Weaselhead/Glenmore Park
SWCRR Impact Study 2016-2022

Environmental Monitoring Report 2021

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

Author: Cassiano Porto, Lisa Dahlseide & Dylann Golbeck

Calgary, May 2022

Table of Contents

Please note that raw data not included in the report is available on request.

Lisa Dahlseide, email: biodiversity4u@gmail.com

Maureen Luchsinger, email: weasel@theweaselhead.com

INTRODUCTION

Construction of the Southwest Calgary Ring Road (SWCRR) started in fall 2016. The project's EIA[1] (Environmental Impact Assessment; carried out by AMEC in 2006, updated in 2014) 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 embarked upon a seven-year study, the SWCRR Impact Study, (herein referred to as the Study) that would span the years from initiation to completion of the road. The Study aims to quantify the SWCRR's impacts on biophysical components of the park and on park users. The objective of the biophysical aspect 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].

The first SWCRR Impact Study Environmental Monitoring Report described conditions in the study area in 2016 prior to the extensive disturbance of the Elbow Valley required to accommodate the SWCRR. The 2017 report described conditions at the start of the construction phase. The 2018, 2019 and 2020 reports describe conditions during the three years of construction (all reports are available on the Society's website). Figure 1 summarizes the timeline of the project. Figure 2 shows aerial images of the Weaselhead and TUC (Transportation Utility Corridor) in 2016 before construction started (Figure 2A), and the same area in May 2021 (Figure 2B), after the opening of the section of the SWCRR adjacent to the Weaselhead on October 1, 2020. Major work undertaken in 2021 included building wildlife fencing, revegetation, and additional erosion mitigation.

When contrasted with the baseline conditions of 2016, later conditions offer insights into the long-term effects of the SWCRR on the adjacent ecosystems. These ecosystems included different features within the Weaselhead, with mapping and designations provided in Figure 3.

Data from annual monitoring can also give early warning about immediate changes in habitat quality and ecological processes – allowing remedial action to be taken before damage worsens and becomes more costly to rectify. These are discussed in the final section of the report '*Final Considerations*'.

By continuing to collect data until the end of 2022, when this section of the SWCRR will have been in operation for two years, the Study will allow an objective evaluation of the road's impact on selected environmental components and the success/failure of the mitigation measures adopted and expected to render the impact on these components acceptable (as detailed in the construction company's contract with Alberta Transportation). 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 studies are rare 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.

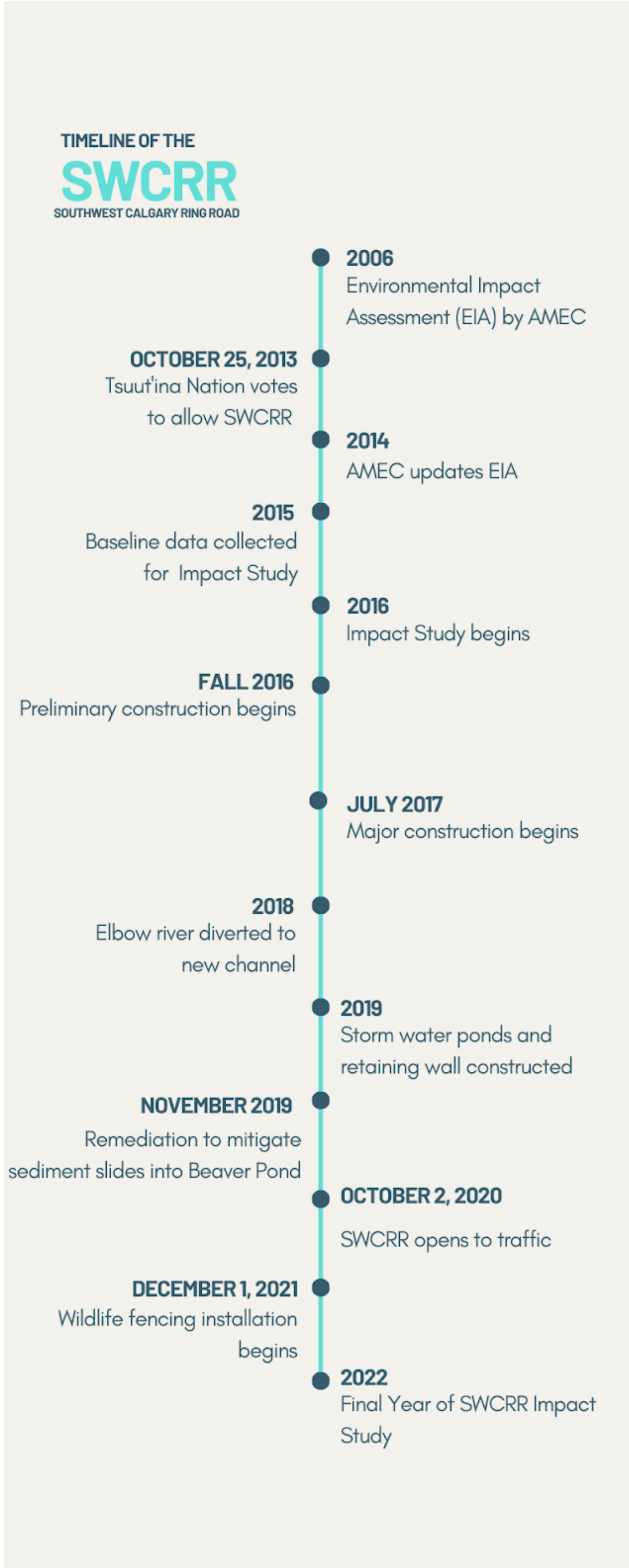

Figure 1. Timeline of assessments & construction phases

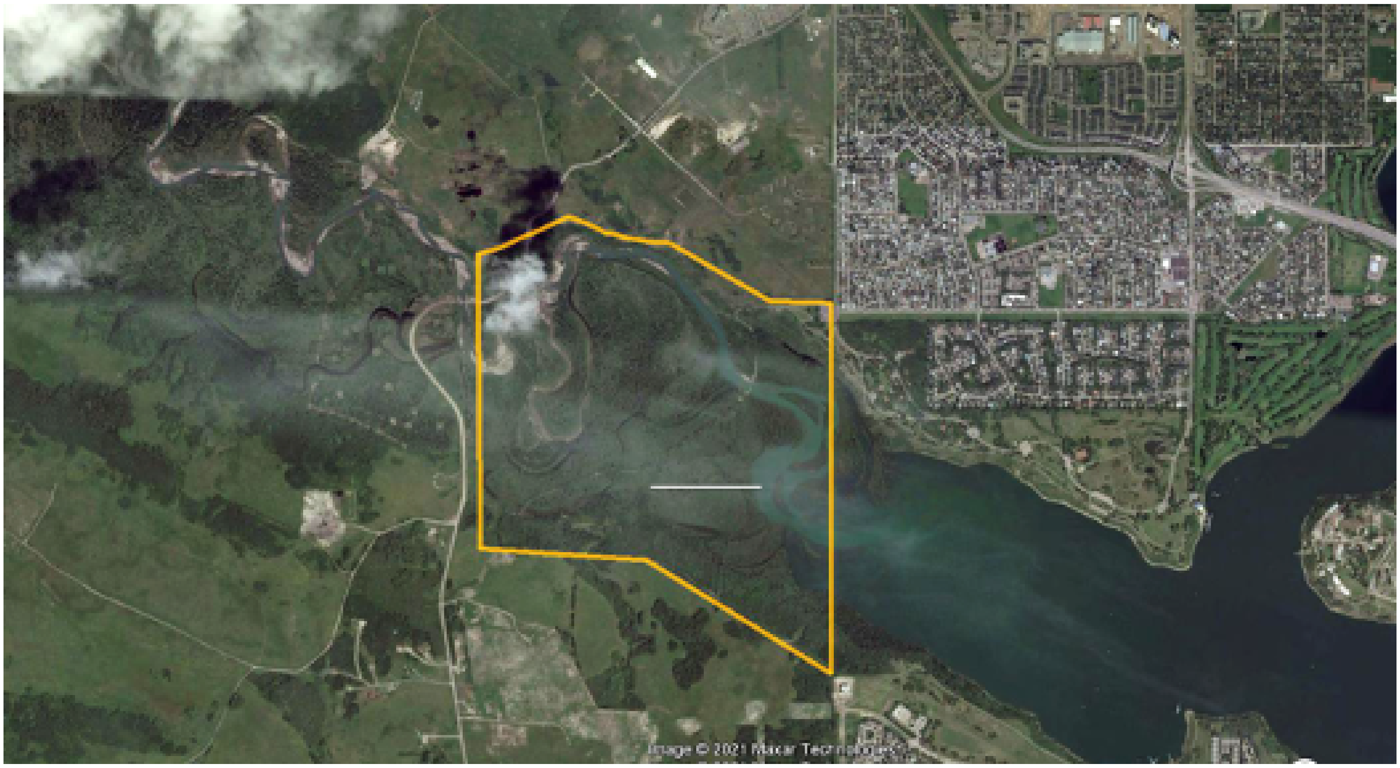

Figure 2A. An aerial image Sept. 8, 2016 before major construction began (*downloaded from Google Earth); o*range line shows Weaselhead boundary; scale: white line = 500 m.

