Weaselhead/Glenmore Park
SWCRR Impact Study 2016-2023

Environmental Monitoring Report 2018

Part I: birds, noise, vegetation, wildlife movement, water quality, aquatic invertebrates, amphibians, fish.

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INTRODUCTION

Construction of the South West Calgary Ring Road (SWCRR) started in fall 2016. The project's EIA[1] (Environmental Impact Assessment) predicted 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, a seven year study spanning the years from initiation to completion of the road that would quantify the SWCRR's impacts on biophysical components of the park and on park-users. The objective of the biophysical part of the Study is not to attempt a comprehensive survey of habitats and ecosystem components and their change over the period of the study, but to assess the impacts of the SWCRR on selected environmental indicators, and compare these with those predicted in the EIA[1] (carried out by AMEC in 2006, updated in 2014).

The 2016 report described conditions in the study area prior to the landscape alterations required by construction of the SWCRR, the 2017 described conditions at the start of the construction phase, and this 2018 report describes conditions during the second year of construction. Figure 1 shows a satellite image of the Weaselhead and TUC (Transportation Utility Corridor) before construction of the road started and figure 2 the same area two years later in Oct. 2018. Major work completed in 2018 included diversion of the Elbow River into a new man-made channel, filling in of the old river channel, and construction of 3 parallel bridges to carry the northbound carriageway and southbound carriageway of the SWCRR, and the local road across the river.

When contrasted with the baseline conditions of 2016 the 2017 and 2018 conditions offer insights into the potential effects of the SWCRR on the adjacent ecosystems. Data from 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. These are discussed in the final section of the report '*Final Considerations*'. By continuing to collect data until 2023 (when the SWCRR will be in operation) the Study will allow an objective evaluation of road's environmental effects and of the success of mitigation measures (detailed in the construction company's contract with Alberta Transport). These data will allow the Society to present arguments for improved mitigation if required based upon verifiable and scientific data. The Society hopes that this long-term study will also help improve global road mitigation efforts as there are few studies of road impacts that include baseline data, cover the construction period and continue monitoring into the operational period, and thus allow direct comparison between conditions before and after road construction.

Figure 1: satellite image Sept. 2016 before major construction began *(downloaded from GoogleEarth);* orange line shows Weaselhead boundary; scale: white line = 500m

Figure 2: Satellite image of Study site from Oct. 2018, two years after the start of construction. Weaselhead boundary shown by orange line; scale: white line = 500m; SWCRR construction site visible to west with new river channel and three bridge decks visible, Glenmore Reservoir to east; *(downloaded from GoogleEarth)*

1. RESULTS: TERRESTRIAL HABITATS

a. Breeding Bird Survey

In 2018 the breeding bird survey was conducted using the same protocol and study design as in 2016 and 2017, and as the EIA[1]. In order to produce comparable results period of the year, location of survey stations, and times of observation were also kept constant. Similar weather conditions pertained: low to no wind, clear skies, temperature 10˚C-17˚C, and no precipitation.

On July 8th 2018, three groups of volunteers carried out the survey, each group visiting a different set of sites (see Fig. 3). 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 each pre-determined station, located with GPS.
- Upon arrival at each station 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 28 stations in total 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).

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

Figure 3: location of breeding bird survey points *(scale: white line = 500m)*

During the 2018 bird survey 453 individuals and 44 species were identified (a table showing the raw data is available in appendix I; summaries are shown in tables 2 and 3). The total Simpson’s diversity index for the breeding bird survey was high (1-S = 90.97%). However given the high number of unidentified species observed in 2018, the data was not considered robust enough to allow an accurate estimation of species density as performed in previous years.

As in 2016 and 2017, the 2018 survey found a significant linear regression slope ($p<0.05$) between the cumulative number of different species and the cumulative area investigated. The 2018 survey species per area regression follows the general function: $CS=0.40A+11.5$ ($R^2=0.9567$), 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 0.40 “new” species were recorded with each additional hectare surveyed. It is important to note that the linear relationship between the variables considered was only observed within the interval of area studied (particularly between 10 and 80 hectares). A non-linear relationship is expected beyond this interval at both ends; hence an extrapolation of this linear relationship is unlikely to produce realistic outcomes (see fig. 4).

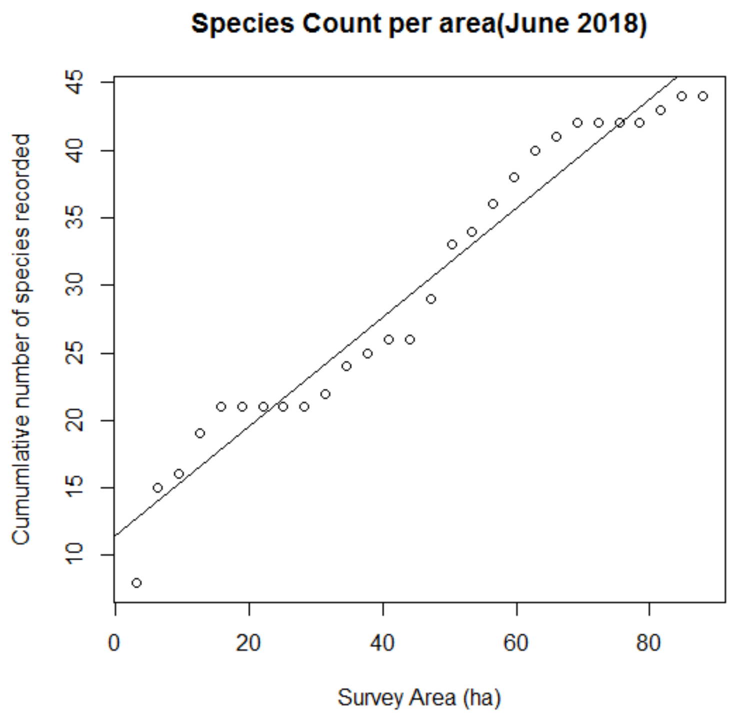

Figure 4: Regression model between cumulative number of species recorded and area, increasing in increments of 3.14ha (= area of a 100m-radius circle around stations, in which area observations were made)

Table 2: Breeding bird survey species list (July 8th, 2018) with total individual counts *(*birds listed as 'sensitive' by AEP[2] 2015)*

Common Name	Species Name	Total Count
American Crow	*Corvus brachyrhynchos*	6
American Goldfinch	*Spinus tristis*	6
American Robin	*Turdus migratorius*	13
American Wigeon	*Mareca americana*	0
Bald Eagle	*Haliaeetus leucocephalus*	0
Baltimore Oriole*	*Icterus galbula*	0
Belted Kingfisher	*Megaceryle alcyon*	0
Black billed Magpie	*Pica hudsonia*	1
Black-capped Chickadee	*Poecile atricapillus*	50
Boreal Chickadee	*Poecile hudsonicus*	0
Brewer's Blackbird	*Euphagus cyanocephalus*	0
Brown Thrasher	*Toxostoma rufum*	0
Brown-headed Cowbird	*Molothrus ater*	2
Calliope Hummingbird	*Selasphorus calliope*	0
Canada Goose	*Branta canadensis*	25
Cedar Waxwing	*Bombycilla cedrorum*	21

Chipping Sparrow	*Spizella passerina*	*6*
Clay-colored Sparrow	*Spizella pallida*	*17*
Cliff Swallow	*Petrochelidon pyrrhonota*	*108*
Common Goldeneye	*Bucephala clangula*	*1*
Common Raven	*Corvus corax*	*1*
Common Yellowthroat*	*Geothlypis trichas*	*0*
Dark-eyed Junco	*Junco hyemalis*	*5*
Double-crested Cormorant	*Phalacrocorax auritus*	*0*
Downy Woodpecker	*Picoides pubescens*	*7*
Franklin's Gull	*Leucophaeus pipixcan*	*1*
Gadwall	*Mareca strepera*	*0*
Gray Catbird	*Dumetella carolinensis*	*4*
Great Horned Owl	*Bubo virginianus*	*0*
Hairy Woodpecker	*Leuconotopicus villosus*	*2*
Hermit Thrush	*Catharus guttatus*	*0*
House Finch	*Haemorhous mexicanus*	*0*
House Wren	*Troglodytes aedon*	*13*
Killdeer	*Charadrius vociferus*	*0*
Least Flycatcher*	*Empidonax minimus*	*11*
Lincoln's Sparrow	*Melospiza lincolnii*	*2*
Mallard	*Anas platyrhynchos*	*5*
Merlin	*Falco columbarius*	*1*
Northern Flicker	*Colaptes auratus*	*2*
North. Rough-Winged Swallow	*Stelgidopteryx serripennis*	*3*
Northern Waterthrush	*Parkesia noveboracensis*	*0*
Olive-sided Flycatcher*	*Contopus cooperi*	*1*
Osprey	*Pandion haliaetus*	*2*
Ovenbird	*Seiurus aurocapilla*	*0*
Pileated Woodpecker*	*Hylatomus pileatus*	*0*
Pine Siskin	*Spinus pinus*	*0*
Red-breasted Nuthatch	*Sitta canadensis*	*12*
Red-eyed Vireo	*Vireo olivaceus*	*3*
Red-necked Grebe	*Podiceps grisegena*	*0*
Red-winged Blackbird	*Agelaius phoeniceus*	*12*
Ring-necked pheasant	*Phasianus colchicus*	*0*
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	*0*
Ruby-crowned kinglet	*Regulus calendula*	*0*
Ruddy Duck	*Oxyura jamaicensis*	*0*
Savannah Sparrow	*Passerculus sandwichensis*	*0*
Song Sparrow	*Melospiza melodia*	*7*
Sora*	*Porzana carolina*	*0*
Spotted Sandpiper	*Actitis macularius*	*3*
Spotted Towhee	*Pipilo maculatus*	*0*
Tree Swallow	*Tachycineta bicolor*	*10*
Unknown Gull Species		*2*
Unknown Hummingbird Species		*1*
Unknown Sparrow Species		*5*
Unknown Swallow Species		*5*
Unkown Thrush Species		*1*
Unkown Warbler Species		*1*
Veery	*Catharus fuscescens*	*13*

Warbling Vireo	*Vireo gilvus*	*0*
Western Wood Peewee*	*Contopus sordidulus*	*0*
White Throated Sparrow	*Zonotrichia albicollis*	*36*
White-breasted Nuthatch	*Sitta carolinensis*	*8*
Wilson's Snipe	*Gallinago delicata*	*0*
Wilson's Warbler	*Cardellina pusilla*	*0*
Winter Wren	*Troglodytes hiemalis*	*0*
Yellow-bellied Sapsucker	*Sphyrapicus varius*	*2*
Yellow Warbler	*Setophaga petechia*	*16*
	TOTAL	***453***

Table 3: Breeding bird survey (July 8th, 2018) – birds observed flying overhead or further than 100m from survey points

Other >100m		
Bald Eagle	*Haliaeetus leucocephalus*	*2*
Canada Goose	*Branta canadensis*	*2*
Common Goldeneye	*Bucephala clangula*	*1*
Common Merganser	*Mergus merganser*	*1*
Franklin's Gull	*Leucophaeus pipixcan*	*6*
Great Horned Owl	*Bubo virginianus*	*1*
Song Sparrow	*Melospiza melodia*	*1*
Incidentals/Flyovers		
American Crow	*Corvus brachyrhynchos*	*4*
American Golfinch	*Spinus tristis*	*6*
American Robin	*Turdus migratorius*	*4*
Bald Eagle	*Haliaeetus leucocephalus*	*1*
Black Capped Chickadee	*Poecile atricapillus*	*4*
Brown headed Cowbird	*Molothrus ater*	*1*
Cedar Waxwing	*Bombycilla cedrorum*	*2*
Cliff Swallow	*Petrochelidon pyrrhonota*	*4*
Common Goldeneye	*Bucephala clangula*	*1*
Dark-eyed Junco	*Junco hyemalis*	*2*
Double-crested Cormorant	*Phalacrocorax auritus*	*1*
Downy Woodpecker	*Picoides pubescens*	*3*
Franklin's Gull	*Leucophaeus pipixcan*	*3*
Gray Catbird	*Dumetella carolinensis*	*1*
Osprey	*Pandion haliaetus*	*4*
Red winged Blackbird	*Agelaius phoeniceus*	*3*
Spotted Sandpiper	*Actitis macularius*	*2*
Tree Swallow	*Tachycineta bicolor*	*1*
Unknown Gull Species		*9*
White Throated Sparrow	*Zonotrichia albicollis*	*1*

Species of 'sensitive' status ([2]Alberta Environment and Parks, 2015) that were recorded in past years but not recorded in 2018 included:

- Recorded in 2016 and 2017: Pileated Woodpecker and Western Wood-peewee
- Recorded in 2017 only: Sora and Baltimore Oriole
- Recorded in 2016 only : Common Yellowthroat

Although not observed during the 2018 survey these species were present in the Weaselhead Park during June 2018 according to eBird Basic Dataset (2019)[3]

b. Noise pollution

Because some bird species can be particularly vulnerable to noise pollution such as is associated with construction and operation of roads ([4]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 12th and 13th of July 2018. Levels were measured at the same points (stations) as used in the breeding bird survey (table 1, fig. 3). On each site, the sound level was measured for 2 minutes. The results are shown in table 4. *(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.)*

The recordings from 2018 may have been affected by additional construction occurring in North Glenmore Park near survey points P17 and P18 as part of the Cities storm sewage upgrade.

