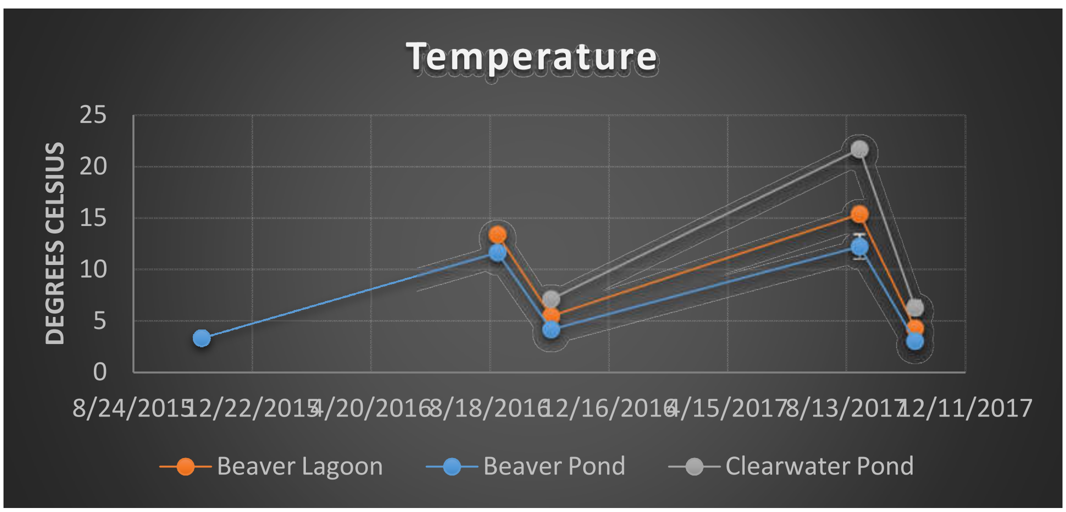

Figure 20: Temperature recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) in 2015, 2016 and 2017.

b. Aquatic macroinvertebrates

Aquatic macroinvertebrates are considered good indicators of water quality. These organisms are made up of species that occupy a broad range of trophic levels and pollution tolerances, thus providing robust information for interpreting cumulative effects ([7]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 ([7]EPA, 2017).

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

In August and October 2017, 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 (figures 11 and 12; table 14). The sampling sites were selected based on how well they represented local aquatic habitats and for their accessibility. 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. The location of the CP habitat in the Elbow River Valley but upstream from the SWCRR construction zone make it a good reference site for the Weaselhead monitoring campaign.

Table 14: Geographic coordinates for macro-invertebrate sampling sites.

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

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 2017 a total of 493 specimens were identified to 36 taxa for the habitats studied (BP, BL and CP). The 36 taxa identified represent the greatest taxonomic resolution achieved, consisting of 31 groups identified to genus/species levels and 5 groups identified to family/subfamily/ superfamily levels (tables 15 and 16).

i. Taxa Richness

The total taxa recorded do not represent 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 at each site. High taxa richness is associated with good water quality ([7]EPA, 2017).

When comparing taxa richness before and after the start of the SWCRR construction (represented by the 2016 and 2017 sampling campaigns respectively), no changes were recorded for the Beaver Lagoon and the Clearwater Pond ($p>0.05$). However the Beaver Pond experienced a significant drop in taxa richness in 2017 compared with 2016 (paired t test, df=5, $p<0.05$) (table 15 and figure 21).

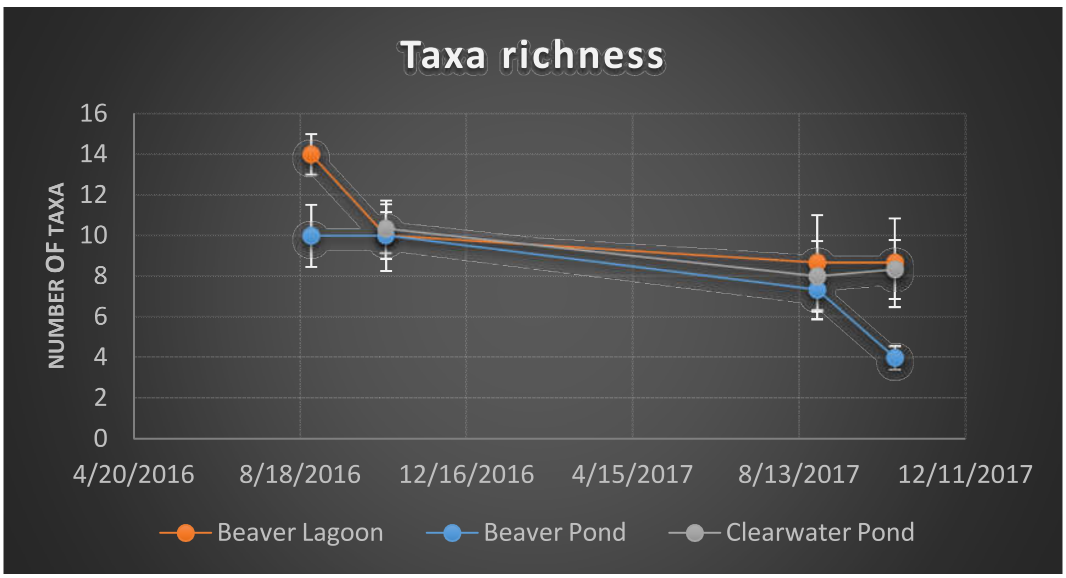

Figure 21: Taxa richness recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) in 2016 and 2017.