Figure 2B. The same area in May 30, 2021, with the SWCRR nearly complete; of the Weaselhead and its boundary shown by orange line; scale: white line = 500m.

Figure 3. An aerial view of the Weaselhead with the SWCRR under construction and the different hydrological features indicated (Aug. 4, 2020).

RESULTS: TERRESTRIAL HABITATS

a. Breeding Bird Survey

In 2021 the breeding bird survey was conducted using the same protocol and study design as in 2016 – 2020 and as the EIA[1]. In order to produce comparable results, time of year, location of survey stations, and times of observation were also kept constant. Similar weather conditions as in previous years pertained on the day of the survey: gentle to moderate breeze (Beaufort Scale), sunny, temperature 12 - 15˚C during the hours of observation, and no precipitation.

Volunteer groups were limited to three people with at least one expert observer. On June 22, 2021, three groups of volunteers carried out the survey, each group visiting a different set of sites (Figure 4). Data from survey point P1 was collected on June 29, as this station was accidentally missed on June 22, 2021. The conditions on June 29, 2021 remained similar and within the timeframe for surveying that had been used in past years. 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 predetermined 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 station, 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	Station	Latitude	Longitude
P1	50° 59.789’ N	114° 09.427’ W	P15	50°59.513’N	114° 08.709’ W
P2	50° 59.772’ N	114° 09.221’ W	P16	50°59.572’N	114° 08.470’ W
P3	50° 59.738’ N	114° 08.931’ W	P17	50°59.431’N	114° 08.343’ W
P4	50°59.701’ N	114°09.347’ W	P18	50°59.331’N	114° 08.072’ W
P5	50°59.647’ N	114°09.180’ W	P19	50°59.200’N	114° 09.278’ W
P6	50°59.584’ N	114°09.359’ W	P20	50°59.141’N	114° 09.435’ W
P7	50°59.446’ N	114°09.346’ W	P21	50°59.189’N	114° 09.673’ W
P8	50°59.477’ N	114°09.128’ W	P22	50°59.114’N	114° 09.097’ W
P9	50°59.324’ N	114°09.621’ W	P23	50°59.119’N	114° 08.887’ W
P10	50°59.320’N	114° 09.355’ W	P24	50°58.977’N	114° 08.894’ W
P11	50°59.320’N	114° 09.092’ W	P25	50°58.963’N	114° 08.618’ W
P12	50°59.359’N	114° 08.815’ W	P26	50°58.816’N	114° 08.506’ W
P13	50°59.560’N	114° 08.948’ W	P27	50°58.875’N	114° 08.312’ W
P14	50°59.663’N	114° 08.757’ W	P28	50°58.766’N	114° 08.018’ W

Figure 4. Location of breeding bird survey points ***(scale: white line = 500m)***

During the 2021 bird survey 371 individuals from 47 different species were identified within the 100 m of the survey sites (raw data is available on request; summaries are shown in Tables 2 and 3). As in earlier years the total Simpson's index of diversity for the breeding bird survey was high (1-S = 95.31%). The Simpson's index of diversity (1-S) is a measure of the likelihood that any two random birds you select out of the sample belong to different species, taking into account species richness and species evenness. With a 95% chance that any two randomly selected data points from 2021 are birds of a different species, that is a good indicator of high biodiversity. Density was calculated in some previous years, however, due to unidentified bird species found in recent years in the breeding bird surveys, statistical analysis or comparison was unable to be completed on this metric for 2021.

Table 2. Breeding bird survey species list (June 22, 2021) with total individual counts (species indicated as *sensitive; ** may-be-at-risk Alberta Wild Species General Status Listing[2] , * Previously listed)**

Clay-colored Sparrow	*Spizella pallida*	33
Yellow Warbler	*Setophaga petechia*	33
White Throated Sparrow	*Zonotrichia albicollis*	27
Cedar Waxwing	*Bombycilla cedrorum*	25
Black-capped Chickadee	*Poecile atricapillus*	22
American Robin	*Turdus migratorius*	20
House Wren	*Troglodytes aedon*	17
Veery	*Catharus fuscescens*	17
American Goldfinch	*Spinus tristis*	15
Red-winged Blackbird	*Agelaius phoeniceus*	14
Canada Goose	*Branta canadensis*	13
Least Flycatcher***	*Empidonax minimus*	13
Brown-headed Cowbird	*Molothrus ater*	12
Tree Swallow	*Tachycineta bicolor*	11
Cliff Swallow	*Petrochelidon pyrrhonota*	8
Red-breasted Nuthatch	*Sitta canadensis*	7
Gray Catbird	*Dumetella carolinensis*	6
Red-eyed Vireo	*Vireo olivaceus*	6
White-winged Crossbill	*Loxia leucopyere*	6
Franklin's Gull	*Leucophaeus pipixcan*	5
Pine Siskin	*Spinus pinus*	5
Common Goldeneye	*Bucephala clangula*	4
Downy Woodpecker	*Picoides pubescens*	4
Ring-necked duck	*Aythya collaris*	4
Song Sparrow	*Melospiza melodia*	4
White-breasted Nuthatch	*Sitta carolinensis*	4
Yellow-rumped Warbler	*Setophaga coronata*	4
Chipping Sparrow	*Spizella passerina*	3
Lincoln's Sparrow	*Melospiza lincolnii*	3
Sora*	*Porzana carolina*	3
Spotted Sandpiper	*Actitis macularius*	3
American Crow	*Corvus brachyrhynchos*	2

Common Raven	*Corvus corax*	2
North. Rough-Winged Swallow	*Stelgidopteryx serripennis*	2
Warbling Vireo	*Vireo gilvus*	2
Alder Flycatcher***	*Empidonax alnorum*	1
Bank Swallow*	*Riparia riparia*	1
Blue-headed Vireo	*Vireo solitarius*	1
Common Yellowthroat*	*Geothlypis trichas*	1
House Finch	*Haemorhous mexicanus*	1
Killdeer	*Charadrius vociferus*	1
Lesser Scaup	*Aythya affinis*	1
Mallard	*Anas platyrhynchos*	1
Philadelphia Vireo	*Vireo philadelphicus*	1
Pileated Woodpecker*	*Hylatomus pileatus*	1
Sapsucker Sp.		1
Savannah Sparrow	*Passerculus sandwichensis*	1
Unknown Swallow Species		1
Western Wood Pewee**	*Contopus sordidulus*	1

Table 3. Breeding bird survey (June 22, 2021) – birds seen or heard between stations or further than 100m from survey points or flying overhead.

Species	Latin Name	
Canada Goose	*Branta canadensis*	41
Franklin's Gull	*Leucophaeus pipixcan*	36
White Throated Sparrow	*Zonotrichia albicollis*	9
American Robin	*Turdus migratorius*	6
Cliff Swallow	*Petrochelidon pyrrhonota*	5
Mallard	*Anas platyrhynchos*	5
American Crow	*Corvus brachyrhynchos*	2
Cedar Waxwing	*Bombycilla cedrorum*	2
Red-winged Blackbird	*Agelaius phoeniceus*	2
Spotted Sandpiper	*Actitis macularius*	2
Yellow Warbler	*Setophaga petechia*	2
Bald Eagle*	*Haliaeetus leucocephalus*	1
Black billed Magpie	*Pica hudsonia*	1
Blue-winged Teal	*Spatula discors*	1

Clay-colored Sparrow	*Spizella pallida*	1
Common Goldeneye	*Bucephala clangula*	1
Common Loon	*Gavia immer*	1
Gray Catbird	*Dumetella carolinensis*	1
Northern Flicker	*Colaptes auratus*	1
Northern Shoveler	*Spatula clypeata*	1
Tree Swallow	*Tachycineta bicolor*	1
Veery	*Catharus fuscescens*	1
Franklin's Gull	*Leucophaeus pipixcan*	496
American Robin	*Turdus migratorius*	9
Common Goldeneye	*Bucephala clangula*	8
Tree Swallow	*Tachycineta bicolor*	8
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	5
Mallard	*Anas platyrhynchos*	4
American Goldfinch	*Spinus tristis*	3
American Crow	*Corvus brachyrhynchos*	2
American Wigeon	*Mareca americana*	2
Cedar Waxwing	*Bombycilla cedrorum*	2
Common Raven	*Corvus corax*	2
American Coot	*Fulica americana*	1
Bald Eagle*	*Haliaeetus leucocephalus*	1
Black Capped Chickadee	*Poecile atricapillus*	1
Downy Woodpecker	*Picoides pubescens*	1
Lincoln's Sparrow	*Melospiza lincolnii*	1
Northern Flicker	*Colaptes auratus*	1
Red winged Blackbird	*Agelaius phoeniceus*	1
Song Sparrow	*Melospiza melodia*	1
Spotted Sandpiper	*Actitis macularius*	1

Four species of 'sensitive' status were seen or heard during the survey within 100 m of survey points (not including those seen flying overhead): Bank Swallow, Common Yellowthroat, Pileated Woodpecker, and Sora, and one species that 'may-be-at-risk': The Western Wood-pewee ([2]Alberta Environment and Parks). Table 4 shows how this compares with previous years. Two birds previously categorized as sensitive are no longer listed as sensitive on the 2020 Alberta General Species Status Listing, The Alder Flycatcher and Least Flycatcher.