Table 4: Sound pressure measured in peak traffic hours for 2018 (minimum, maximum, average and peak)

Site	Time UTC-6	Sound Pressure (dB)			
		Min	Max	Aver.	Peak
P1	9:02	45.71	47.43	46.57	62.37
P2	8:50	42.25	43.16	42.70	57.33
P3	16:25	37.76	40.20	38.98	55.06
P4	n/a	n/a	n/a	n/a	n/a
P5	8:37	44.90	45.90	45.40	59.40
P6	17:26	36.21	38.07	37.14	56.82
P7	17:33	35.68	38.01	36.85	54.45
P8	17:46	36.19	39.76	37.98	57.02
P9	17:58	41.92	47.65	44.79	63.73
P10	17:10	39.23	45.12	42.18	62.88
P11	16:57	35.68	37.10	36.39	51.42
P12	9:35	35.98	37.70	36.84	52.58
P13	9:23	38.48	41.63	40.05	56.26
P14	18:32	37.16	41.65	39.40	56.25
P15	16:39	36.87	39.49	38.18	59.13
P16	16:12	43.68	46.38	45.03	61.52

P17	9:09	45.35	47.37	46.36	60.50
P18	9:20	36.75	39.87	38.31	58.32
P19	7:50	46.18	47.86	47.02	60.80
P20	8:05	44.04	47.20	45.62	59.79
P21	18:06	36.73	42.81	39.77	58.51
P22	7:43	45.85	47.82	46.84	61.26
P23	7:32	47.32	50.63	48.97	63.82
P24	7:21	45.40	46.99	46.20	59.66
P25	7:08	45.47	47.24	46.36	60.63
P26	8:27	43.13	44.92	44.03	58.17
P27	6:58	43.04	43.91	43.47	56.53
P28	6:42	45.70	49.29	47.49	66.69
mean		41.2	43.9	42.6	58.9
sd		4.2	4.0	4.0	3.5

When compared to 2016 results (figure 5), the ambient noise in the Weaselhead became significantly higher during the SWCRR construction phase in 2017 for minimum, average, maximum and peak decibel levels (paired t tests, df= 28, p<0.05). In 2018 a significant drop in average, maximum and peak sound levels was recorded when compared to 2017 levels (paired t tests, df= 27, p<0.05). No significant difference of minimum sound levels was detected in 2018 for the sites when compared to 2017 (paired t tests, df= 27, p>0.05). The minimum sound levels registered in 2018 remained significantly higher than the baseline values of 2016 (paired t tests, df= 27, p<0.05).

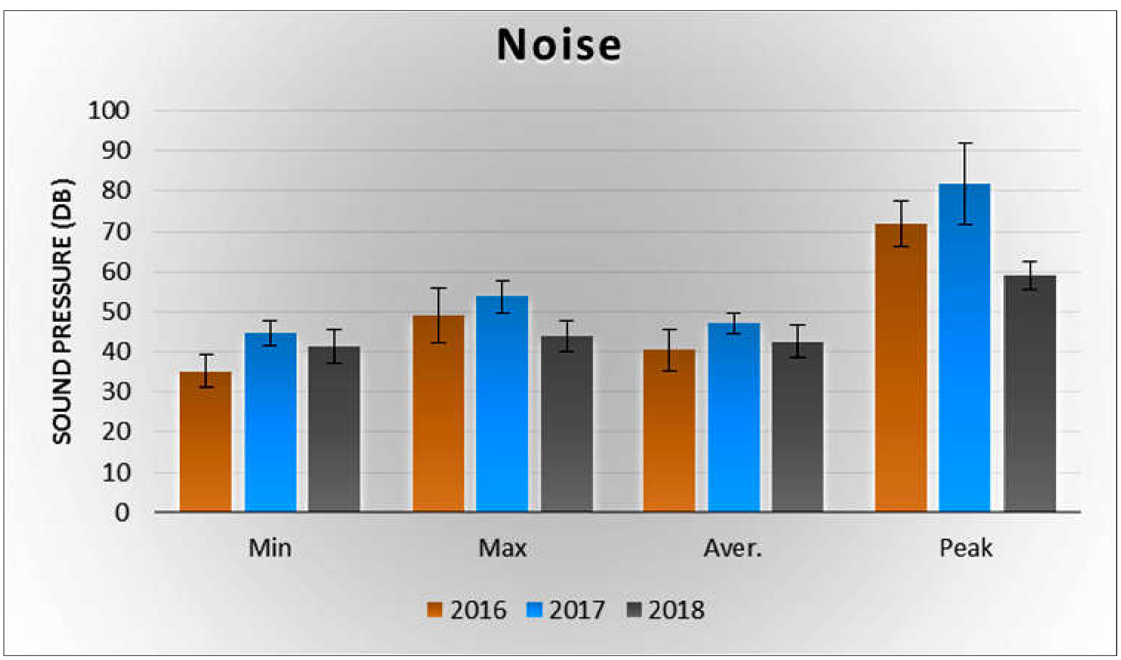

Figure 5: Sound levels measured in the Weaselhead park in July 2016, July 2017 (n=28) and July 2018 (n=27).

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 riparian habitat in immediate proximity to the SWCRR (fig. 7). The results for 2018 are detailed below. The same protocol and site were used as in 2015, 2016 and 2017. The assessments from the first 3 years included only flowering plants in the clade 'eudicots'. In 2018 grasses and other monocots are included as supplemental data.

Figure 7: green line shows location of 50m transect used for vegetation survey on the north bank of the beaver Pond; orange line shows Weaselhead boundary

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 (fig. 6). The quadrats were numbered from 1 to 50 from west to east. A random sample was taken of 15 quadrats from the total of 50. These 15 quadrats represent samples from the Beaver Pond riparian vegetation. On September 9th, 10th and 11th 2018 each selected quadrat was comprehensively screened, and the individual eudicot plants present were counted and identified to species level (data set available in appendix II).

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		16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50

Shoreline (south)

Figure 6: 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 2018 survey (quadrats number 2, 7, 11, 17, 27, 28, 29, 33, 35, 37, 40, 44, 45, 46, 48

The 2018 survey was completed by different researchers than in previous years resulting in differences in the identification of one of the aster species. Samples were taken to an expert from the City of Calgary and determined to be mostly Western willow aster (*Symphyotrichum lanceolatum var. hesperium*). This species was not identified in previous years' results but it is suspected that the Eaton's aster identified in previous samples may have been Western willow aster. (Observers in 2018 also accidently switched north and south quadrat numbering – resulting in even numbers along the north and odd numbers along the south side of the transect – however random selection was still represented.)

In 2018 monocots were included in the survey. These included grasses, sedges and rushes. In some instances, the percentage of canopy cover was taken as opposed to counting individual clumps or plants. The percentage cover of moss was also recorded.

Occurrence (number of quadrats with one or more of the species) and abundance (mean count of the species in occupied quadrats) are summarised in Table 5, and information on the USDA[6] wetland classification provided where available.

Table 5: Eudicots and Monocots: occurrence (number of quadrats with one or more of the species) and abundance (mean count of the species in occupied quadrats) **noxious weed (*[δ]*Alberta Weed Control Act 19/2010);* [nn]*non-native species (unregulated)*

herbaceous species *(note – all are perennials)*	**common name**	**occurrence**	**abundance**	**USDA wetland classification**[6]
*Cirsium arvense**	Creeping Thistle	14	6	FACU
Viola canadensis	Canada Violet	14	28	FACU
Equisetum sp.	Horsetail	14	12	
*Sonchus arvensis**	Field Sow Thistle	11	17	FAC
Solidago canadensis	Canada Goldenrod	11	5	FACU
Symphyotrichum lanceolatum var. hesperium	Western Willow Aster	11	12	FACW
Anemone canadensis	Canada Anemone	10	5	FACW
Mentha arvensis	Wild Mint	9	6	FACW
Zizia aptera	Heart-leaved Alexanders	9	5	FAC
Maianthemum stellatum	Solomon's Seal	9	3	FACU
Taraxacum officinale	Dandelion	8	12	FACU
Thalictrum venulosum	Veiny Meadow Rue	7	10	FAC
Pyrola asarifolia	Common Pink Wintergreen	7	7	FACU
Persicaria amphibium	Swamp smartweed	6	18	OBL
Galium boreale	Northern Bedstraw	5	3	FACU
Vicia americana	American Vetch	5	6	FACU
Symphyotrichum laeve	Smooth Blue Aster	5	1	FACU
Fragaria virginiana	Wild Strawberry	4	4	FACU
Heracleum maximum	Cow Parsnip	2	1	FAC
Geum rivale	Water Avens	2	1	FACW
Actaea rubra	Baneberry	2	2	FACU
Lysimachia ciliata	Fringed Loosestrife	1	5	FACW
Achillea millefolium	Common Yarrow	1	4	FACU

Scutellaria galericulata	Skullcap	1	6	OBL
Ranunculus aquatilis	Water Crowfoot?	1	57	OBL
Antennaria pulcherrima	Showy Everlasting	1	2	__
Cornus sericea	Red-Osier Dogwood	13	6	FACW``
Rosa acicularis	Prickly Rose	10	13	FACU
Salix bebbiana	Bebb's Willow	10	1	FACW
Elaeagnus commutata	Silverberry	10	6	UPL
Arctostaphylos uva-ursi	Bearberry	10	1	UPL
Rosa woodsii	Wood's Rose	7	2	FACU
Dasiphora fruticosa	Shrubby cinquefoil	6	2	FACW
Symphoricarpos occidentalis	Buckbrush	5	3	UPL
Lonicera dioica	Twining Honeysuckle	5	4	FACU
Rubus pubescens	Trailing Raspberry	5	4	FACW
Amelanchier alnifolia	Saskatoon	4	2	FACU
Picea glauca	White Spruce	3	3	FACU
Shepherdia canadensis	Buffaloberry	2	3	FACU
Viburnum trilobum	Highbush Cranberry	2	1	--
Salix pseudomonticola	False Mountain Willow	1	1	FACW
Ribes oxyacanthoides	Wild Gooseberry	1	1	FACU
Betula occidentalis	Water Birch	1	1	FACW
Moncots		**occurrence**	**abundance**	
Carex atherodes	Wheat Sedge	12	0	OBL
Poa pratensis^{nn}, *Poa palustris*	Kentucky Blue Grass + Fowl Blue Grass	12	0	FACU + FACW
Agrostis stolonifera	Creeping Bentgrass	7	0	FACW
Typha latifolia	Cattail	6	1	OBL
Juncus balticus	Baltic Rush	4	0	FACW
Calamagrostis inexpansa	Northern Reed Grass	4	6	__
Glyceria grandis	Tall Manna grass ??	3	3	OBL
Bromus inermis^{nn}	Smooth Brome	2	0	UPL
Moss Cover %		12	0	

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*

Species diversity: The 2018 results show a total taxa richness of 38 species of eudicot plants found in the total area surveyed, 60m^2 (15 quadrats x 4m^2 per quadrat). Canada violet (*Viola canadensis*) was the dominant species in the area surveyed, comprising 21.9% of the total individuals counted (including all species). The area revealed an average richness of 3.73±1.57

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 78.9%±17.6% per quadrat (2m x 2m) in 2018. Figure 8 compares Simpson's Diversity Index (1-S) per quadrat for 2015, 2016, 2017 and 2018 sampling campaigns.