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 Simpson's Diversity Index before and after the start of the SWCRR construction (represented by the 2016 and 2017 sampling campaigns respectively), remained stable for the Beaver Lagoon and the Beaver Pond ($p>0.05$). However the Clearwater Pond experienced a significant increase in diversity in 2017 in relation to what was recorded in 2016 (paired t test, df=5, $p<0.05$) (table 11 and figure 22). This increase in diversity brought the Clearwater Pond to diversity values close to those of the other sampling stations (Beaver Pond and Lagoon).

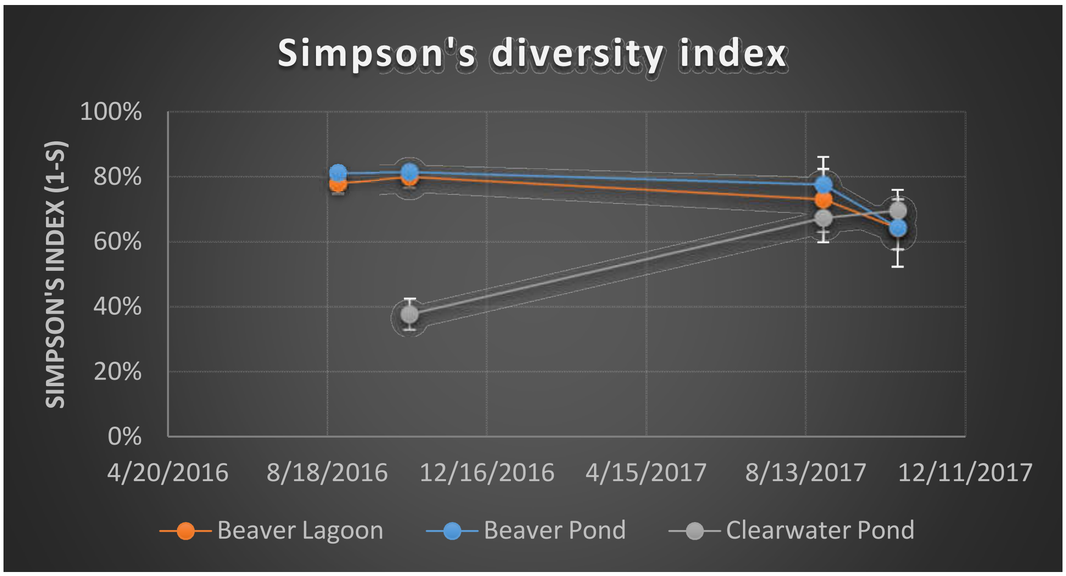

Figure 22: Simpson's Diversity Index recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) in 2016 and 2017.

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** taxa richness, is an example of such a parameter. The EPT group contain a relatively high proportion of species intolerant to water pollution.

No changes in EPT taxa % were recorded for the Beaver Lagoon and the Clearwater Pond between 2016 and 2017 ($p>0.05$). However as observed for taxa richness (paragraph i. above) the Beaver Pond experienced a significant drop in EPT taxa % in 2017 compared with 2016 (paired t test, df=5, $p<0.05$) (table 11 and figure 23). Of particular note is that no EPT taxa specimens were observed in the Beaver Pond during the 2017 sampling campaign despite their presence on the other station habitats (BL and CP) during the same period.

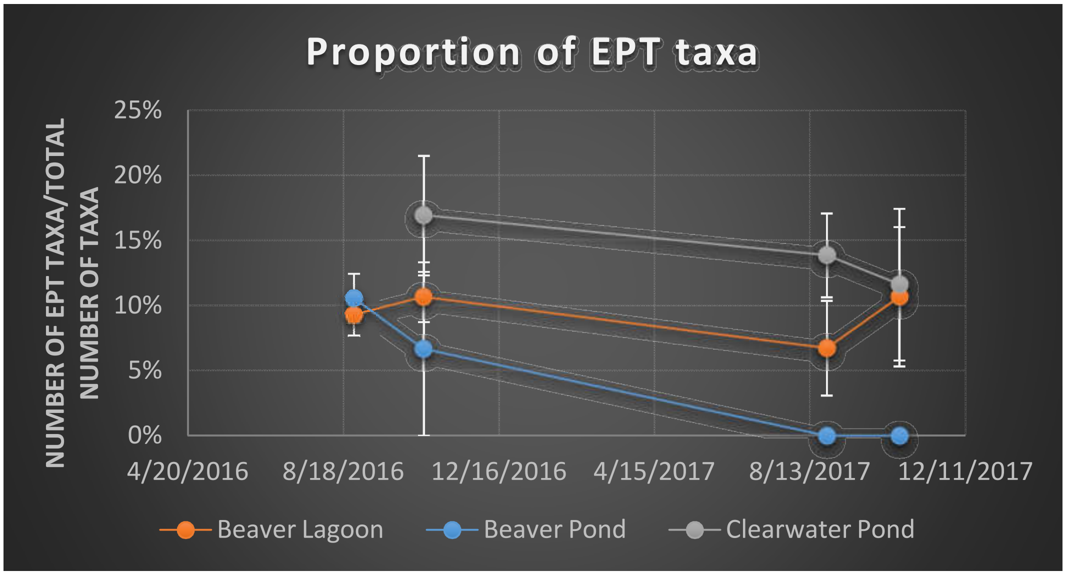

Figure 23: EPT taxa % recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) in 2016 and 2017.