Table 4. Birds of 'sensitive' or 'may-be-at-risk' status, recorded during surveys 2016 - 2021

	status	2016	2017	2018	2019	2020	**2021**
Western Wood-pewee	may-be-at-risk	X	X		X	X	**X**
Bank Swallow	sensitive	X	X				**X**
Olive-sided flycatcher	sensitive			X			
Pileated Woodpecker	sensitive	X	X		X		**X**
Baltimore Oriole	sensitive		X			X	
Common Yellowthroat	sensitive		X				**X**
Sora	sensitive		X				**X**
Alder Flycatcher	Previously listed as sensitive					X	**X**
Least Flycatcher	Previously listed as sensitive	X	X	X	X	X	**X**

As in previous surveys, a significant linear regression slope (d.f.=26, $p<0.05$) was found between the cumulative number of different species and the cumulative area investigated. The 2021 survey species per area regression follows the general function: $CS=0.49A+6.2$ ($R^2=0.99$), 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 0.49 "new" species were recorded with each additional hectare surveyed. This represents an important recovery from the 2020 slope value (0.31A).

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 (Figure 5).

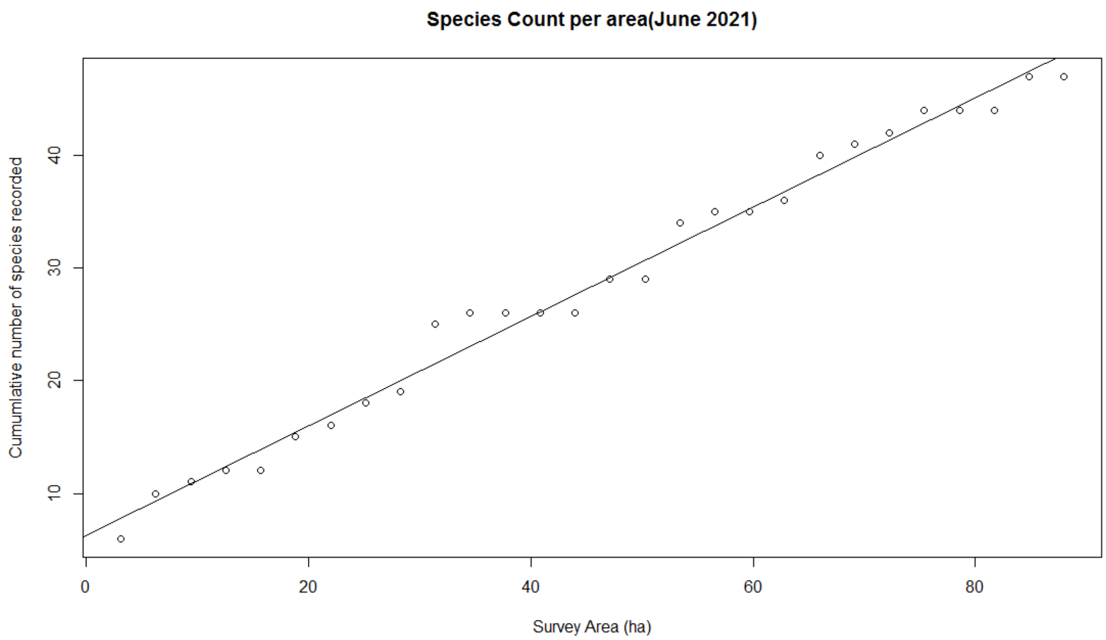

Figure 5. Regression model between cumulative number of species recorded and area, increasing in increments of 3.14ha (= area of a 100m-radius circle around stations in which observations were made)

Data from [3]eBird records for June and July 2021 show an additional 21 avian species were observed in the Weaselhead during this period (Table 6). This information can be found at https://ebird.org/hotspot/L267671.

Table 5. An additional 21 species were observed and reported to eBird in June, and July 2020 in the Weaselhead that were not recorded during the WGPPS survey. (Species indicated with a * were previously listed in the Alberta Wild Species General Status Listing[2]).

Common Name	***Species***	***Status 2021***
American Avocet	*Recurvirostra americana*	Secure
Baltimore Oriole*	*Icterus galbula*	Secure
Barn Swallow	***Hirundo rustica***	**May Be at Risk**
Brewer's Blackbird	*Euphagus cyanocephalus*	Secure
Calliope Hummingbird	*Selasphorus calliope*	Secure
Canvasback	*Aythya valisineria*	Secure
Cinnamon Teal	*Spatula cyanoptera*	Secure
European Starling	*Sturnus vulgaris*	Exotic/Alien
Mourning Dove	*Zenaida macroura*	Secure
Northern Pintail	*Anas acuta*	Secure
Peregrine Falcon	***Falco peregrinus***	**At Risk**
Red-breasted Merganser	*Mergus serrator*	Secure
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	Secure

Ruby-throated hummingbird	*Archilochus colubris*	Secure
Rufous Hummingbird	*Selasphorus rufus*	Secure
Swainson's Thrush	*Catharus ustulatus*	Secure
Tundra Swan	*Cygnus columbianus*	Secure
Turkey Vulture*	*Cathartes aura*	Secure
Vesper Sparrow	*Pooecetes gramineus*	Secure
Violet-green Swallow	*Tachycineta thalassina*	Secure
Willow Flycatcher	*Empidonax traillii*	Secure

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, Quest Soundpro SE, (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 28^{the} and 29th June 2021. Levels were measured at the same points (stations) as used in the breeding bird survey (Table 1, Figure 4). On each site, the sound level was measured for 2 minutes (Table 6). Please note that water levels in the Glenmore Reservoir were raised days prior to the survey resulting in water levels being too deep to access sites P12, P15 and P23. Site P12 noise survey was conducted 20 m north of site. The 'average' was calculated as the average between the minimum and maximum levels. *(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 2021 (minimum, maximum, average and peak).

Site	Date	Time (UCT-6)		Sound Pressure (dB)		
			Avg*	Max	Min	Peak
P1	6/29/2021	8:49	52.45	59.3	45.6	75.9
P2	6/29/2021	7:36	56.95	66	47.9	87.4
P3	6/29/2021	7:06	53.15	56.4	49.9	72.9
P4	6/29/2021	7:52	75.4	100.8	50	94.4
P5	6/29/2021	7:45	54.45	59.9	49	74.3
P6	6/29/2021	8:06	76.15	103	49.3	98.3
P7	6/29/2021	8:26	50.9	55.1	46.7	72.1
P8	6/29/2021	8:33	53.25	59.9	46.6	87.9
P9	6/28/2021	16:27	47.25	49.8	44.7	79.5
P10	6/28/2021	16:20	48.1	51.9	44.3	78.3
P11	6/28/2021	16:56	67.15	89.3	45	83.9
P12	6/28/2021	17:11	57.85	71	44.7	72.2
P13	6/29/2021	7:26	68.8	88.5	49.1	88.6
P14	6/29/2021	6:58	50.9	54.9	46.9	86.8
P15						
P16	6/29/2021	9:26	72.75	98.7	46.8	90.2
P17	6/29/2021	6:34	49.3	50.8	47.3	74.1
P18	6/29/2021	6:42	54	60.2	47.8	88.2
P19	6/28/2021	16:11	73.75	103.1	44.4	98.5
P20	6/28/2021	17:47	70.6	87.3	53.9	77.7
P21	6/28/2021	16:36	71.25	96.9	45.6	90.9
P22	6/28/2021	16:03	73.6	102.8	44.4	97.7
P23						
P24	6/28/2021	15:52	48.15	51.7	44.6	71.9
P25	6/28/2021	15:42	50.95	57.3	44.6	85.4
P26	6/28/2021	18:06	57.05	69.2	44.9	66.6
P27	6/28/2021	15:33	45.65	47	44.3	64.1
P28	6/28/2021	18:18	46.4	48.4	44.4	75.8

The sound level data is not homoscedastic, therefore a non-parametric analysis was performed. A Kruskal-Wallis test identifies that all sound parameters (average, minimum, maximum and peak) for different years have non-identical populations (Kruskal-Wallis rank sum test df = 5, $p<0.05$). Most of the sound parameters have their highest recordings after 2019 (Figure 6). 2017 is when construction noise was first recorded in the survey, and 2021 was the first noise data collected after the opening of the road.