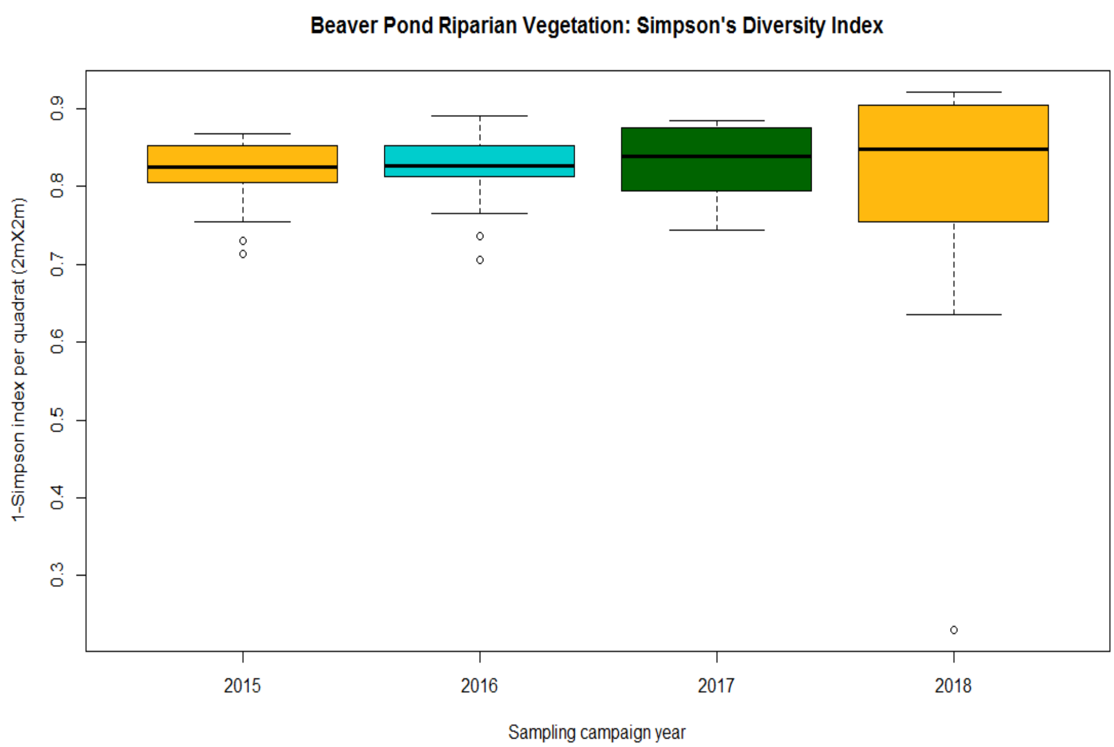

Figure 8: Simpson's Diversity Index (1-S) per quadrat for 2015, 2016, 2017 and 2018 sampling campaigns.

Species richness: When analysed by linear regression, there was no association between richness or Simpson's diversity index and the year for the period between 2015 and 2018 (for both linear regressions, df = (58), $p>0.05$). A log transformation of the richness data was necessary for meeting the assumptions of the regression. A Kruskal-Wallis non-parametric test, however, identifies that the richness data for different years have non-identical populations, with the lowest average richness observed in 2015 and the highest was recorded in 2017 (Kruskal-Wallis rank sum test df = 3, $p<0.05$). Additional data from the next 4 years will help to clarify if there is any quantifiable trend in the data.

The measured mean of eudicot species per square meter along the shore of the Beaver Pond in 2018 is 3.7±1.6 species/m^2, (n=15). Figure 9 compares eudicots species richness per square meter for 2015, 2016, 2017 and 2018 sampling campaigns.

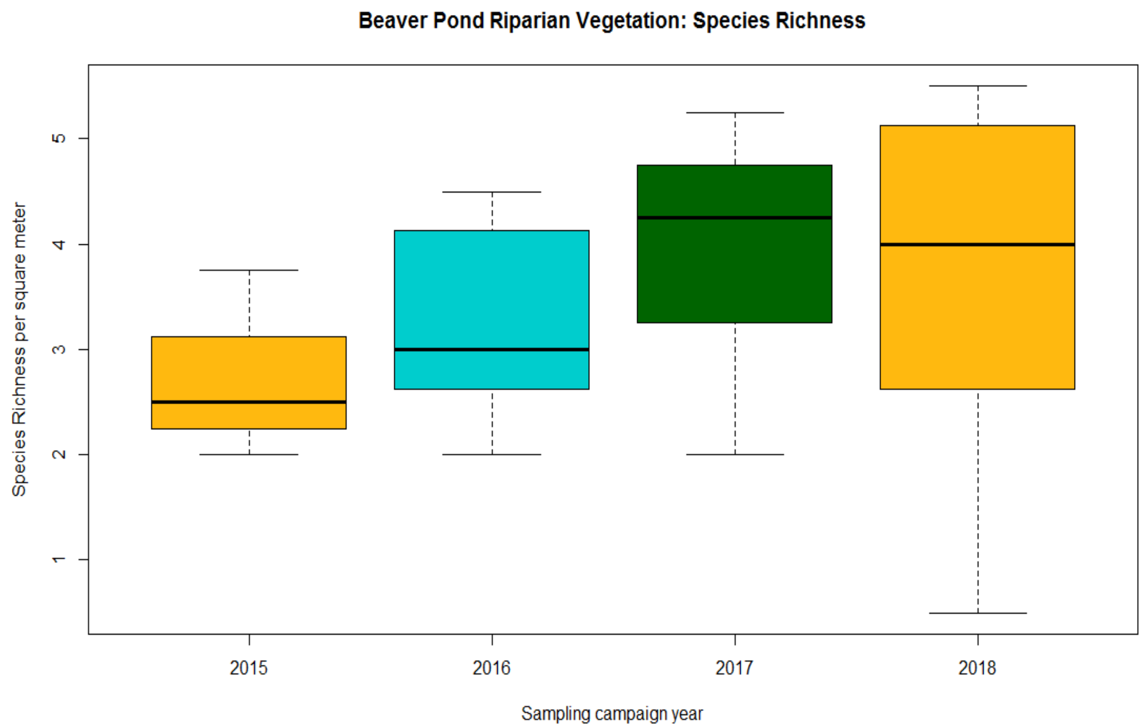

Figure 9: Eudicots species richness per square meter for 2015, 2016, 2017 and 2018 sampling campaigns.

d. Wildlife movement

In 2016 the Society partnered with The Southern Alberta Institute of Technology (SAIT) to assess the impact of the SWCRR construction on the movement of medium to large mammals in the Weaselhead. The specific questions the project aimed to answer were:

- Does mammal occurrence in the park differ before, during and after construction? If so, which mammals are affected and how much?
- Does location of occurrences differ by construction period? If so, which mammals are affected, where and how?
- Are mitigation infrastructures (the wildlife corridors, see figure 10) used by mammals? If so, which mammals use them and which do not?

Figure 10: Nov. 2018; looking west from the Weaselhead under the SWCRR bridges - the two wildlife corridors are on either bank

To help answer these questions 30 motion-activated cameras were set up in the park to record wildlife from January 2016 to early 2018. The photos from these cameras are still being processed.

In November 2018 the Society partnered with the Miistakis Institute in a larger project '*Calgary Captured'* ([7]Kahal *et al,* 2017). The goals of this project are to better understand wildlife occurrence in Calgary's natural areas and to identify key infrastructure associated with roads that wildlife use to move around the urban environment. This project has installed and is collecting data from 12 motion-activated cameras in the Weaselhead (fig. 11) and adjacent Glenmore Parks. Photos taken in Jan. and Feb. 2018 show the presence of cougar, white-tailed deer and bobcat in the Weaselhead/Glenmore Parks. Anecdotal evidence of mammal presence (photos, scat and track observations shared online) indicate other large mammals such as bear and moose (including a moose with calf in fall) and coyotes were using the area in 2018. Photos from the wildlife cameras from the entire year are expected to be processed and the results available in 2020, which will help confirm presence of these species, and provide information on when and where they occurred.

In 2018 Golder Associates carried out monthly monitoring of the efficacy of the wildlife corridor on behalf of KGL, the company constructing the SWCRR. The Sept. 2018 to Jan 2019 reports were shared with the Society by Alberta Transport. In these months observers failed to find any evidence of mammals using the wildlife corridors other that a white-tailed jackrabbit and semi-aquatic animals (beaver and mink). A motion-activated camera installed under the central bridge on the south river bank recording between 7pm and 7am , 22nd Aug. to 8th Nov. 2018 also failed to record any mammals moving along the corridor.

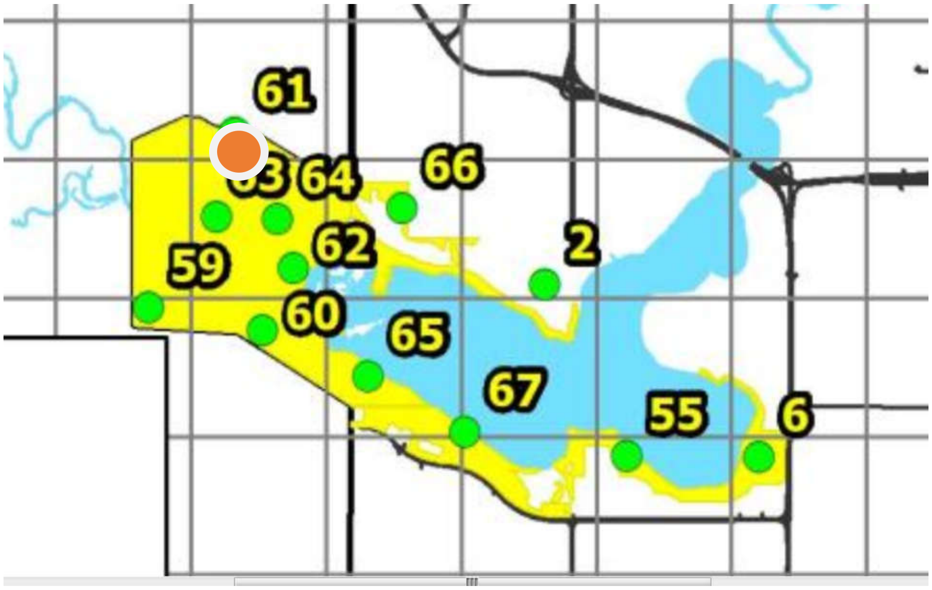

Figure 11: location of 'Calgary Captured' cameras = green dots; Golder motion-activated camera = red dots; Weaselhead and Glenmore Parks shown in yellow, Glenmore Reservoir in blue

Intermittent presence of mammals such as moose and bear in 2018 in the Weaselhead indicates movement in and out of the park along the river valley (the north, south and east of the parks being bordered by residential communities). It seems likely animals are travelling across the construction zone (as yet unfenced) rather than using the wildlife corridors.