Table 15: Aquatic macro-invertebrates statistics (average ± SEM) (n=3)

Water body	Site	Assessment Date	Taxa Richness per Site/Sample	Simpson's Diversity Index (1-S) per Site/Sample	% of EPT Taxa
Beaver Pond	**BP**	Aug. 26th 2017	7.3 (±1.5)	77.5% (±5.0%)	0.0% (±0.0%)
		Oct. 21st 2017	4.0 (±0.6)	64.4% (±6.7%)	0.0% (±0.0%)
Beaver Lagoon	**BL**	Aug. 26th 2017	8.7 (±2.3)	73.0% (±13.1%)	6.7% (±3.6%)
		Oct. 21st 2017	8.7 (±2.2)	64.2% (±11.8%)	10.7% (±5.4%)
Clearwater Pond	**CP**	Aug. 26th 2017	8.0 (±1.7)	67.3% (±4.3%)	13.9% (±3.2%)
		Oct. 21st 2017	8.3 (±1.5)	69.6% (±3.4%)	11.6% (±5.8%)

Figures 24 to 28: results from 2016 (pre-SWCRR construction phase) and 2017 (start of SWCRR construction phase) are compared in terms of relative proportion of aquatic invertebrate biological classes for the same site and period of the year.

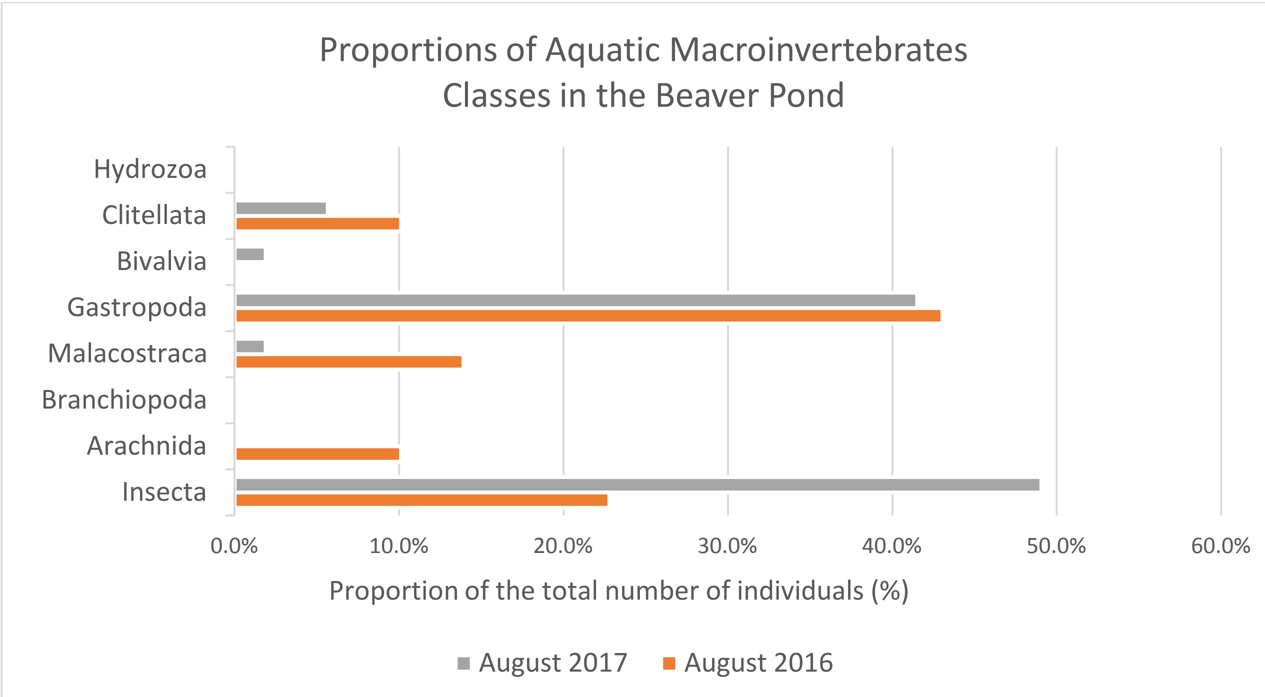

Figure 24: Relative abundance of macroinvertebrates classes in the Beaver Pond sample (August 2016- August 2017).