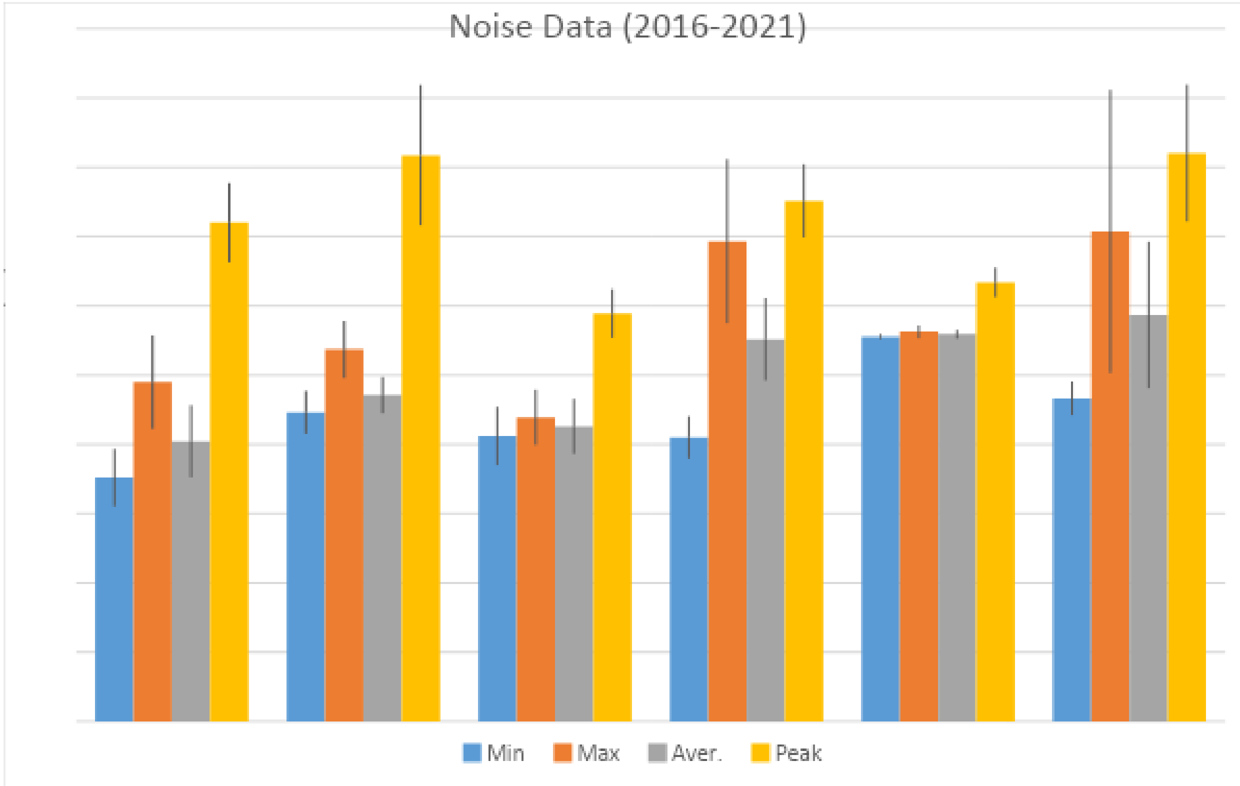

Figure 6. Sound levels measured in the Weaselhead from 2016-2021. The error bars represent ± standard deviation.

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 (Figure 7). The results for 2021 are detailed below. The same site was used from 2015 to 2021. The same protocol was used as in 2015 to 2019. The assessments from the first 3 years included only flowering plants in the clade 'eudicot'. From 2018 on, estimates of % cover of graminoids and moss have been included as supplemental data. In 2019, 2020, and 2021 monocots in the orchid and lily families were found during the survey (and the title of the table of results amended to "vascular plants").

Figure 7. Green line shows location of 50m transect used for vegetation survey on the north bank of the east Beaver Pond; orange line shows the Weaselhead boundary. (Aerial image from Google Earth, May 30, 2021).

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 8). 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 2021 each selected quadrat was comprehensively screened, and individual vascular plants present counted and identified to species level (Table 7). For graminoids the percentage of canopy cover was recorded rather than counting individual clumps or plants (except for cattails where individual plants were counted). The percentage cover of moss was also estimated (Table 9).

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

Shoreline (south)

Figure 8. Disposition of 50 quadrats (2m x 2m) on a west-east transect along the Beaver Pond shoreline. From these 15 randomly selected quadrats were included in the survey using a random generator app (numbers 1, 5, 11, 12, 15, 19, 20, 21, 27, 37, 41, 47, 48, 49, 50).

Occurrence (number of quadrats with one or more of the species) and abundance (mean count of species in occupied quadrats) of vascular plants are summarized (Table 8), and information on the [5]USDA wetland classification for 'Great Plains' region provided where available.

Table 7. Vascular plants occurrence (number of quadrats with one or more of the species) and abundance (mean count of the species in occupied quadrats); *noxious weed *([6]Alberta Weed Control Act 19/2010);* [nn]non-native species *(unregulated)*

Vascular plants - eudicots	Common name	Occurrence	Abundance	USDA wetland classification
Viola canadensis	Canada Violet	14	29.5	FACU
*Cirsium arvense**	Creeping/Canada Thistle*	14	14.6	FACU
Rosa acicularis	Prickly Rose	13	16.5	FACU
Anemone canadensis	Canada Anemone	12	4.8	FACW
*Sonchus arvensis**	Field Sow Thistle*	12	12.0	FAC
Euthamia graminifolia	Goldenrod (Canadian, flat top and giant grouped)	12	10.8	FAC
Cornus sericea	Red-Osier Dogwood	12	3.3	-
Taraxacum officinale[nn]	Dandelion[nn]	11	4.4	FACU
Persicaria amphibia var. stipulacea	Water smartweed	11	5.0	-
Thalictrum venulosum	Veiny Meadow Rue	11	9.8	FAC
Pyrola asarifolia	Common Pink Wintergreen	10	14.6	-
Symphyotrichum ciliolatum	Lindleys Aster	10	37.9	-
Galium boreale	Northern Bedstraw	10	9.7	FACU
Amelanchier alnifolia	Saskatoon	10	3.7	FACU
Elaeagnus commutata	Silverberry	10	4.2	UPL
Rubus pubescens	Trailing Raspberry	10	8.9	-
Senecio pauperculus	Balsam Groundsel	9	4.3	FACU
Potentilla fruticosa	Shrubby cinquefoil, Potentilla	9	2.7	FACW
Shepherdia canadensis	Buffaloberry	8	2.4	FACU
Monarda fistulosa	Wild Bergamot	8	13.3	UPL
Antennaria pulcherrima	Showy Everlasting	7	8.1	-
Symphoricarpos albus	Snowberry	7	6.3	UPL
Fragaria virginiana	Wild Strawberry	7	13.3	FACU
Salix bebbiana	Bebb's Willow	6	1.3	FACW
Heracleum maximum	Cow Parsnip	5	1.8	FAC
Lysimachia ciliata	Fringed Loosestrife	5	15.4	FACW
Arctostaphylos uva-ursi	Bearberry	4	6.5	UPL
Sanicula marilandica	Maryland Sanicle	4	1.5	FACU

Betula occidentalis	Water Birch	4	1.5	FACW
Aster hesperium	Western Willow Aster	4	6.0	-
Mentha arvensis	Wild Mint	4	9.0	FACW
Vicia americana	American Vetch	3	1.7	FACU
Achillea millefolium	Common Yarrow	3	6.7	FACU
Scutellaria galericulata	Skullcap	3	7.3	OBL
Mertensia paniculata	Tall lungwort	3	2.0	-
Lonicera dioica	Twining Honeysuckle	3	4.7	FACU
Prunus virginiana	Chokecherry	3	1.3	FACU
Stellaria media	Chickweed	3	3.0	FACU
Salix pseudomonticola	False Mountain Willow	2	1.5	FACW
Stachys pilosa	Hairy Hedgenettle	2	2.0	FACW
Zizia aptera	Heart-leaved Alexanders	2	5.5	FAC
*Rhamnus cathartica**	Buckthorn*	2	1.0	FACU
Symphoricarpus occidentalis	Buckbrush	1	2.0	UPL
Sorbus aucuparia[nn]	European Mountain Ash[nn]	1	5.0	-
Trifolium repens	White Clover	1	1.0	FACU
Rosa woodsii	Wood's Rose	1	5.0	
Geum aleppicum	Yellow Avens See notes	1	2.0	FACU
Plantago major	Plantain	1	1.0	FAC
Symphyotrichum puniceum	Purple-stemmed aster	1	1.0	OBL
Packera paupercula	Balsam ragwort	1	1.0	FAC

Vascular plants - other	Common name	Occurrence	Abundance	USDA wetland classification
Equisetum arvense	Field Horsetail	15	11.9	FAC
Picea glauca	White Spruce	10	6.2	FACU

Vascular plants - monocots (excluding graminoids)	Common name	Occurrence	Abundance	USDA wetland classification
Maianthemum stellatum	Solomon's Seal	6	2.7	FACU
Orchidacea	orchid species, unable to be further identified	2	2.5	-

Table 8. Occurrence and estimated % cover of graminoids and bryophytes *(occurrence = total number of quadrats with presence of either taxa;* mean percentage cover = mean of % cover in occupied quadrats*)* *noxious weed *([6]Alberta Weed Control Act 19/2010);* [nn]non-native species *(unregulated).*

Graminoids (Poaceae and Cyperaceae)	Common name	Occurrence	Mean % cover	
Poa pratensis[nn] , P. palustris	Kentucky Blue Grass+ Fowl Blue Grass and creeping bentgrass	12	<8.3%	FACU+FACW
Calamagrostis canadensis/ C. inexpansa	Canada Reed Grass/Northern Reed Grass	11	<14.7%	FACW+-
Carex utriculata/C. capillaris	Small Bottle Sedge/Hair-Like Sedge/two seeded sedge/wheat sedge	7	<1.6%	OBL+FACW
Juncus balticus	Baltic Rush	4	<2%	FACW
Typha latifolia	Cattail	3	<10.3%	OBL
Bromus inermis[nn]	Smooth Brome[nn]	1	<2%	UPL
Bryophytes	Moss Cover %	12	<25.3%	

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*

Diversity of eudicot species: The 2021 results show a total taxa richness of 49 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 14.3% of the total eudicot individuals counted. This tiny plant occupies much of the ground cover in the studied region, with each plant individually only occupying a few square centimeters.