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 (fig. 12). It is intended to represent a reference site. The Beaver Pond is in immediate proximity to the SWCRR and the Beaver Lagoon with which it is hydrologically connected is further downstream. A drainage plan designed by the SWCRR contractor, KGL (fig. 15) aims to maintain surface flow to these wetlands during and post SWCRR construction.

Water quality data was collected in 2015, 2016 and 2017 from 3 sites in each of the three wetlands and from the Elbow River (figs. 13 and 14; table 6). One of the wetlands, the Beaver Pond, is split into two cells connected by a culvert under a paved pathway. To better understand the hydrology of this wetland in October 2018 a pressure sensor was lowered to the bed of the wetland near point BP3 to track changes in depth (retrieval planned for October 2019) and four additional sample sites were added: another sample site in each cell (BP4 and BP5) and a sample site (SB and RC) in each of the two intermittent streams that flow into the wetland. Ravine Creek feeds into the east cell of the Beaver Pond and Spring Brook into the west cell. Both of these streams have been impacted by construction of the SWCRR across their catchment areas (fig. 15).

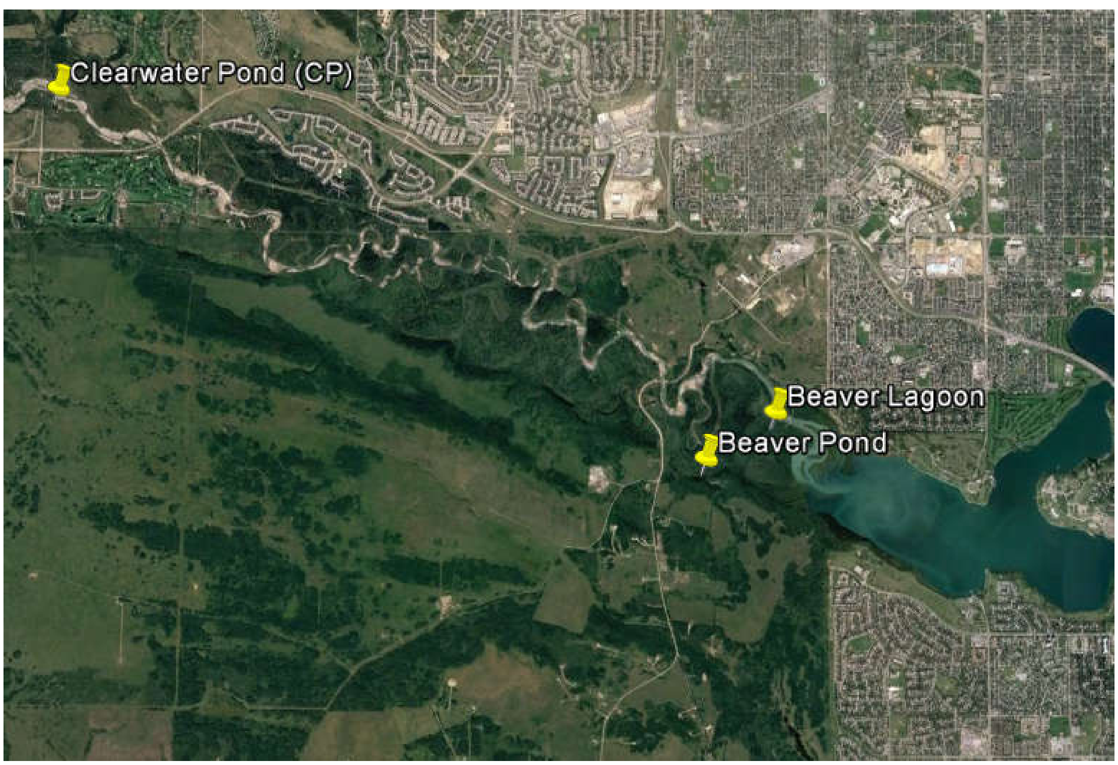

Figure 12: Location of monitored wetlands

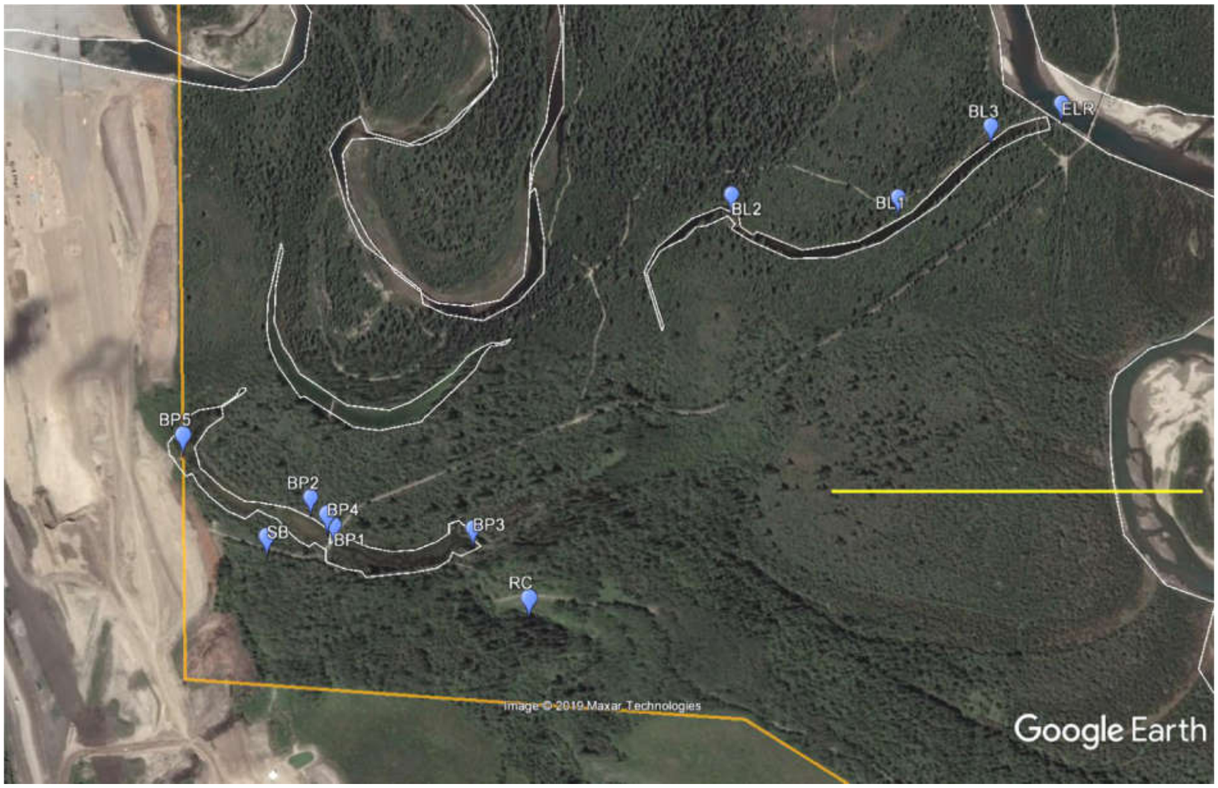

Figure 13: Location of sampling sites at the Beaver Pond (BP), Beaver Lagoon (BL), Spring Brook (SB), Ravine Creek (RC) and Elbow River (ELR); white lines show edges of permanent wetlands; orange line shows park boundary; scale: yellow line = 500m;

Figure 14: Location of sampling sites at Clearwater Pond

Table 6: Geographic coordinates of water quality monitoring sampling sites

Wetland	Sampling site	Latitude	Longitude
Beaver Pond	BP1	50.9864	-114.161
	BP2	50.9867	-114.162
	BP3	50.9864	-114.159
	BP4	50.9865	-114.161
	BP5	50.9874	-114.164
Spring Brook	SB	50.9862	-114.163
Ravine Creek	RC	50.9855	-114.158
Beaver Lagoon	BL1	50.9903	-114.15
	BL2	50.9903	-114.154
	BL3	50.9911	-114.149
Elbow River	ELR	50.9914	-114.147
Clearwater Pond	CP1	51.0202	114.255
	CP2	51.0205	-114.256
	CP3	51.0204	-114.257

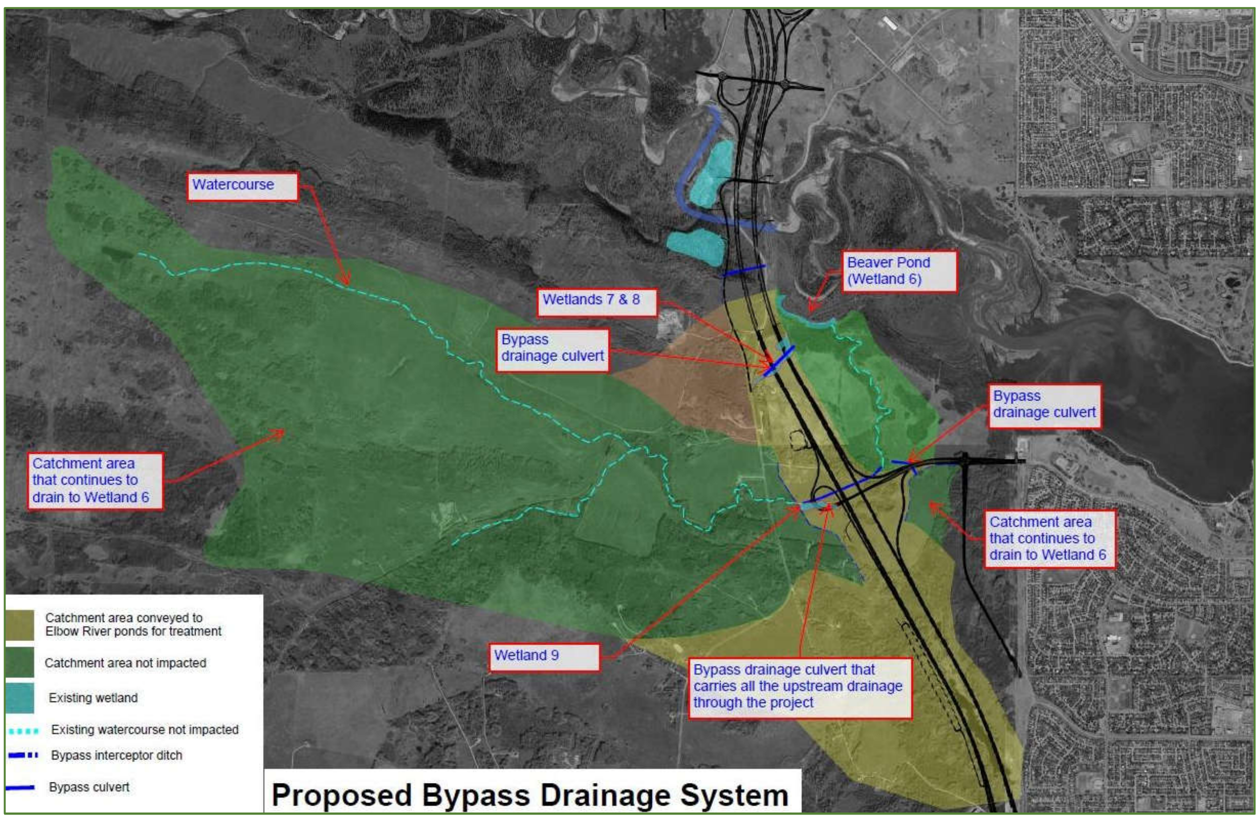

Figure 15: bypass drainage for Spring Brook (northern culvert) and Ravine Creek (southern culvert) intended to maintain surface flow across the Transportation Utility Corridor into the Beaver Pond (*Sept. 201, courtesy of KGL – the construction company for the SWCRR)*

Water sampling and in-situ assessments were performed four times: on 27th August and 1st, 15th and 21st October 2018. This compares to only two sampling campaigns in 2016 and 2017. The additional sampling on 1st and 15th October occurred because early snowfall and freezing temperatures raised concerns that the wetlands would be frozen by 21st October. This did not happen and sampling was conducted on October 21st. (The additional data collected on October 1st and 15th are available in appendix III.)