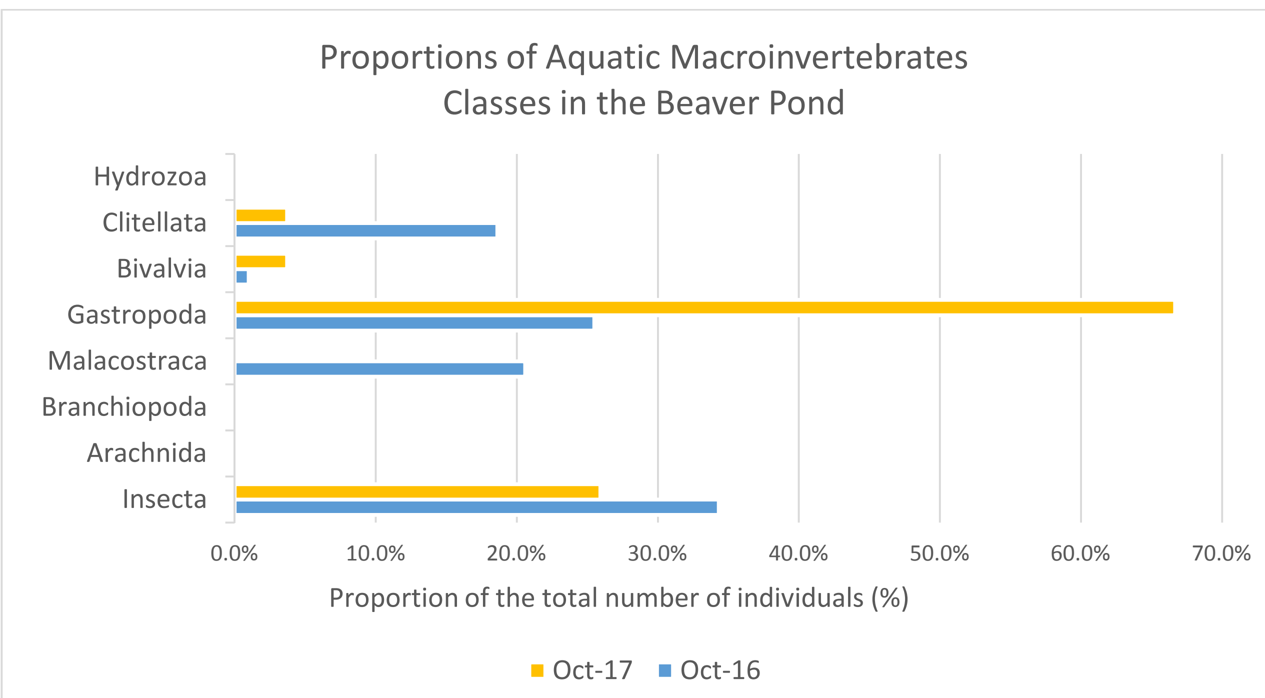

Figure 25: Relative abundance of macroinvertebrates classes in the Beaver Pond sample (October 2016- October 2017).

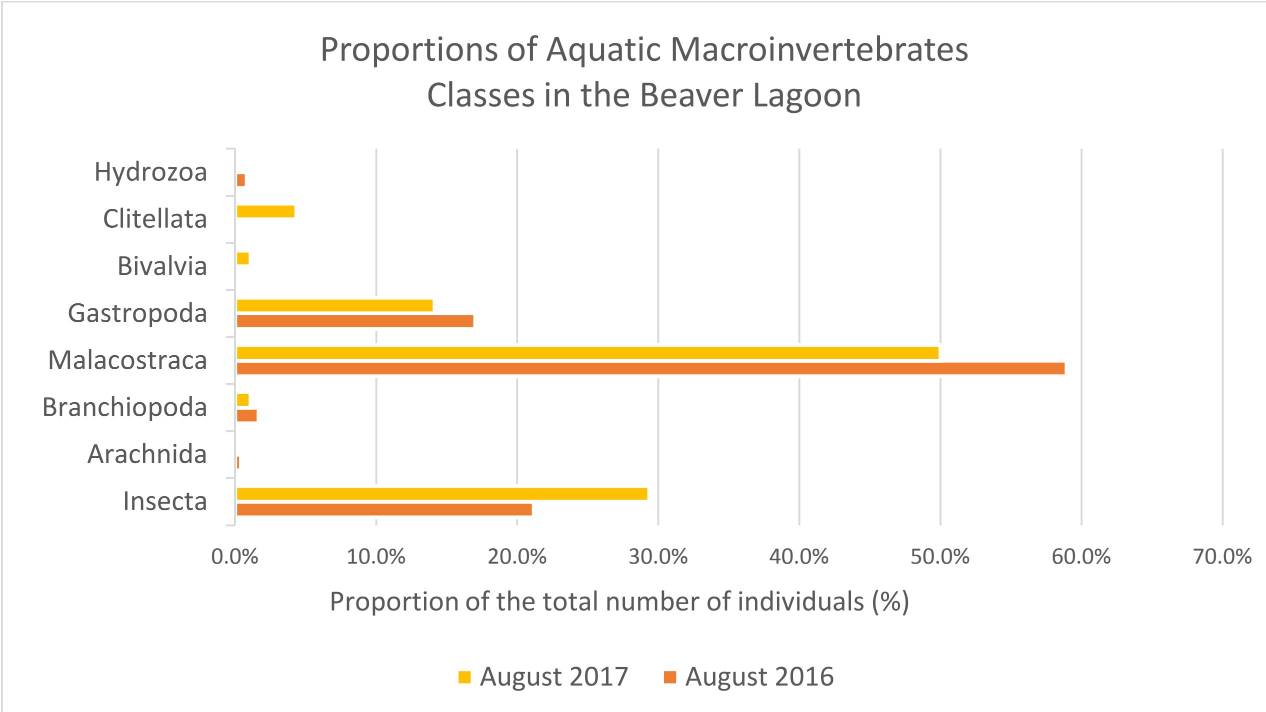

Figure 26: Relative abundance of macroinvertebrates classes in the Beaver Lagoon sample (August 2016-August 2017).