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 84.3%±11.7% per quadrat (2m x 2m) in 2021. Figure 9 compares Simpson's Diversity Index (1-S) per quadrat across the 2015 to 2021 sampling campaigns. The diversity has not changed significantly in this period (Kruskal-Wallis rank sum test df = 5, $p>0.05$).

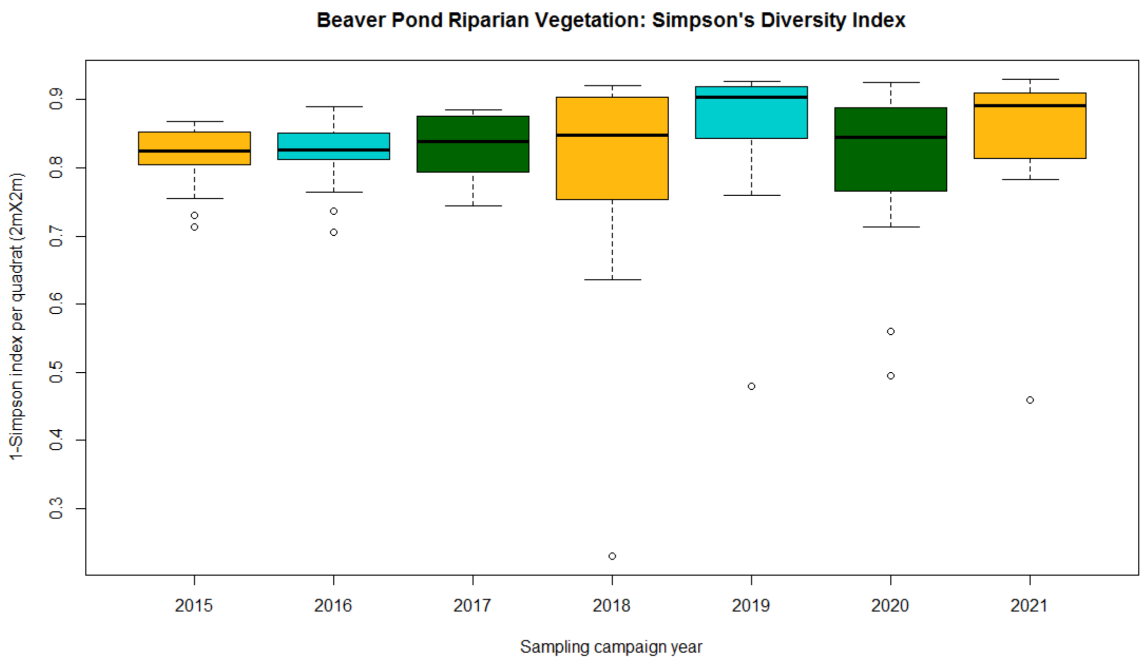

Figure 9. Simpson's Diversity Index (1-S) per quadrat for 2015 to 2021 sampling campaigns.

Richness of eudicot species: the data is neither homoscedastic nor normal, therefore a non-parametric analysis was performed. A Kruskal-Wallis test identifies that the richness data for different years have non-identical populations, with the lowest mean richness observed in 2015 and the highest was recorded in 2021 (Kruskal-Wallis rank sum test df = 5, $p<0.05$).

The measured mean of eudicot species per square meter along the shore of the Beaver Pond in 2021 was 5.17±2.10 species/m^2, (n=15). Figure 10 compares eudicots species richness per square meter between 2015 and 2021 sampling campaigns.

Increasing species richness suggests that the study area is gradually increasing in number of species over time. The species richness in a riparian zone is often limited by the presence of water or periodic inundations. Under these conditions, only species tolerant to water saturated soils would thrive. An increase in plant species richness might indicate a lowering of average water levels in the Beaver Pond, producing drier soil conditions, and allowing the colonization of other species. Additional data from future years will help to clarify if there is any quantifiable trend in the data.

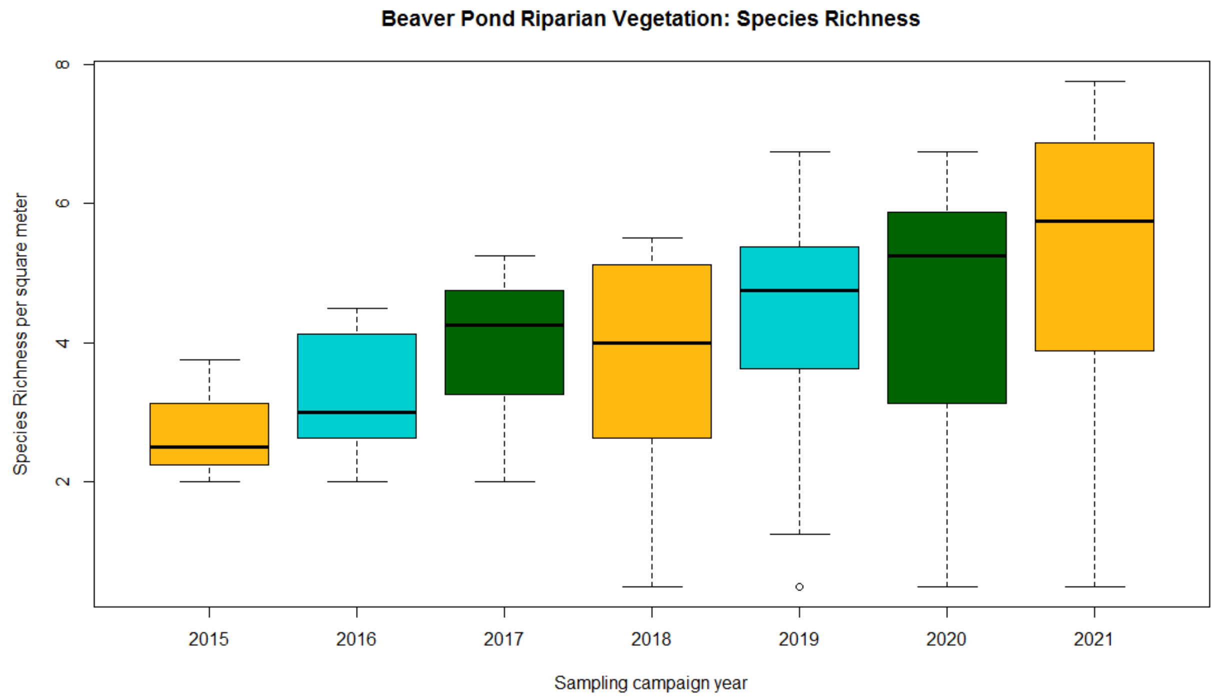

Figure 10. Eudicot species richness per square meter for 2015 to 2021 sampling campaigns.

d. Wildlife movement

In November 2018 the Society partnered with the Miistakis Institute in a 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. In 2020 this project collected data from 11 motion-activated cameras in the Weaselhead and adjacent Glenmore Parks, including two cameras relocated in the wildlife passages under the SWCRR (cameras 122, 123 and 134, Figure 9). '*Calgary Captured*' will give data on any change in presence/absence of species, change in seasonal use, and change in use of the area for breeding/raising young across the period of the Study, as well as identify wildlife utilizing the wildlife corridor. A preliminary list of species captured by these cameras (Table 9), including bobcat, moose, coyote, racoon, and white-tailed deer. (Full analysis of the *'Calgary Captured'* data is not expected till later in the project. Data from a similar study of wildlife in the Weaselhead also using motion-activated camera that was sponsored by the Society and run by SAIT from 2016 to 2018 has been incorporated where possible into the Calgary Captured dataset.[8])

Figure 11. Location of '*Calgary Captured'* cameras in 2021 (note – 2 cameras relocated under bridge in the wildlife corridor)

Table 9. Species identified in camera-trap photographs in 2021; * indicates photos of young and/or adult with young.