On August 27th a YSI® Pro Plus multimeter was used to measure in-situ water temperature, conductivity, pH, dissolved oxygen, oxidation reduction potential, and turbidity at the sample sites. For the determination of ortho-phosphate (method: Molybdenum Blue) and chloride (method: Silver Nitrate Turbidimetric) an Orbeco Mini-Analyst Model 942 was used onsite.

In October a different YSI® Pro Plus was used with the ability to measure temperature, conductivity, pH, dissolved oxygen and salinity, but without the attachments to measure oxidation reduction potential or turbidity. A Secchi Disc was used to measure turbidity, and LaMotte 'TesTabs' used to measure phosphate and nitrate levels as new reagents are no longer being supplied for the Orbeco Mini-Analyst (obsolete). Data on chloride levels was not collected.

Water quality data collected on 27th August and 21st October 2018 are presented in tables 7 and 8. Table 9 presents sampling campaign summary statistics.

Statistical hypothesis tests (linear regression analysis) were conducted for the parameters that exhibited a complete data series for all sites: conductivity, pH, temperature and dissolved oxygen (complete datasets including data unused in this report are available in Appendix III). Results are discussed separately below.

Monitoring of water quality and water flow in the Beaver Pond (referred to as 'wetland 06') was also carried out in 2018 on behalf of KGL by Hemmera Envirochem Inc. on July 5th and Oct. 11th. The summary from the [9]Wetland 06 Water Monitoring Report on the 2018 results reads:

> During Year 1 of monitoring, the following key observations were noted:
>
> - Water quality results show variation in water quality parameters among sampling locations within Wetland 06, as well between summer and fall sampling visits.
> - The majority of surface water quality parameters measured were consistent with CCME criteria for the protection of aquatic life. Two parameters, pH and DO, were found in exceedance of CCME criteria within Wetland 06.
> - Chloride and conductivity concentrations measured in Wetland 06 in 2018 were higher than historic measurements taken in 2016 and 2017.
> - Inflow and outflow channel measurements found limited to no surface water flow into or out of Wetland 06 during the two monitoring visits.
> - Smaller wetted widths were recorded during the fall site visit at all transects in Wetland 06 indicating a reduction in surface water quantity. During the fall site visit the reference wetland was dry.

These results are consistent with those found in this study and described below.

Table 7: Water quality parameters on August 27th 2018

	Water body / Site									
	Beaver Pond			Beaver Lagoon			Elbow River	Clearwater Pond		
Parameters	**BP1**	**BP2**	**BP3**	**BL1**	**BL2**	**BL3**	**ELR**	**CP1**	**CP2**	**CP3**
Temperature (°C)	11.5	10	10.6	13.2	12.6	12.8	10.8	13.7	13.9	14.3
pH	7.99	8.42	8.09	8.1	7.77	7.93	8.22	9.18	9.22	9.12
Conductivity - C (µS/cm)	464.6	503	434	372.9	478.5	395	302.6	170.5	174.4	199.3
DO (mg/L)	4.27	11.68	5.3	9.47	12.26	8.41	10.26	9.36	10	11.32
DO (%)	39.2	103.7	48.7	90.6	115.5	79.5	92.7	90.4	96.6	110.4
Phosphate (mg/L)	0.02	0.4	0	0	0	0.1	0	N/A	0.02	N/A
Chloride (mg/L)	19.69	13.8	22.6	6.44	N/A	N/A	7.24	N/A	1.05	N/A

Table 8: Water quality parameters on October 21st 2018

	Water body / Site											
	Beaver Pond					Beaver Lagoon			Elbow River	Clearwater Pond		
Parameters	**BP1**	**BP2**	**BP3**	**BP4**	**BP5**	**BL1**	**BL2**	**BL3**	**ELR**	**CP1**	**CP2**	**CP3**
Temperature (°C)	3.67	4.7	3	3.9	4.6	3.9	4.6	4.9	4.7	4.1	4.4	5.9
pH	7.9	8.36	7.82	8.22	7.88	8.22	7.88	7.81	7.87	7.77	7.86	8.35
Conductivity - C (µS/cm)	793.6	847.7	775.9	837.2	1164.3	837.2	1164.3	591.8	670.5	589.9	428.9	336.9
DO (mg/L)	7.05		6.33	8.24	6.68	8.24	6.68	7.01	10.21	7.35	6.23	7.61
DO (%)	61.37	79.7	53.6	71	58.9	71	58.9	62.03	89.6	63.47	54.7	69.2
Phosphate (mg/L)	0.1	9.2	0.5	0.5	0.3	0.5	0.3	1	0.8	2	1	0.8
Chloride (mg/L)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 9: Water quality parameters in 2018. Each value represents the average (±SEM).

Water body	Site	Number of Replicates	Assessment Date 2018	Temperature (°C)	pH	Conductivity (µS/cm)	DO (%)	Phosphate PO4 (mg/L)
Beaver Pond	BP		August 27th	10.7 (±0.4)	8.17 (±0.13)	467 (±20)	64 (±20)	0.14(±0.13)
		5	October 21st	4.0 (±0.3)	8.04(±0.11)	884 (±71)	65 (±5)	2.12(±1.77)
Beaver Lagoon	BL	3	August 27th	12.9 (±0.2)	7.93 (±0.10)	415 (±32)	95 (±11)	0.03(±0.03)
		3	October 21st	4.6 (±0.2)	7.82(±0.03)	617 (±26)	72 (±9)	1.27(±0.37)
Clearwater Pond	CP	3	August 27th	14.0 (±0.2)	9.17 (±0.03)	181 (±9)	99 (±6)	N/A
		3	October 21st	7.0 (±0.7)	8.24(±0.06)	340 (±2)	71 (±1)	N/A

i) Conductivity

Conductivity 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 ([8]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. This can be achieved by continuous monitoring of the electric conductivity of a water body.

Regression analysis for the Beaver Pond and Beaver Lagoon (Weaselhead sites that are hydrologically connected) for the period between 2015 and 2018 revealed a significant increase in conductivity over year when comparing the same months (linear regression, df=21 (Beaver Pond), df=16 (Beaver Lagoon), p<0.05). During the same period, the reference wetland (Clearwater Pond) has not showed any association between conductivity and time (linear regression, df=3, p>0.05). See figure 16.

A Kruskal-Wallis non-parametric test identifies that the conductivity is non-identical for different sites and dates between 2016 and 2018, in particular a significant increase in conductivity during the October 2018 assessment was observed in all sites (Kruskal-Wallis rank sum test df = 3, p<0.05).

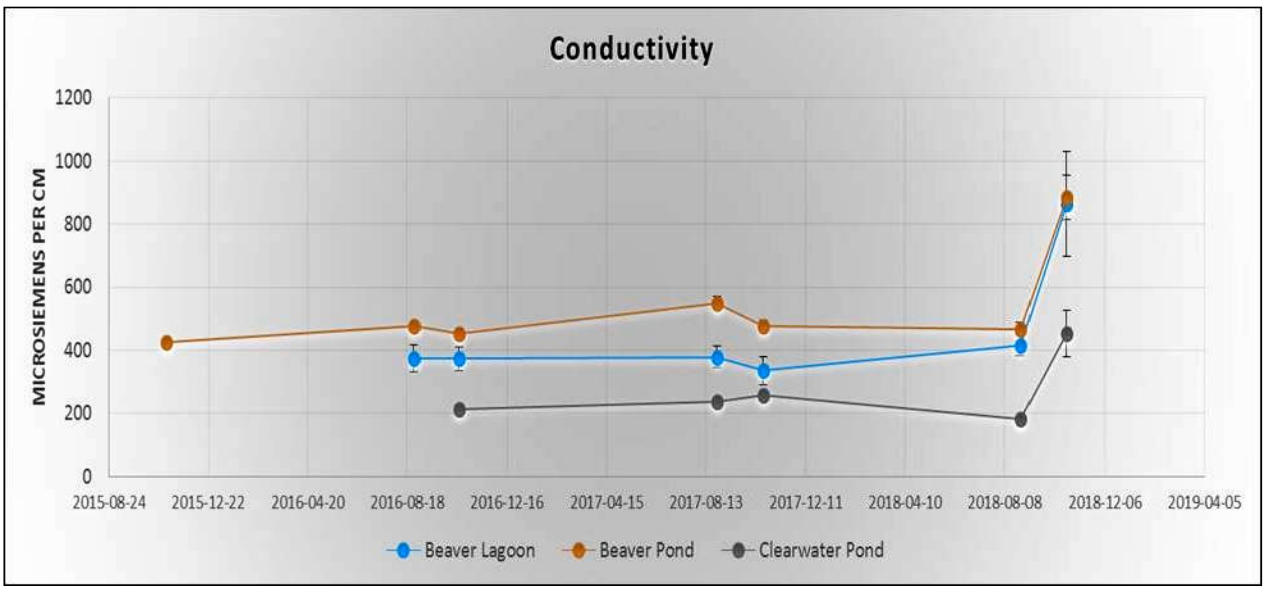

Figure 16: Conductivity recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) between 2015 and 2018.

iii) Chloride

Chloride is one of the important dissolved ions that can increase the electric conductivity of water ([8]Sawyer *et al.*, 2003). The measure of chloride (figure 17) complements the data collected on conductivity by assessing the concentration of an ion that is of special interest in the study: the future use of de-icing salts on the SWCRR may increase chloride concentration in adjacent wetlands.

(Lack of a complete data in 2018 set did not allow statistical testing of results.)

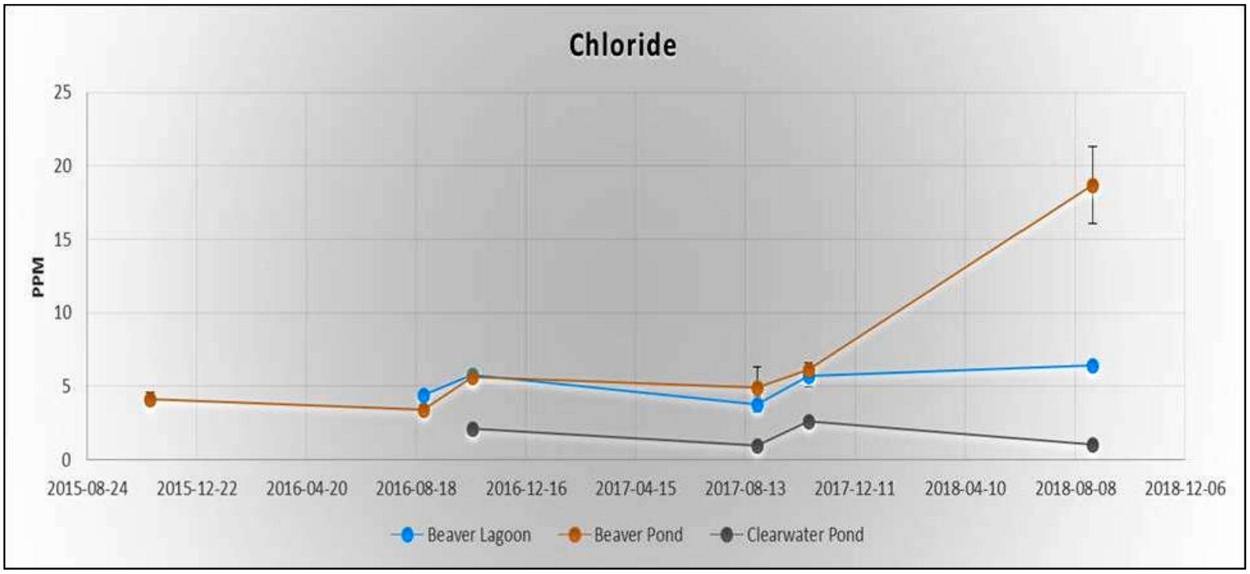

Figure 17: Chloride recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP) between 2015 and 2018.

iii) pH

The measure of pH responds to the chemical balance of the elements present in the water that determine its acidic, neutral or basic conditions ([8]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.