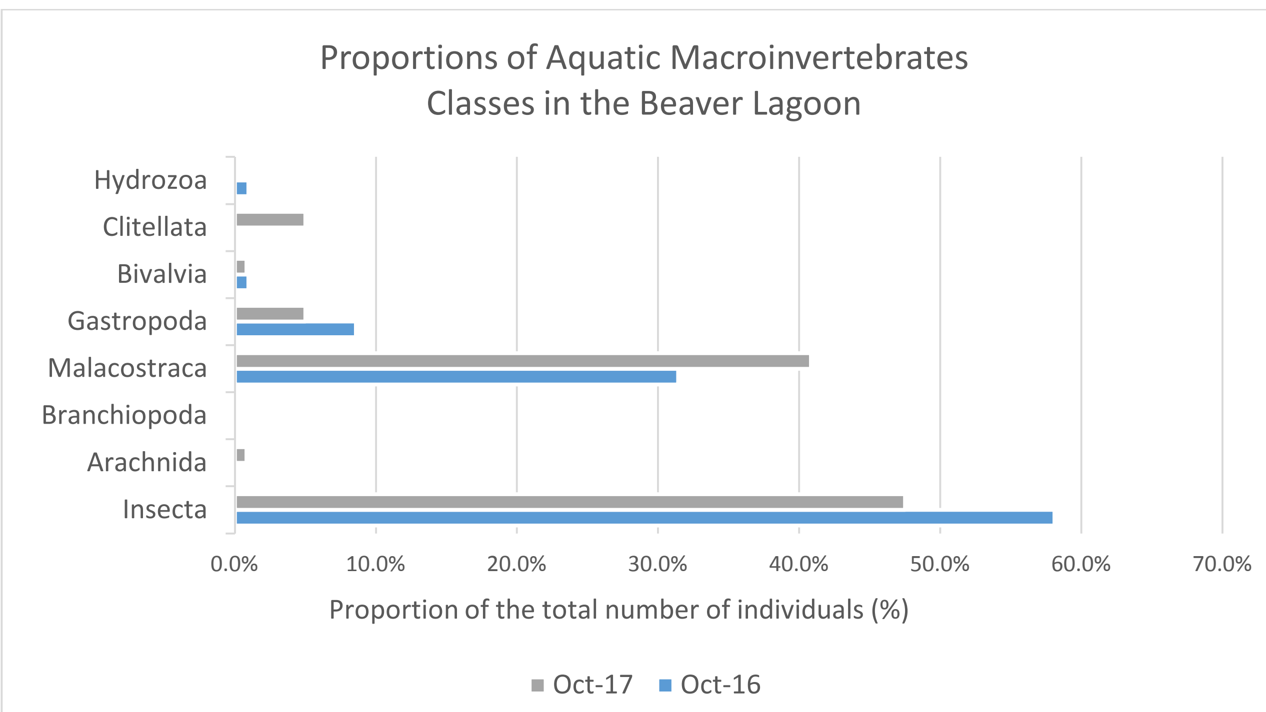

Figure 27: Relative abundance of macroinvertebrates classes in the Beaver Lagoon sample (October 2016-October 2017).

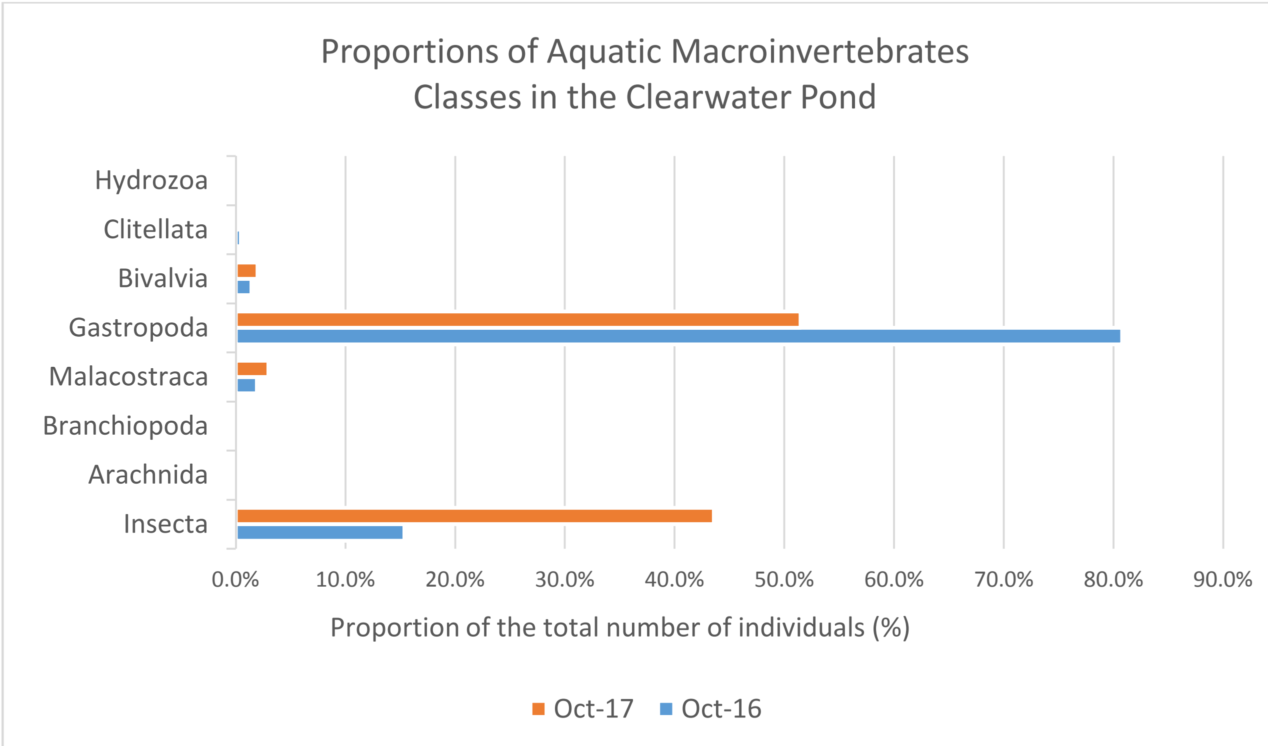

Figure 28: Relative abundance of macroinvertebrates classes in the Clearwater Pond sample (October 2016-October 2017).