	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
bobcat	2019		X	X	X					X			
	2020		X					X				X	X
	2021	X											
white-tailed deer	2019				X	X	X*	X	X				
	2020						X*	X*		X			
	2021						X				X		
moose	2019				X		X*	X					
	2020					X*	X	X	X*		X		
	2021				X						X*		
black bear	2019								X				
	2020				X					X			
	2021												
coyote	2019			X	X	X	X						
	2020			X			X			X		X	
	2021	X											

cougar	2019												
	2020												
	2021												
racoon	2019												
	2020											X	
	2021			X				X					
porcupine	2019												
	2020												
	2021											X	
mink	2019												
	2020			X									
	2021												
beaver	2019												
	2020					X							
	2021												
snowshoe hare	2019												
	2020			X									
	2021												
red squirrel	2019												
	2020			X									
	2021												
striped skunk	2019												
	2020			X									
	2021												
great blue heron	2019												
	2020									X			
	2021												
sora	2019												
	2020							X					
	2021												
	Total	2	2	8	6	4	7	7	3	5	3	4	1

In a separate study for Alberta Transportation (AT), Golder Associates is monitoring use of the wildlife underpasses (Table 10). Each bank of the river is checked for signs of use (e.g., tracks, scat) every month. The corridor under the road itself was examined as well as the regions just outside of the corridor, called buffer regions. The 2021 reports showed large mammal presence (domestic dog, beaver, mink, cougar, deer, coyote) to the east and west of the Elbow River Crossing using the Buffer regions, but had limited evidence of corridor use (observation of tracks) under the bridges. Signs of animals under or between the bridges were much fewer than in the buffer regions though Calgary Capture cameras were able to confirm deer use under the bridges (Figure 12).

Table 10. Mammal tracks observed in wildlife corridors under one or more bridges, recorded by Golder Associates during monthly monitoring (The ? indicates tracks that were unable to be identified between domestic canine or coyote tracks.)

	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
small mammals	2019	X		X	X								
	2020												
	2021												
mink	2019							X		X			
	2020												
	2021												
domestic dog	2019			X									X
	2020	X	X										
	2021				X								
deer	2019												X
	2020				X								
	2021	X							X	X			
beaver	2019							X					
	2020												
	2021									X			
coyote	2019												
	2020	X?										X	X
	2021		X		X	X				X		X	X
white-tailed jackrabbit	2019												
	2020												X
	2021												
human	2019			X									
	2020												
	2021								X				
Bear	2019												
	2020												
	2021												
	Total	4	2	3	4	1	0	2	2	4	0	2	5

Figure 12. '*Calgary Captured'* photo of deer under bridge in the wildlife corridor.

Figure 13. Construction and sediment spill timeline

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, upstream of the SWCRR construction zone and not located in the Weaselhead (Figure 14). It is intended to represent a reference site against which to compare changes observed in the Weaselhead wetlands. The Beaver Pond is in immediate proximity to the SWCRR and is split into two cells by a paved pathway. The two cells are connected by a culvert. The Beaver Lagoon with which it is hydrologically connected, is further downstream. A drainage plan designed by the SWCRR contractor, KGL (Figure 17) aims to maintain surface flow to these wetlands during and post SWCRR construction.

Water quality data was collected from 2015 to 2021 from 3 sites in each of the three wetlands and from the Elbow River (Figures 15 and 16; Table 11). Four additional sample sites were added in 2018: another sample site in the east and west cells of the Beaver Pond (BP4 and BP5) and a sample site (SB and RC) in each of the two intermittent streams that flow into the wetland. Ravine Creek (RC) feeds into the east cell of the Beaver Pond (BP) and Spring Brook (SB) into the west cell. Both these streams have been impacted by construction of the SWCRR across their catchment areas (Figure 17).

These wetlands are upstream of the Glenmore Reservoir and Glenmore Dam. In September 2020 the City of Calgary completed updates to the dam to increase the storage capacity of the reservoir. This resulted in significantly higher June to late fall water levels in the reservoir compared to previous years. During this period the Beaver Lagoon effectively becomes part of the reservoir due to the significant hydrological connectivity. In 2021 in the Beaver Lagoon water level was increased by-~1.8m for this period.

Figure 14. Location of monitored wetlands.

Figure 15. 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; scale: yellow line = 500m

Figure 16. Location of sampling sites at Clearwater Pond; scale: yellow line = 100m

Table 11. 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

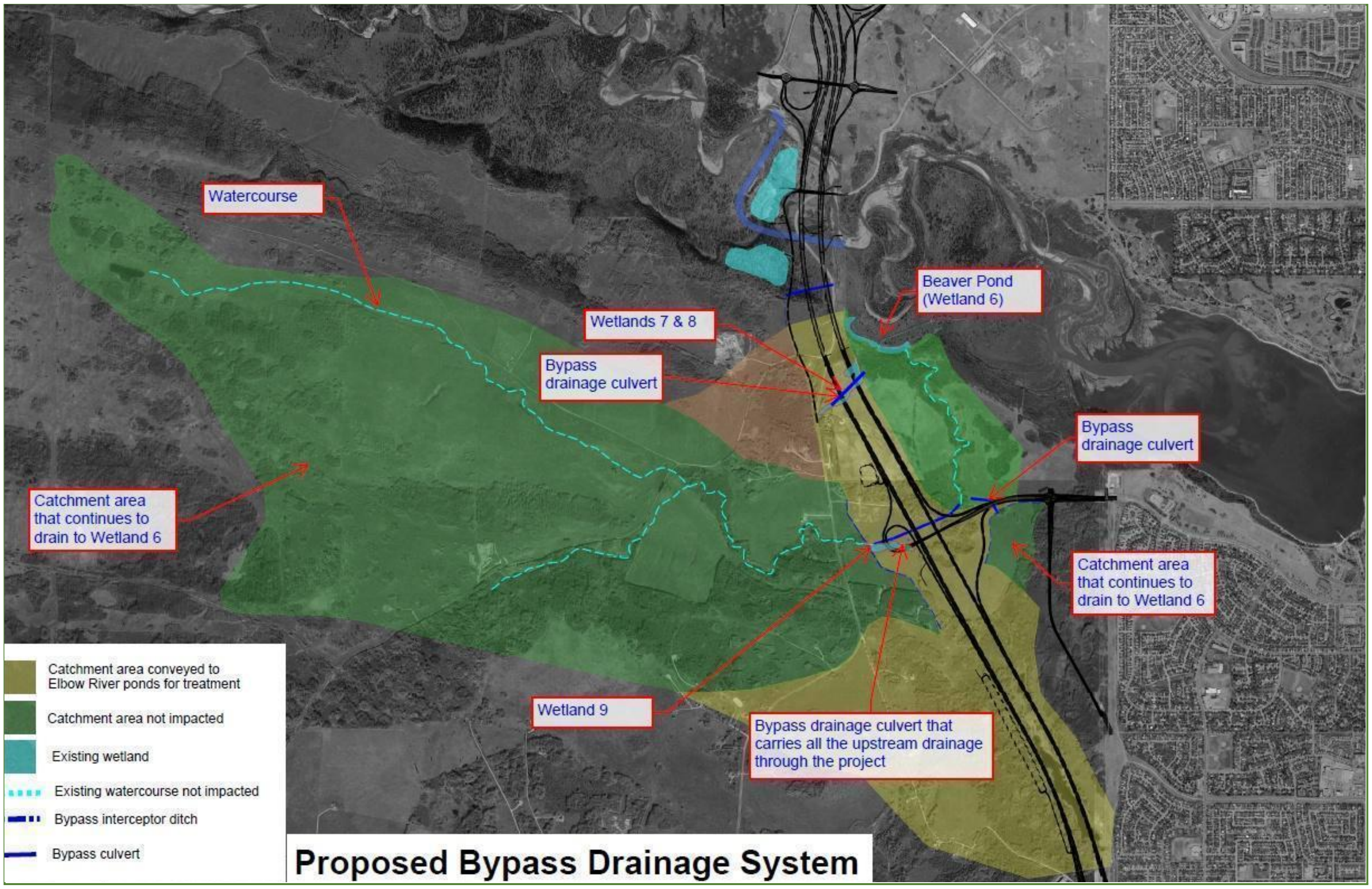

Figure 17. Bypass drainage for Spring Brook (northern culvert) and Ravine Creek (southern culvert) intended to maintain surface flow across the Transportation Utility Corridor into the Beaver Pond (*image courtesy of KGL – construction company for the SWCRR)*

Water sampling and in-situ assessments were performed on 21st Aug. and 16th Oct. 2021. In August we used a YSI® 556 Multimeter and in October we used a YSI® Pro DSSYI Pro DSS Multimeter to measure temperature, turbidity, conductivity, pH, and dissolved oxygen; a turbidity tube was used to measure transparency; and an YSI 9300 Photometer to measure phosphate, chloride salts and nitrate. Water quality data (Tables 12 and 13) and summary statistics for temperature, pH, conductivity, dissolved oxygen, phosphate, and chloride (Table 14) are shown below.