A regression analysis for the Beaver Pond for the period between 2016 and 2018 revealed a significant increase in pH over year when comparing the same months (linear regression, df=21, $p<0.05$). During the same period, the reference wetland (Clearwater Pond) has not showed any association between pH and time (linear regression, df=3, $p>0.05$). See figure 18.

A Kruskal-Wallis non-parametric test identifies that the pH is non-identical for different sites between 2016 and 2018, indicating that the Clearwater Pond had a higher average pH in that period (Kruskal-Wallis rank sum test df = 3, $p<0.05$). This result is likely related to some extremely high pH measurements in the Clearwater Pond (i.e. above 9), possibly induced by photosynthetic activity of aquatic vegetation at this site.

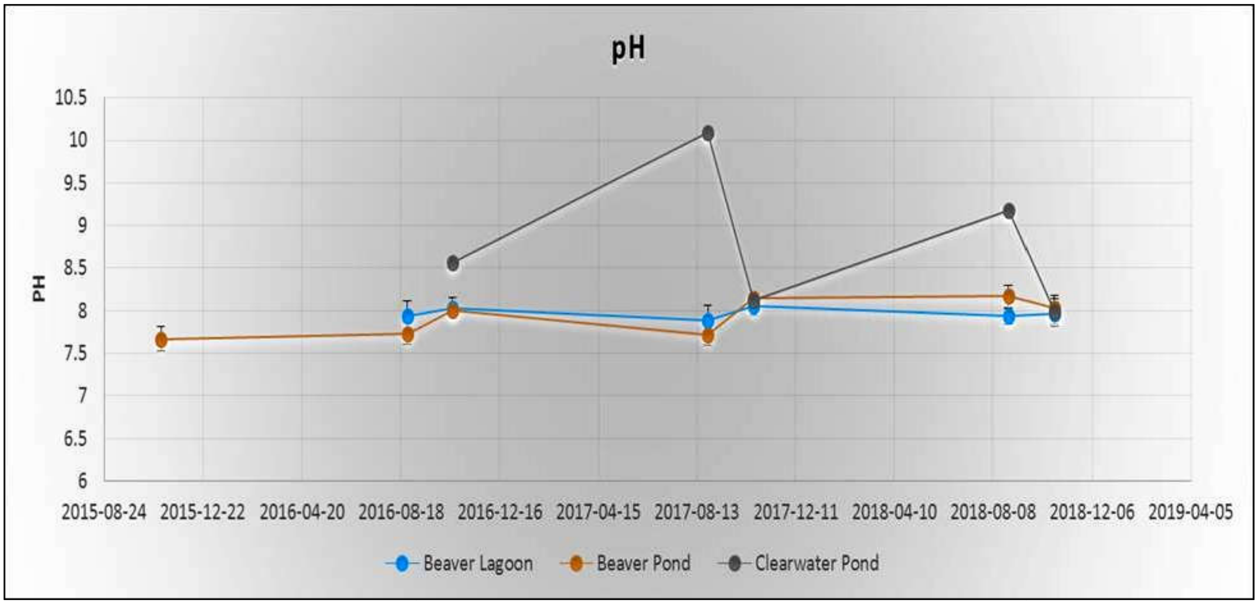

Figure 18: pH recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP) between 2015 and 2018.

iv) Phosphorus

Phosphorus is one of the most important limiting nutrients in aquatic ecosystems ([8]Sawyer *et al.*, 2003). The introduction of phosphorus into a water body can lead to an exponential increase in algal and cyanobacterial productivity, accelerating the rate of eutrophication. The resultant low levels of dissolved oxygen can cause fish and invertebrate mass mortality or decreased fertility

Owing to a temporary change in method when testing for phosphates in 2018 the results obtained in 2018 are omitted from this report. If after review the data are considered consistent with data from 2016 and 2017, results will be added to the 2019 report.

v) Dissolved Oxygen

Regression analysis of data from the Beaver Pond, Beaver Lagoon and Clearwater Pond, 2015 to 2018, does not show any association between dissolved oxygen (DO) and year when comparing the same months (linear regression, df=21 (Beaver Pond), df=16 (Beaver Lagoon and Clearwater Pond), $p<0.05$). See figure 19.

Kruskal-Wallis non-parametric test, however, identifies that the dissolved oxygen is non-identical for different sites between 2016 and 2018, indicating that the Beaver Pond had lower average dissolved oxygen levels than the other wetlands in that period (Kruskal-Wallis rank sum test df = 3, $p<0.05$).

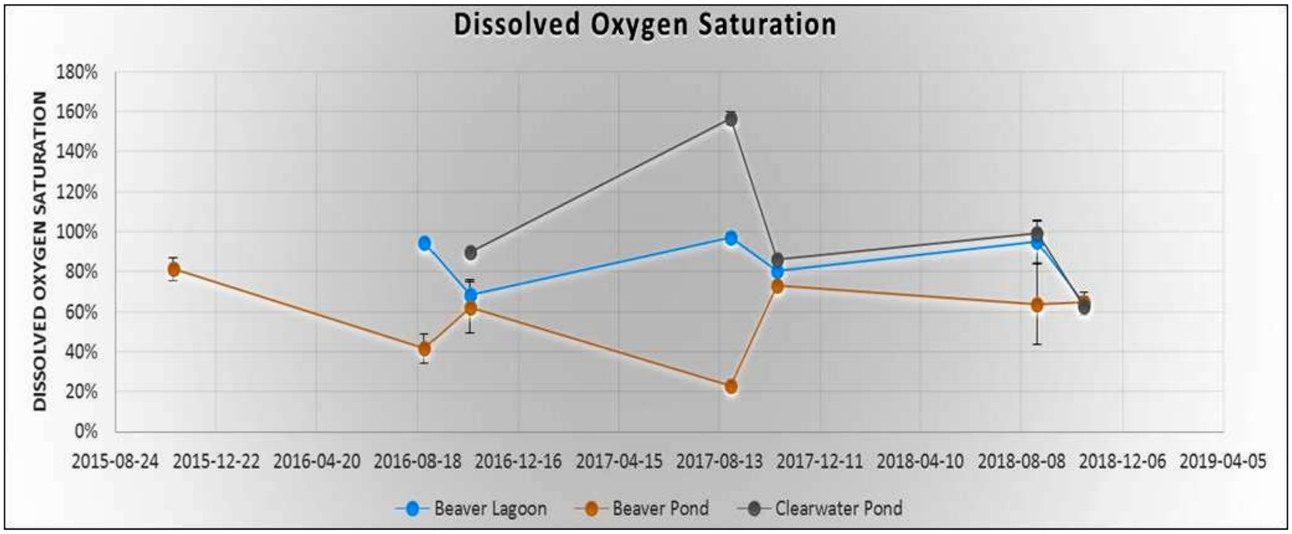

Figure 19: Dissolved oxygen (DO) recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) between 2015 and 2018.

vi) Temperature

Regression analysis of data from the Beaver Pond, Beaver Lagoon and Clearwater Pond for the period 2015 to 2018 does not show any association between water temperature and year when comparing the same months (linear regression, df=21 (Beaver Pond), df=16 (Beaver Lagoon and Clearwater Pond), $p<0.05$). i.e. No trend towards temperature increase or decrease was evident across different years between 2015 and 2018 . See figure 20.

On average the Beaver Pond registered lower temperatures than the other sites between 2015 and 2018 (two way ANOVA, df=4,2,8, $p<0.05$).

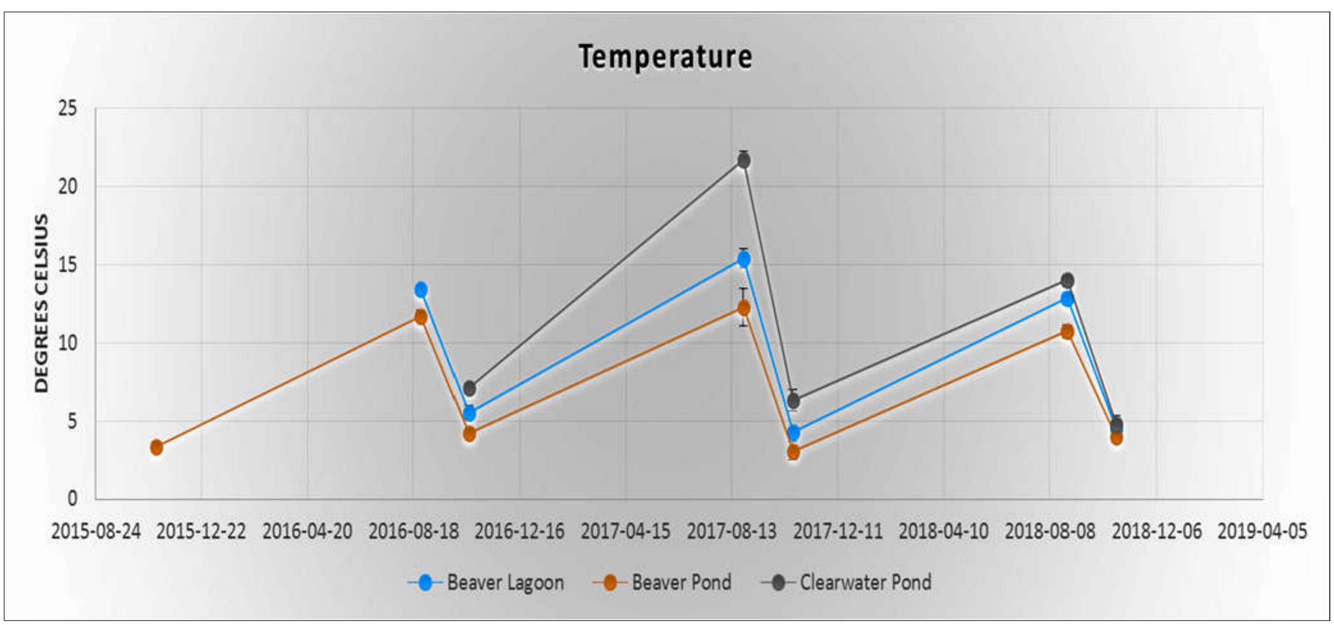

Figure 20: Temperature recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) in 2015, 2016 and 2017.

b. Aquatic macro-invertebrates

In 2018 a total of 912 specimens were identified to 39 taxa for the habitats studied (BP, BL and CP, table 10 and 11). The 39 taxa identified represent the greatest taxonomic resolution achieved in 2018, consisting of 34 groups identified to genus/species levels and 5 groups identified to family/subfamily/ superfamily levels.

Table 10: Taxonomic classification for the aquatic macroinvertebrates sampled on August 19th 2018.