Table 16: Taxonomic classification for the aquatic macroinvertebrates sampled on August 26th 2017.

				sampled in August 26th 2017												
				Taxa				**Beaver Pond**			**Beaver Lagoon**			**Clear Water - Control**		
Phylum	**Subphylum**	**Class**	**Subclass**	**Order**	**Suborder**	**Family/Group**	**Greatest Taxonomic Resolution Obtained**	**BP1**	**BP2**	**BP3**	**BL1**	**BL2**	**BL3**	**C1**	**C2**	**C3**
Arthropoda		**Insecta**		Ephemeroptera		Caenidae	*Caenis* sp. Stephens, 1835	0	0	0	0	0	0	1	0	0
						Baetidae	*Centroptilum* sp. Eaton 1869	0	0	0	5	0	0	0	0	0
				Trichoptera		Limnephilidae	*Anabolia* sp. Stephens, 1837	0	0	0	0	1	0	0	0	0
							Limnephilus sp. Leach in Brewster, 1815	0	0	0	0	0	0	0	0	2
						Phryganeidae	*Agrypnia* sp. Curtis, 1835	0	0	0	0	0	0	0	1	0
							Phryganea sp. Curtis, 1835	0	0	0	0	0	0	0	0	0
				Odonata	Zygoptera	Coenagrionidae	*Ischnura* sp. Charpentier, 1840	0	0	1	3	1	0	0	0	0
							Enallagma sp. Charpentier, 1840	0	0	0	0	0	0	0	2	0
					Epiprocta	Corduliidae	*Somatochlora* sp. Selys, 1871	1	1	0	0	0	0	0	0	0
						Aeshnidae	*Aeshna* sp. Fabricius, 1775	0	0	0	0	0	0	0	0	0
				Diptera		Dixidae	*Dixella* sp. Dyar & Shannon, 1924	0	0	0	0	0	0	0	1	0
						Chironomidae	Orthocladiinae	0	2	3	0	0	0	1	1	0
							Tanypodinae	0	0	0	0	0	0	0	0	0
						Culicidae	*Anopheles earlei* Vargas, 1943	0	0	0	1	0	0	0	0	0
						Tabanidae	*Tabanus* sp. Linnaeus, 1758	0	0	0	0	0	0	0	0	0
				Coleoptera		Dytiscidae	*Laccophilus* sp. Leach, 1815	0	0	0	0	1	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	0	0	0	0	0
							Ilybius sp. Erichson, 1832	0	0	0	0	0	0	0	0	0
							Hygrotus sp. Stephens 1828	1	0	0	0	0	3	0	0	0
							Agabus sp. Leach, 1817	0	0	0	0	0	0	0	0	0
							Liodessus sp. Guignot, 1939	0	0	0	0	2	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	0	0	1	3	1
						Gyrinidae	*Gyrinus* sp. Geoffroy, 1762	0	0	0	0	0	0	0	0	0
				Hemiptera	Heteroptera	Corixidae	Corixidae	7	0	9	3	0	3	22	2	2
						Notonectidae	*Notonecta* sp. Linnaeus, 1758	1	0	0	0	3	0	0	1	0
						Belostomatidae	*Lethocerus americanus* (Leidy, 1847)	0	0	0	0	0	0	0	0	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
				Laevicaudata		Lynceidae	*Lynceus* sp. Müller, 1776	0	0	0	0	1	0	0	0	0
		Malacostraca		Amphipoda		Gammaridae	*Gammarus lacustris* G.O. Sars, 1864	0	0	0	2	4	25	0	0	0
						Hyalellidae	*Hyalella azteca* (Saussure, 1858)	0	1	0	5	8	2	2	2	0
Mollusca		**Gastropoda**				Physidae	*Physa* sp. Draparnaud, 1801	2	2	0	3	3	2	2	3	4
						Lymnaidae	*Fossaria* sp.	0	0	0	0	0	0	1	0	0
							Lymnaea stagnalis Linnaeus 1758	0	0	0	0	0	0	0	0	0
							Stagnicola sp. Jeffreys, 1830	1	3	0	0	4	0	0	0	0
						Hydrobiidae	*Probythinella lacustris* (F. C. Baker, 1928)	0	0	0	0	0	0	0	0	0
						Planorbidae	*Gyraulus crista* (Linnaeus, 1758)	1	0	0	0	0	0	0	0	0
							Planorbula campestris (Dawson, 1875)	0	1	0	0	0	0	0	0	0
							Promenetus umbilicatellus (Cockerell, 1887)	4	3	5	0	1	0	16	15	12
		Bivalvia		Veneroidea		Sphaeriidae	*Pisidium* sp. Pfeiffer, 1821	0	0	1	0	1	0	0	0	0
Annelida		**Clitellata**	**Hirudinea**	Rhynchobdellida		Glossiphoniidae	*Glossiphonia complanata* (Linnaeus, 1758)	2	0	0	0	0	0	0	2	0
				Arhynchobdellida		Erpobdellidae	*Dina* sp. Blanchard, 1892	1	0	0	0	0	0	0	0	0
			Oligochaeta	Haplotaxida		Naididae	Naididae	0	0	0	0	4	0	0	0	0
				Lumbriculida		Lumbriculidae	Lumbriculidae	0	0	0	0	0	0	0	0	0
Cnidaria		**Hydrozoa**		Anthomedusae		Hydridae	*Hydra* sp. Linnaeus, 1758	0	0	0	0	0	0	0	0	0