Statistical hypothesis tests (linear regression analysis) were only conducted for the parameters that were recorded using the same method since the start of the Study in 2016: conductivity, chloride, pH, phosphorous, dissolved oxygen, and temperature. Results are discussed separately below.

Table 12. Water quality parameters on August 21, 2021.

	Water body/Site													
Field:Aug 21 2021	Beaver Pond					Beaver Lagoon			Elbow River	Clearwater Pond			Beaver Pond Feeder Streams	
Parameters	BP1	BP2	BP3	BP4	BP5	BL1	BL2	BL3	ER	CP1	CP2	CP3	RC	SB

Transparency (cm)	13.3	7.2	15.5	19	17.5	>120	>120	> 120	> 120	>120	48	92.5	>120	>120
Turbidity (NTU)	55	81	48	41	47	<5	<5	<5	<5	<5	17	11	<5	<5
Temperature (°C)	16.0	14.3	12.6	14.4	15.6	12.6	13.1	13.0	10.4	14.9	14.9	15.0	11.1	9.7
Electrical Conductivity (uS/cm)	504.0	688.0	461.3	678.0	558.0	310.0	313.3	314.0	296.3	180.3	194.3	176.0	734.7	540.3
Total Dissolved Solids-TDS (g/L)	0.40	0.56	0.39	0.55	0.44	0.26	0.26	0.27	0.27	0.14	0.16	0.14	0.65	0.50
Dissolved oxygen (%)	79.70	41.63	79.77	93.33	75.20	91.33	102.17	88.60	86.10	130.50	99.00	113.20	90.87	81.77
Dissolved oxygen (mg/L)	7.78	4.12	8.36	9.57	10.69	9.66	10.49	9.30	9.56	13.12	9.87	11.26	9.90	9.23
pH	8.17	7.56	7.66	8.12	8.60	7.92	7.85	7.97	7.86	9.21	8.78	9.24	7.59	8.16
Phosphate (mg/L PO4)	0.14	0.05	0.16	0.23	0.24	0.04	0.07	0.02	0.01	0.10	0.06	0.00	0.02	0.02
Chloride (mg/L CL)	8.00	12.00	7.00	5.00	9.00	5.00	4.00	1.00	0.00	2.00	5.00	2.00	14.00	36.00
Nitrate (mg/L N)	0.44	0.30	0.60	0.79	0.62	0.21	0.23	0.29	0.29	0.44	0.34	0.52	0.69	0.51

Table 13. Water quality parameters on October 16, 2021.

	Water body/Site													
Field:Oct 16 2021	Beaver Pond					Beaver Lagoon			Elbow River	Clearwater Pond			Beaver Pond Feeder Streams	
Parameters	BP1	BP2	BP3	BP4	BP5	BL1	BL2	BL3	ER	CP1	CP2	CP3	RC	SB
Transparency (cm)	6.1	4.5	5.8	5.6	26	>120	>120	>120	>120	>120	22	6.2	34	>120
Turbidity (NTU)	86	95	87	89	39	<5	<5	<5	<5	<5	35	85	21	<5
Temperature (°C)	2.0	1.3	1.9	1.8	4.4	4.9	4.4	4.3	5.2	6.2	7.0	4.2	4.1	2.5
Electrical Conductivity (uS/cm)	771.0	263.6	783.3	809.3	795.3	429.8	423.9	436.8	442.4	269.2	276.8	265.9	989.7	801.3
Dissolved oxygen (%)	27.5	48.7	64.4	56.9	73.7	89.9	91.9	85.3	82.4	113.8	96.8	103.4	40.9	82.9
pH	7.7	8.0	8.2	8.1	8.1	8.4	8.3	8.3	8.3	9.3	8.9	9.2	7.6	8.1
Oxidation Reduction Potential-ORP (mv)	58.5	82.3	17.8	102.0	-1.5	95.3	111.3	73.2	61.4	69.0	75.0	80.2	126.3	43.2

Phosphate (mg/L PO4)	<<	0.49	0.16	0.1	0.21	0.05	0.36	0.45	0.02	0.12	0.3	0.11	0.06	0.03
Chloride (mg/L CL)	15	18	17	18	23	28	22	30	30	1	8	7	18	11
Nitrate (mg/L N)	0.087	<<	0.11	0.037	0.145	0.305	0.65	0.335	0.305	0.371	0.229	0.285	0.356	0.455
Salinity (ppm)	0.4	0.2	0.4	0.4	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.5	0.3

Table 14. 2021 summary statistics for temperature, pH, conductivity, dissolved oxygen, phosphate, and chloride (only parameter for which statistical testing was conducted); each value represents the average (±SEM).

	site	number of replicates	assessment date (2021)	temperature (°C)	pH	conductivity (µS/cm)	DO (%)	phosphate PO4 (mg/L)	chloride (mg/L)
Beaver Pond	BP	5	Aug. 21	14.6 (±0.60)	8.0 (±0.19)	577.9 (±45.6)	73.9 (±8.63)	0.16 (±0.03)	8.2 (±1.16)
		5	Oct. 16	2.28 (±0.54)	8.0 (±0.09)	684.4 (±105.42)	54.2 (±7.86)	0.19 (±0.08)	18.2 (±1.32)
Beaver Lagoon	BL	3	Aug. 21	12.9 (±0.15)	7.91 (±0.03)	312.4 (±1.2)	94.0 (±4.14)	0.04 (±0.01))	3.33 (±1.20)
		3	Oct. 16	4.5 (±0.19)	8.3 (±0.03)	430.2 (±3.73)	89.0 (±1.95)	0.29 (±0.12)	26.7 (±2.40)
Clearwater Pond	CP	3	Aug. 21	14.9 (±0.03)	9.1 (±0.15)	183.5 (±5.5)	114.2 (±9.11)	0.05 (±0.03)	3 (±1.0)
		3	Oct. 16	5.8 (±0.83)	9.1 (±0.12)	270 (±3.23)	104.7 (±4.95)	0.18 (±0.06)	5.3 (±2.19)

(Note: monitoring of water quality and water flow in the Beaver Pond (referred to as 'wetland 06') was also carried out in 2021 by Hemmera Envirochem Inc. on May 28, 2020, and Oct 15, 2020. The 2020 [10]Wetland 06 Annual Water Monitoring Report found elevated zinc concentrations in the Beaver Pond. Further monitoring has been carried out by the consultant and high levels of zinc were again identified as a concern in 2021.

<u>i) Turbidity</u>

Turbidity is dictated by the concentration of suspended and dissolved solids in the water column ([11]Sawyer *et al.*, 2003). It is a parameter that is sensitive to mechanical disturbances in the watershed such as erosion processes and sediment transport. Large increases in turbidity can also be linked to algal blooms ([11]Sawyer *et al.*, 2003).

Prior to Oct. 2018 turbidity was measured in NTU using a YSI ProPlus. From Oct. 2018 on the transparency of the water was measured using a turbidity tube. A conversion table published by [12]ORSANCO was used to estimate NTU from the turbidity tube results. Results from the former method cannot accurately be compared with the latter, therefore Table 15, below gives a qualitative rather than quantitative picture of turbidity in the monitored wetlands over the period of the Study.

Table 15. Turbidity levels recorded from 2015 to 2021

Turbidity assessment date	**Beaver Pond** *(n=3, *n=5)*	**Beaver Lagoon** *(n=3)*	**Clearwater Pond** *(n=3)*	**Ravine Creek** *(n=1)*	**Spring Brook** *(n=1)*
using YSI ProPlus (NTU ± SEM)					
Nov. 1st 2015	4.3 (±0.8)				
Aug. 26th 2016	12.0 (±9.4)	2.2 (±0.4)			
Oct 19th 2016	3.6 (±3.2)	0.0 (±0.0)	11.0 (±1.0)		
Aug. 26th 2017	19.1 (±5.8)	0.1 (±0.0)	21.7 (±6.9)		
Oct. 21st 2017	22.8 (±2.1)	0.0 (±0.0)	16.0 (±1.7)		
Aug. 27th 2018	296.0 (±236.7)	3.1 (±3.8)	1.6 (±1.8)	3.4	4.3
using a:turbidity tube (estimated NTU ± SEM)					
Oct. 21st 2018	19.8* (±3.9)	81.3 (±7.6)	81.8 (±3.6)	0.0	0.0
Aug. 19th/20th 2019	11.8* (±3.1)	1.7 (±1.7)	0.0 (±0.0)	7.0	0.0
Oct 13th/14th 2019	10.2* (±2.1)	2.0 (±2.0)	8.7 (±4.4)	0.0	7.0
Aug. 27th 2020	12.8* (±3.4)	<3	<3	<3	4.7
Oct. 15th 2020	71.3* (±17.1)	<3	<3	4.0	<3
Aug. 21st 2021	54.4* (±7.0)	<5 (±0)	<11(±3.5)	<5	<5
Oct. 16th 2021	79.2 (±10.2)	<5 (±0)	<5	41.7 (±23.3)	<5

No significant change in turbidity was recorded before 2018 ([13]Environmental Monitoring Report 2018, WGPPS). Very high levels of turbidity were recorded intermittently in all three wetlands in 2018. In Oct. 2020 turbidity recorded in the Beaver Pond was high (statistical testing of the data was not possible).