	Greatest Taxonomic Resolution Obtained	Beaver Pond			Beaver Lagoon			Clearwater - Control		
		BP1	**BP2**	**BP3**	**BL1**	**BL2**	**BL3**	**C1**	**C2**	**C3**
Mayflies	*Caenis* sp. Stephens, 1835							1		
	Centroptilum sp. Eaton 1869			8	6	1	12			
Caddisflies	*Oxyethira* sp.							2		
	Phryganea sp.								1	1
	Limnephilus sp. Leach in Brewster, 1815									
Damselflies	*Ischnura* sp. Charpentier, 1840			1						
	Enallagma sp. Charpentier, 1840			2	1	2	6	2	3	1
Dragonflies	*Aeshna sp. Fabricius, 1775*					5			1	
	Somatachlora sp.Selys,1871					5				
True flies	Orthocladiinae			3	1	2		1		
	Anopheles earlei Vargas, 1943			10		3	1			
	Prionocera sp.					1				
	Dixella sp. Dyar & Shannon, 1924			3						
Beetles	*Laccophilus* sp. Leach, 1815				1		1			
	Graphoderus occidentalis Horn, 1883									
	Potamonectes sp. Zimmermann, 1921				8					
	Liodessus sp. Guignot, 1939			6		12	5			
	Ilybius sp. Erichson, 1832			2						
	Coptotomus sp. Say, 1830									
	Haliplus sp. Latreille, 1802		1	7	5				14	9
True bugs	Corixidae		1	7	22		26	35	26	31
	Gerris sp.		2	1					3	
	Notonecta sp. Linnaeus, 1758			1					1	
Water mites	Hydrachnidia								1	
Water fleas	*Diaphanosoma* sp. Fischer, 1850									
	Chydoridae									
Scuds	*Gammarus lacustris* G.O. Sars, 1864		1		2					1
	Hyalella azteca (Saussure, 1858)	11	4	3	10	47			1	
Snails	*Physa* sp. Draparnaud, 1801				6	1	5		1	3
	Stagnicola sp. Jeffreys, 1830	1		2	6	1				
	Probythinella lacustris (F. C. Baker, 1928)				1					
	Helisoma sp.	1								
	Planorbula campestris (Dawson, 1875)			1						
	Promenetus umbilicatellus (Cockerell, 1887)	1		1	2		2	1	4	65
Freshwater clams	*Pisidium* sp. Pfeiffer, 1821				138		43	1		
Oligochaete worms	Naididae							2		
Leeches	*Batrachobdella picta* (Verrill)							4		
Hydras	*Hydra* sp. Linnaeus, 1758									

Table 11: Taxonomic classification for the aquatic macroinvertebrates sampled on October 1st 2018

	Greatest Taxonomic Resolution Obtained	Beaver Pond			Beaver Lagoon			Clearwater - Control		
		BP 1	BP 2	BP 3	BL 1	BL 2	BL 3	C1	C2	C3
Mayflies	Caenis sp. Stephens, 1835	2		1				1		
	Eaton 1869	1	3		47	2	16			
Caddisflies	Limnephilus sp. Leach in Brewster, 1815									
Damselflies	*Ischnura sp. Charpentier, 1840*									
	Enallagma sp. Charpentier, 1840			1	1				1	
Dragonflies	*Somatochlora sp.*					1				
	Aeshna sp. Fabricius, 1775			2						
True flies	Orthocladiinae								1	
	Tanypodinae									
	Anopheles earlei Vargas, 1943									
	Tabanus sp. Linnaeus, 1758									
Beetles	Laccophilus sp. Leach, 1815									
	Graphoderus occidentalis Horn, 1883									
	Potamonectes sp. Zimmermann, 1921				1					
	Ilybius sp. Erichson, 1832									
	Liodessus sp.					2				
	Agabus sp. Leach, 1817									
	Coptotomus sp. Say, 1830									
	Haliplus sp. Latreille, 1802	1		1	1	2	7			
True bugs	*Corixidae*	2	3		1	2	4	1	1	1
	Notonecta sp. Linnaeus, 1758	1				2			2	1
	Lethocerus americanus (Leidy, 1847)									
Water mites	*Hydrachnidia*									
Water fleas and other small crustaceans	Daphnia sp.				1					
	Ostracoda	2		1						
	Diaphanosoma sp. Fischer, 1850									
	Chydoridae									
Scuds	Gammarus lacustris G.O. Sars, 1864	1			11	1	2			
	Hyalella azteca (Saussure,1858)	2	1	9	7	11			1	
Snails	Physa sp. Draparnaud, 1801	3		6	4				1	
	Stagnicola sp. Jeffreys, 1830			1	1					
	Fossaria (Bakerilymnaea) bulimoides (I. Lea, 1841)									
	Gyraulus crista				2					
	Probythinella lacustris (F.C.Baker,1928)									
	Valvata sincera helicoidea		1							
	Planorbula campestris (Dawson, 1875)			3						
	Promenetus umbilicatellus (Cockerell, 1887)	4	1	8	2	1			2	7
Freshwater clams	Pisidium sp. Pfeiffer, 1821				6					
Leeches	Erpobdella puncata			3						
	Placobdella ornata								1	
	Placobdella puncata			1						
Oligochaete worms	Naididae									
Hydras	Hydra sp. Linnaeus, 1758									1

Table 12: Aquatic macroinvertebrates statistics (average ± SEM) (n=3)

Water body	Site	Assessment Date (2018)	Taxa Richness per Site/Sample	Simpson's Diversity Index (1-S) per Site/Sample	% of EPT Taxa
Beaver Pond	BP	August 19th	7.3 (±1.5)	77.5% (±5.0%)	0.0% (±0.0%)
		October 1st	4.0 (±0.6)	64.4% (±6.7%)	0.0% (±0.0%)
Beaver Lagoon	BL	August 19th	8.7 (±2.3)	73.0% (±13.1%)	6.7% (±3.6%)
		October 1st	8.7 (±2.2)	64.2% (±11.8%)	10.7% (±5.4%)
Clearwater Pond	CP	August 19th	8.0 (±1.7)	67.3% (±4.3%)	13.9% (±3.2%)
		October 1st	8.3 (±1.5)	69.6% (±3.4%)	11.6% (±5.8%)

Taxa richness, Simpson's Diversity Index and % of EPT were calculated from the data (Table 12). The results are discussed under separate headings below.

Taxa Richness

Regression analysis of data from the Beaver Pond, Beaver Lagoon (Weaselhead sites) and Clearwater Pond (reference wetland), for the period between 2016 and 2018, does not reveal any significant association between taxa richness and when comparing the same months (linear regression, df=4 Beaver Pond and Beaver Lagoon df = 3 Clearwater pond, p>0.05). A two-way ANOVA allowing time and site as factors did not revealed any significant difference in the richness means of sites on collection dates (df=2,4,8; p>0.05).

These results suggest that the SWCRR Impact Study has not detected any significant trends of taxa richness for any sites during this period. After a drop in taxa richness (paired t test, df=5, p<0.05) observed in 2017 compared with 2016, the Beaver Pond site appears to have recovered to more usual values. (See figure 21.)

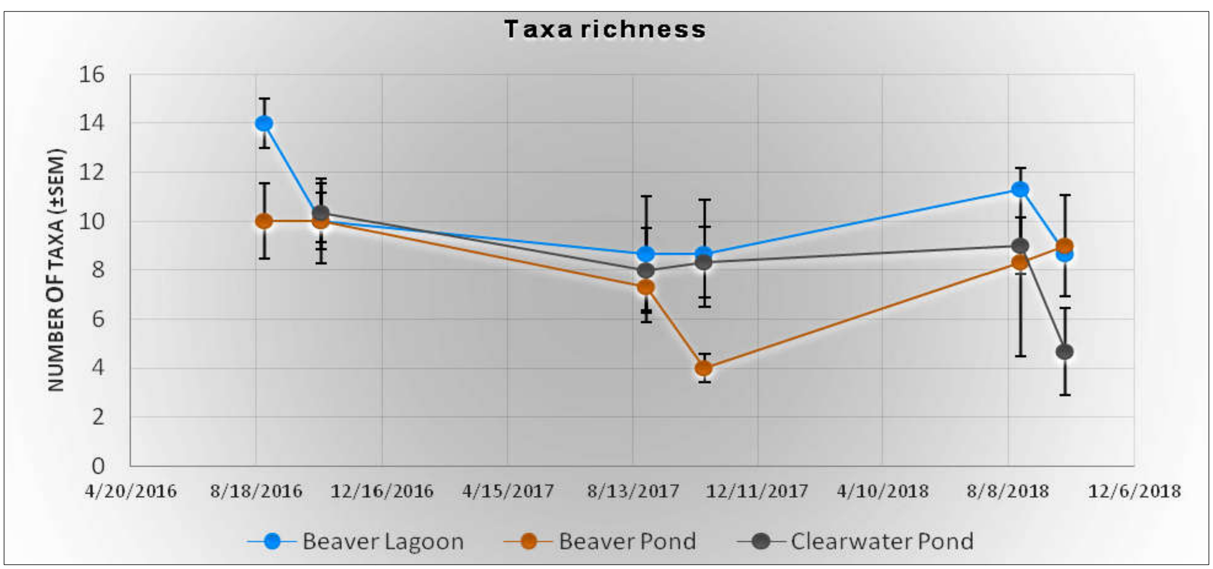

Figure 21: Taxa richness recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) from 2016 to 2018.

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.

A regression analysis of data from the Beaver Pond, Beaver Lagoon (Weaselhead sites) for the period between 2016 and 2018 revealed a significant decrease in diversity over when comparing the same months (linear regression, df=4, $p<0.05$). See figure 22. During the same period, the reference wetland (Clearwater Pond) did not show any association between diversity and time (linear regression, df=3, $p>0.05$; figure 22). This result may suggest that the Weaselhead wetlands under investigation have experienced a loss in diversity between 2016 and 2018 when compared to the reference wetland.

During 2018 the recorded invertebrate taxa diversity was significantly lower than during 2016 and 2017 for all sites (two –way ANOVA, df=4,2,8, $p<0.05$). Although not extirpated from the wetlands, some sensitive species might be experiencing competitive disadvantage when compared to disturbance-tolerant species. The small number of observations however imposes limits to the conclusions that can be taken at this point, and further investigation is necessary.

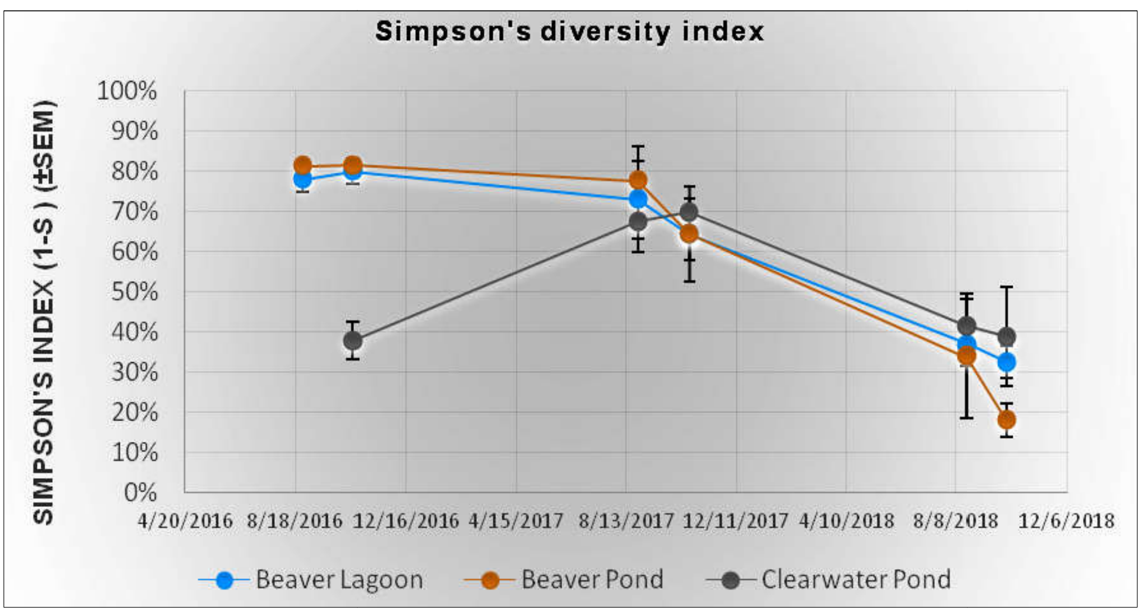

Figure 22: Simpson's diversity index recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) in 2016 and 2017.