Table 17: Taxonomic classification for the aquatic macroinvertebrates sampled on October 21st 2017.

				sampled in October 21st 2017												
		Taxa						Beaver Pond			Beaver Lagoon			Clear Water - Control		
Phylum	**Subphylum**	**Class**	**Subclass**	**Order**	**Suborder**	**Family/Group**	**Greatest Taxonomic Resolution Obtained**	**BP1**	**BP2**	**BP3**	**BL1**	**BL2**	**BL3**	**C1**	**C2**	**C3**
Arthropoda		**Insecta**		Ephemeroptera		Caenidae	*Caenis* sp. Stephens, 1835	0	0	0	0	0	0	0	2	0
						Baetidae	*Centroptilum* sp. Eaton 1869	0	0	0	27	10	0	0	0	0
				Trichoptera		Limnephilidae	*Anabolia* sp. Stephens, 1837	0	0	0	0	0	0	0	0	0
							Limnephilus sp. Leach in Brewster, 1815	0	0	0	0	0	0	0	0	2
						Phryganeidae	*Agrypnia* sp. Curtis, 1835	0	0	0	0	0	0	0	0	0
							Phryganea sp. Curtis, 1835	0	0	0	0	2	0	0	1	0
				Odonata	Zygoptera	Coenagrionidae	*Ischnura* sp. Charpentier, 1840	0	0	0	0	0	0	0	0	0
							Enallagma sp. Charpentier, 1840	0	0	0	0	0	0	1	2	0
					Epiprocta	Corduliidae	*Somatochlora* sp. Selys, 1871	0	0	0	0	0	0	0	0	0
						Aeshnidae	*Aeshna* sp. Fabricius, 1775	0	0	0	0	0	0	0	0	0
				Diptera		Dixidae	*Dixella* sp. Dyar & Shannon, 1924	0	0	0	0	0	0	0	0	0
						Chironomidae	Orthocladiinae	0	0	0	0	3	0	1	2	0
							Tanypodinae	0	0	0	0	0	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	0	0	0	0	0	0	0
				Coleoptera		Dytiscidae	*Laccophilus* sp. Leach, 1815	0	0	1	0	0	1	0	0	0
							Graphoderus occidentalis Horn, 1883	0	0	0	0	0	0	0	0	0
							Potamonectes sp. Zimmermann, 1921	0	0	0	0	0	0	0	0	0
							Ilybius sp. Erichson, 1832	0	0	0	0	0	0	0	0	0
							Hygrotus sp. Stephens 1828	0	0	0	0	0	1	0	0	0
							Agabus sp. Leach, 1817	0	0	0	0	0	0	0	0	0
							Liodessus sp. Guignot, 1939	0	0	0	0	0	0	0	0	0
							Coptotomus sp. Say, 1830	0	0	0	0	0	0	0	0	0
						Haliplidae	*Haliplus* sp. Latreille, 1802	0	1	0	1	0	0	1	3	1
						Gyrinidae	*Gyrinus* sp. Geoffroy, 1762	0	3	0	0	2	0	0	0	0
				Hemiptera	Heteroptera	Corixidae	Corixidae	2	0	0	1	0	3	23	1	3
						Notonectidae	*Notonecta* sp. Linnaeus, 1758	0	0	0	0	6	0	0	1	0
						Belostomatidae	*Lethocerus americanus* (Leidy, 1847)	0	0	0	0	0	0	0	0	0
		Arachnida	**Acari**	Trombidiformes	Prostigmata	Hydrachnidia	Hydrachnidia	0	0	0	0	1	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
				Laevicaudata		Lynceidae	*Lynceus* sp. Müller, 1776	0	0	0	0	0	0	0	0	0
		Malacostraca		Amphipoda		Gammaridae	*Gammarus lacustris* G.O. Sars, 1864	0	0	0	7	1	24	0	0	0
						Hyalellidae	*Hyalella azteca* (Saussure, 1858)	0	0	0	11	4	2	2	1	0
Mollusca		**Gastropoda**				Physidae	*Physa* sp. Draparnaud, 1801	0	0	0	0	1	1	2	3	3
						Lymnaidae	*Fossaria* sp.	0	0	1	0	0	0	1	0	1
							Lymnaea stagnalis Linnaeus 1758	0	0	0	1	0	0	0	0	0
							Stagnicola sp. Jeffreys, 1830	0	0	0	0	1	1	0	0	0
						Hydrobiidae	*Probythinella lacustris* (F. C. Baker, 1928)	0	0	0	0	0	0	0	0	0
						Planorbidae	*Gyraulus crista* (Linnaeus, 1758)	0	0	0	0	0	0	0	0	0
							Planorbula campestris (Dawson, 1875)	1	0	8	0	0	0	0	0	0
							Promenetus umbilicatellus (Cockerell, 1887)	2	1	5	0	1	0	17	15	10
		Bivalvia		Veneroidea		Sphaeriidae	*Pisidium* sp. Pfeiffer, 1821	1	0	0	0	1	0	0	2	0
Annelida		**Clitellata**	**Hirudinea**	Rhynchobdellida		Glossiphoniidae	*Glossiphonia complanata* (Linnaeus, 1758)	0	0	0	0	0	0	0	0	0
				Arhynchobdellida		Erpobdellidae	*Dina* sp. Blanchard, 1892	0	0	0	0	0	0	0	0	0
			Oligochaeta	Haplotaxida		Naididae	Naididae	0	0	0	0	6	0	0	0	0
				Lumbriculida		Lumbriculidae	Lumbriculidae	1	0	0	0	0	0	0	0	0
Cnidaria		**Hydrozoa**		Anthomedusae		Hydridae	*Hydra* sp. Linnaeus, 1758	0	0	0	0	0	0	0	0	0

FINAL CONSIDERATIONS

The *Environmental Monitoring Report 2017* represents the first opportunity to compare the baseline environmental conditions acquired in 2016 with the results obtained after the start of the SWCRR construction phase. As more data is acquired in coming years the impact of the SWCRR and the success or otherwise of mitigation measures adopted during construction and the operational phase can be evaluated. To ensure results are comparable future surveys should employ the same sampling and analytical methods presented here. The success of this monitoring effort depends on the continuation of this Impact Study over the construction phase and into the operational phase of the SWCRR.

Although a correlation between the timing of the SWCRR phases and alterations observed in the Weaselhead's ecosystems may be evident, it is significantly more difficult to detect direct evidence of causality. A reference site (like the Clearwater Pond), can be useful to eliminate the effects of some confounding factors in the interpretation of the data. However changes observed in the environmental indicators when comparing results over different years might still be associated with differences in seasonal weather conditions (or even natural population fluctuations). Often the monitoring results are likely only to suggest, rather than prove, an association with the SWCRR construction and operation. However even without direct evidence of causality any negative impacts identified by the Impact Study should be investigated as they are noticed and possible remedial action determined.

The following discussions are based on the statistically significant ($p<0.05$) changes found when comparing 2016 and 2017 results:

Terrestrial Habitats

The results revealed **a significant increase in noise pollution levels** in the Weaselhead Park in July 2017 when compared to July 2016. This result is consistent with the general perception of the public ([9]Weaselhead Social Study 2017), and is undoubtedly related to the SWCRR construction activities adjacent to the park. During Summer 2017 machinery at work and construction traffic could clearly be seen and heard from within the park boundaries.

Some bird species can be vulnerable to the noise pollution including that associated with the construction and operation of roads ([3]McClure et al., 2013). Although the results suggest that the SWCRR construction has transformed the Weaselhead area into a noisier environment in 2017, the breeding bird survey hasn't detected any significant adverse effects on breeding bird species diversity or density for that year. However, it is important to persist in monitoring breeding birds to detect any early signs of local loss of diversity. This is particularly relevant for species listed as threatened or sensitive such as the Common Yellowthroat (*Geothlypis trichas*), which was recorded in 2016, but not found in the 2017 survey.

The year of 2017 can be considered a dry year, with a total accumulated precipitation 22% below the average values for the Calgary area ([8]Weather Network, 2018). This likely influenced the hydrology of the Weaselhead area. As seen in figure 29, the Beaver Pond had extremely low water levels in the Summer and Fall 2017. These dry conditions may explain the observed **increase in plant species density in its riparian zone** in 2017. In normal years, the riparian zone at the Beaver Pond has a soil saturated with water or it is even temporally partially submerged. This excess of water is an obstacle for many species of plants and favours survival of specially adapted plants (aquatic or hydrophilic species). The dry conditions in 2017 by displacing the saturated soil zone towards the center of the pond may have allowed the colonization of the riparian zone by other species of plants. This process, however, is not necessarily desirable from the point of view of plant species conservation. The hydrophilic plants group, often containing rare or sensitive species, may lose space to other generalist (and more common) plant species.

Figure 29: Low water level at the Beaver Pond in September 23rd 2017.

Aquatic Habitats

The relatively lower precipitation regime of 2017 may also explain the **higher electric conductivity measured in the Beaver Pond** when compared to 2016. Low precipitation and reduced inflow of surface water from the two creeks that feed into the Beaver Pond could mean that water lost by evapotranspiration in the hydrological system was not being replaced, concentrating the dissolved solids in the water column. This is supported by the fact that the

Clearwater Pond, a reference site, also presented higher conductivity levels in 2017 when compared to 2016.

When the Beaver Pond was reduced to a shallow channel (figure 22), the high loss of water by evapotranspiration associated with low replacement by precipitation, may also have contributed to an increase of the organic matter concentration in the water column. The aerobic decomposition of this organic matter might explain the low dissolved oxygen concentration readings in the Beaver Pond for 2017 (during August 2017 an average dissolved oxygen saturation of 23% was recorded).

The low dissolved oxygen concentration in the Beaver Pond during 2017 makes the pond an inhospitable habitat for many species of invertebrates and fish. This condition is very likely one of the main reasons for the **significant drop in the aquatic invertebrate taxa richness measured in 2017** in the pond when compared to 2016. Furthermore, **the % of EPT (mayflies, stoneflies and caddisflies) taxa richness also decreased significantly** in the Beaver Pond during this period. It is important to note that the EPT taxa are frequently chosen as a bioindicator parameter because many organisms from this group are known to be sensitive to pollution and low dissolved oxygen. Although present in the Beaver Pond in 2016, no specimens of the EPT group were found in the 2017 sampling campaigns in this habitat. Specimens of the EPT group were found in both the Beaver Lagoon and Clearwater Pond in 2017. No significant drop in taxa richness or % EPT taxa was observed in the Beaver Lagoon or the Clearwater Pond in the 2016-2017 period. This suggests that the aquatic invertebrates in the Beaver Pond were under an environmental stress that was not found in the other habitats during the same period. Changes in local hydrological conditions or in the Beaver Pond's mass balance of sediments or nutrients might explain this event.

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