EPT taxa %

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 Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (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.

Significantly lower EPT taxa % were recorded in the Beaver Pond than the Beaver Lagoon and Clearwater Pond from 2016 to 2018 (two –way ANOVA using square root transformation of EPT, df=4,2,8, p<0.05).

However a regression analysis of data from the Beaver Pond, Beaver Lagoon (Weaselhead sites) and Clearwater Pond (reference wetland), for the period between 2016 and 2018 has not revealed any significant association between EPT taxa richness % and year when comparing the same months (linear regression, df=4 Beaver Pond and Lagoon, df = 3 Clearwater Pond, p>0.05). See figure 23. This result suggests that the SWCRR Impact Study has not detected any significant trends on EPT taxa % for any sites during this period. After a drop in EPT taxa % (paired t test, df=5, p<0.05), observed in 2017 in comparison to 2016, the Beaver Pond site appears to have recovered to more usual values.

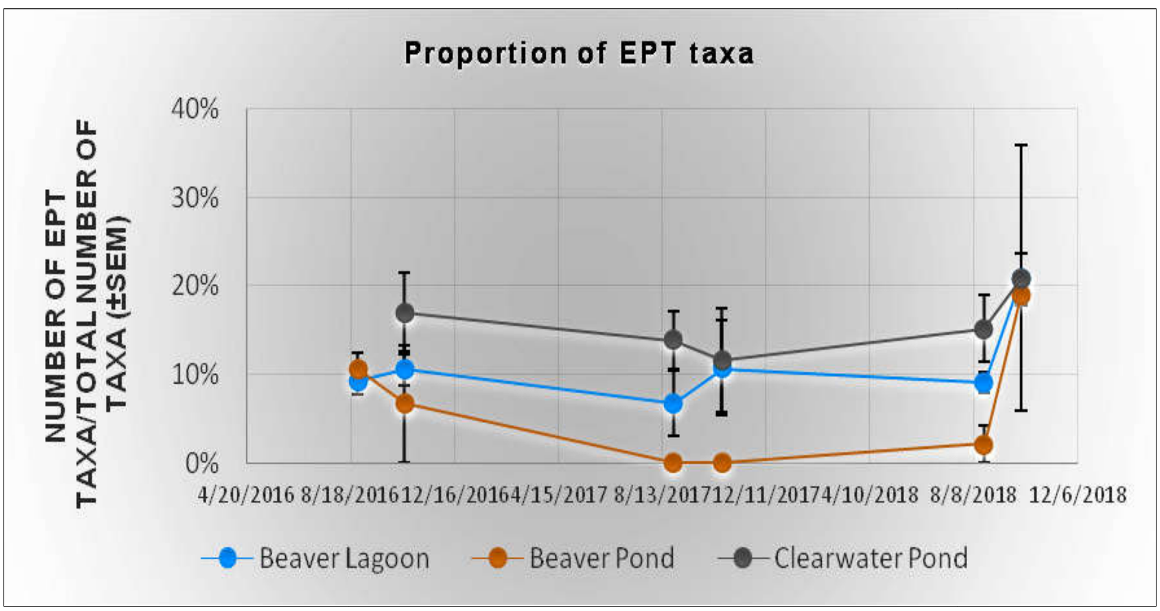

Figure 23: Taxa richness recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) from 2016 to 2018.

c. Amphibians

Nocturnal amphibian call surveys were done at two locations in the Weaselhead in 2017 and 2018. Only boreal chorus frogs, *Pseudacris maculata* and wood frogs, *Lithobates sylvaticus* were detected (figure 24, table 13 and 14). The locations match two used in 2012 and are near to one used in 2014 for the EIA[1]. Surveys were carried out between 9pm and 11pm for 20 min. following a protocol developed by the Miistakis Institute for *'Call of the Wetland'*, a three year study (2017 to 2019) into amphibians in the Calgary area. It is intended that results from the Weaselhead wetlands will be evaluated in the context of the results from this much large study when available.

Figure 24: Locations of amphibian call surveys done in 2012 (green dots) and 2014 (purple dots) carried out for the EIA[1]. 2017 and 2018 sites indicated by white arrows.

Table 13: Boreal Chorus frogs heard during surveys conducted in 2012, 2014, 2017 and 2018 *(2012 and 2014 data from Environmental Impact Assessment for the SWCRR, AMEC 2014[1])*

Boreal Chorus frog	**2012** *(no record of abundance)*		**2014** *(no record of abundance)*		**2017** *(no. of individuals heard)*		**2018** *(no. of individuals heard)*	
	Beaver Pond	Old Oxbow	Beaver Pond	Old Oxbow	Beaver Pond	Old Oxbow	Beaver Pond	Old Oxbow
late April	present		present		0	0		
early May					0	2	0	0
mid May	present		present		0	2	0	0
late May	present		present		1	1		
early June					0	1		
late June					0	0		

Table 14: Wood frogs heard during surveys conducted in 2012, 2014, 2017 and 2018. *(2012 and 2014 data from Environmental Impact Assessment for the SWCRR, AMEC 2014[1])*

Wood frog	EIA[1]: 2012 (no record of abundance)		EIA[1]: 2014 (no record of abundance)		2017 (no. of individuals heard)		2018 (no. of individuals heard)	
	Beaver Pond	Old Oxbow	Beaver Pond	Old Oxbow	Beaver Pond	Old Oxbow	Beaver Pond	Old Oxbow
late April	present		present		3	4		
early May					2	0	4	0
mid May	present		present		0	0	0	0
late May	present		present		0	0		
early June					0	0		
late June					0	0		

d. Fish

Fish sampling is a way of monitoring the ichthyofauna diversity in key habitats in the (Beaver Pond and Beaver Lagoon). The third habitat monitored represents a control at Clearwater Pond to which we can compare any potential changes in fish richness and diversity. In each habitat a minnow trap was installed for one night baited with hot dogs. A Fish Research License was obtained from Alberta Environment and Parks (AEP) for the purpose of this research. Species and size of each captured individual was determined then it was released back into its original water body.

Locations for the minnow traps are the same as three of the locations used for the water quality testing and aquatic invertebrate sampling, BP1, BL1 and CP1 (see figures 13, 14 and 15). AEP identification names/numbers for the wetlands are:

- Beaver Pond Water Body ID 66463 SE-25-23-02-5
- Beaver Lagoon Water Body ID 24267 SE-25-23-02-5
- Elbow River (Clearwater Pond) Water Body ID 2035 SE-5-24-02-5

Minnow traps were set late in the evening on November 7th, 2018 and collected early in the morning on November 8th, 2018. Cold temperatures resulted in breaking surface ice to both set and collect traps. (To avoid impacting fish health traps were kept in the water for the minimum time consistent with the objective of overnight trapping.)

No fish were found in any of the minnow traps. This compares with 11 fathead minnows *(Pimephales promelas)* caught at the Beaver Pond and 19 white suckers *(Catostomus commersonii)* at Clearwater Pond on 20th Oct 2017. (No data from 2016). However brook stickleback *(Culaea inconstans)* although not caught by the traps were found many times in the Beaver Pond by students participating in the Society's education programs in 2018.

FINAL CONSIDERATIONS

The *Environmental Monitoring Report 2018* is an important step in the evaluation of the mitigation measures adopted during the construction phase of the SWCRR.

In April 2018 and again in late June, there were spills of sediment into the Beaver Pond from the construction area next to the wetland (figs. 25 and 26). These occurred during two rain events, overwhelming sediment fencing and other measures intended to prevent erosion. Either because of these or due to natural causes, or possibly a combination of the two, changes in the water chemistry and invertebrate populations of the Beaver Pond, and to a lesser extent, the Beaver Lagoon are evident. Data shows these changes are ether not occurring, or occurring less in the reference wetland, Clearwater Pond:

- Conductivity: a significant positive trend (increase) between 2016 and 2018 in the Beaver Pond and Beaver Lagoon, but not in Clearwater Pond.
- A significant increase in pH from the 2016 baseline levels to the 2018 measurements in the Beaver Pond but not in Clearwater Pond.
- A significant negative trend (decrease) in macro-invertebrate diversity from 2016 to 2018 in the Beaver Pond and Beaver Lagoon, but not in Clearwater Pond.

Figure 25: 18th April 2018. High turbidity in Spring Brook (lower left – arrow points to sediment-laden flow); turbid water flowing into Beaver Pond (lower right); satellite image (top left 7th April 201) shows probable source of sediment from temporary holding pond for runoff and/or adjacent disturbed areas (in yellow dashed circle), white arrow shows where photo of Spring Brook taken); upper right: detail of area, blue arrows show Spring Brook, flows into Weaselhead visible as tree area on lower right (April 28th 2018)

Figure 26: Still images from video captured ion 23rd June 2018; by Jeff Brookman available online[12] showing sediment flowing from the construction site (left) into Beaver Pond (right)

On a more positive note the results show signs of recovery in the Beaver Pond in number of taxa present and proportion of EPT species after a drop in these two indices in 2017. 2017 was an unusually dry year that saw much of the Pond bed exposed for several months and this may have been the cause or contributed to these changes (see fig. 27).

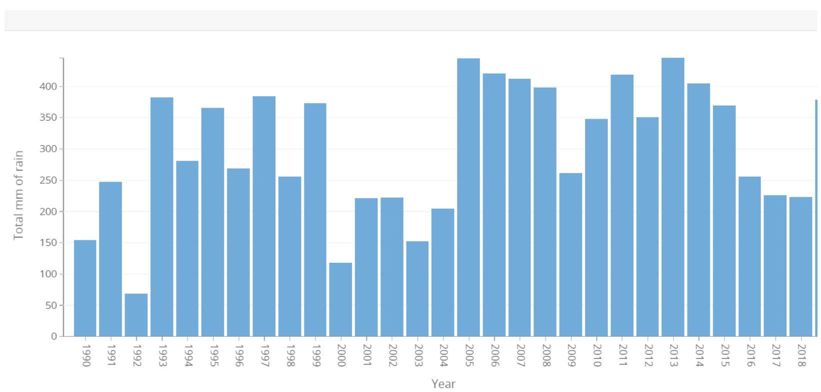

Figure 27: annual rainfall in Calgary 1990 – 2018; downloaded from https://data.calgary.ca/Environment/Annual-Rainfall-by-Channel/hueq-ytym

A reference site (like the Clearwater Pond) can be useful to eliminate the effects of some confounding factors in the interpretation of the data from the Weaselhead wetlands, however these changes may still be associated with differences in seasonal weather conditions (or even natural population fluctuations). Even without direct evidence of causality any continued negative impacts identified by the Impact Study should be investigated as they are noticed, and possible remedial action determined.

Four of the six bird species of 'sensitive' status that were recorded during the breeding bird surveys in 2016 – 2017 were not observed during the 2018 survey, but were present in eBird Basic Dataset (2019)[3]. However given the increase in minimum noise level since the start of construction and the potential for noise to impact breeding birds, the absence of some sensitive species during the survey is of concern.

Large mammals such as moose and bear are still occurring in the park as evidenced from the scat and tracks observed in the park and from photographs shared online by park visitors. However monitoring by Golder and Associates shows no evidence that these are using the wildlife corridors along the banks of the river and they may instead be moving across the construction zone as it is as yet unfenced. The wildlife corridors are still new, un-vegetated and active construction was ongoing in these areas in 2018. Although apparently ineffective in 2018 it is important that they become so once the SWCRR is operational and the road corridor is fenced if medium to large mammals are still to move safely along the river valley in and out of the Weaselhead.

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[10] video captured by Jeff Brookman, available online at https://www.youtube.com/watch?v=UI67SoAEeI