(Note: the 2021[10]Wetland 06 Annual Water Monitoring Report by Hemmera Envirochem also found turbidity higher than historic measurements taken in 2016 and 2017.)

ii) **Temperature**

Regression analysis of data from the Beaver Pond, Beaver Lagoon and Clearwater Pond for the period 2015 to 2021 does not show any association between water temperature and year when comparing the same months (linear regression, $p>0.05$), i.e. no trend towards temperature increase or decrease was evident in any of the monitored wetlands from 2015 to 2021 (Figure 18). However, temperature of the wetlands are likely to vary with the temperature of inflowing water and the air temperature from day to day, so two annual observations (one in August and on in October) as used in this study are probably inadequate to measure slow progressive temperature trends.

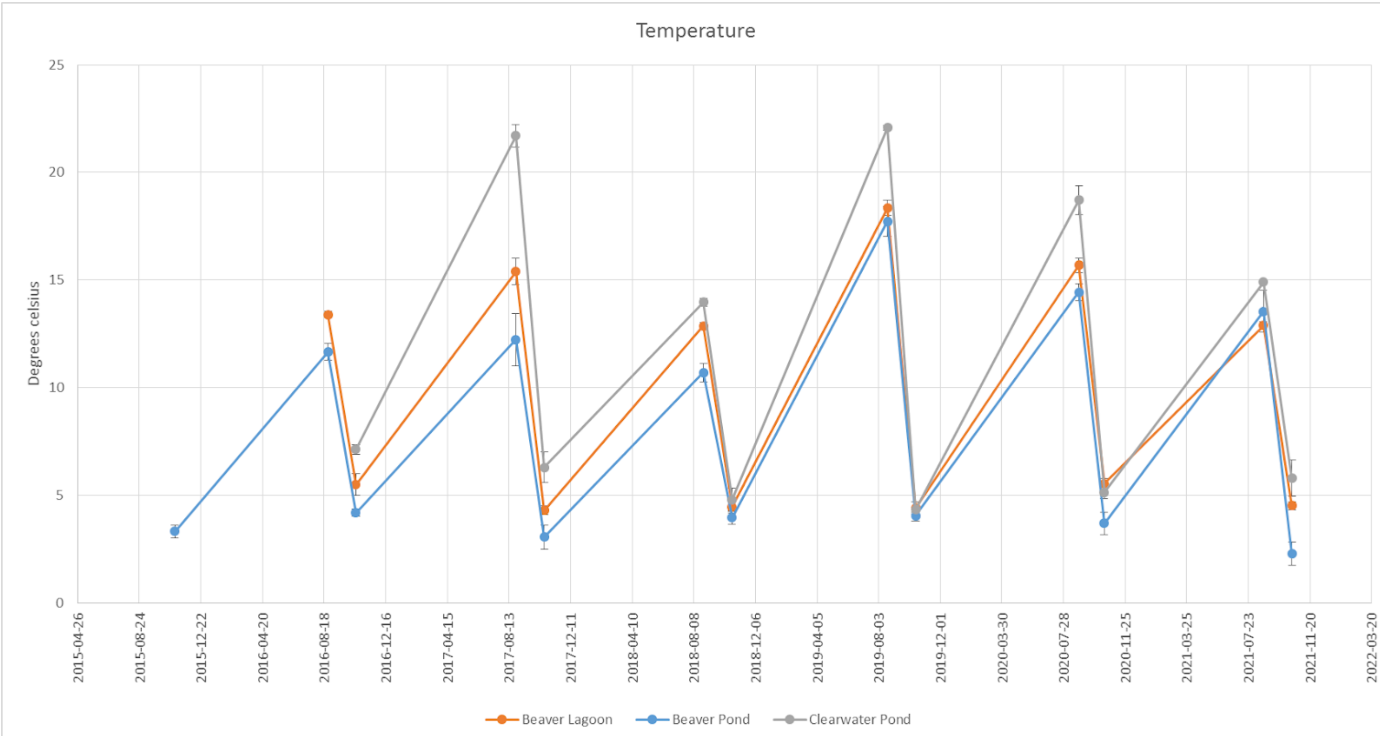

Figure 18. Temperature recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) between 2015 and 2021.

iii) pH

The pH scale reflects the chemical balance of the elements present in water that determine its acidic, neutral, or basic conditions ([11]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, Beaver Lagoon and Clearwater Pond for the period between 2016 and 2021 does not show any association between water pH and year when comparing the same months (linear regression, p>0.05), (Figure 19).

Figure 19. pH recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP) between 2015 and 2021.

iv) Conductivity

Conductivity 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 ([11]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.

Regression analysis for the Beaver Pond for the period between 2015 and 2021 revealed a significant increase in conductivity over time (linear regression, d.f.=49 (Beaver Pond), p<0.05). During the same period, the reference wetland (Clearwater Pond) and the Beaver Lagoon have not shown any association between conductivity and time (linear regression, p>0.05) (Figure 20).

Conductivity fluctuations in the Beaver Pond between 2015 and 2021 shows the average conductivity levels were typically below 600 uS/cm until 2018 when they peaked, and that averages in both wetlands have remained above 600 uS/cm until summer 2020. A drop to values below 600 uS/cm was observed in fall 2020.

In contrast, during this period the reference wetland upstream of the SWCRR development has shown no significant increase in conductivity.

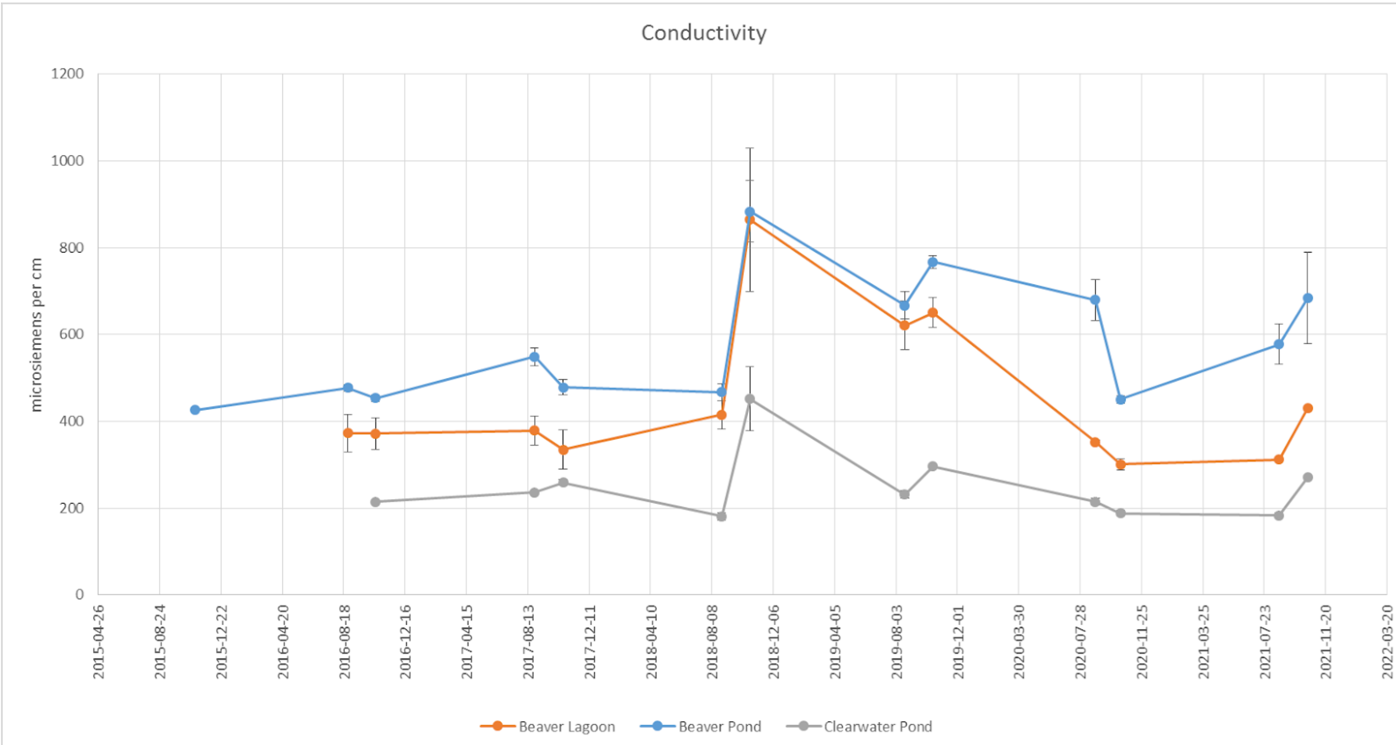

Figure 20. Conductivity recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) between 2015 and 2021.

v) Dissolved Oxygen

Regression analysis of data from Beaver Pond, Beaver Lagoon and Clearwater Pond, 2015 to 2021, does not show any association between dissolved oxygen (DO) and time (linear regression, $p>0.05$) (Figure 21).

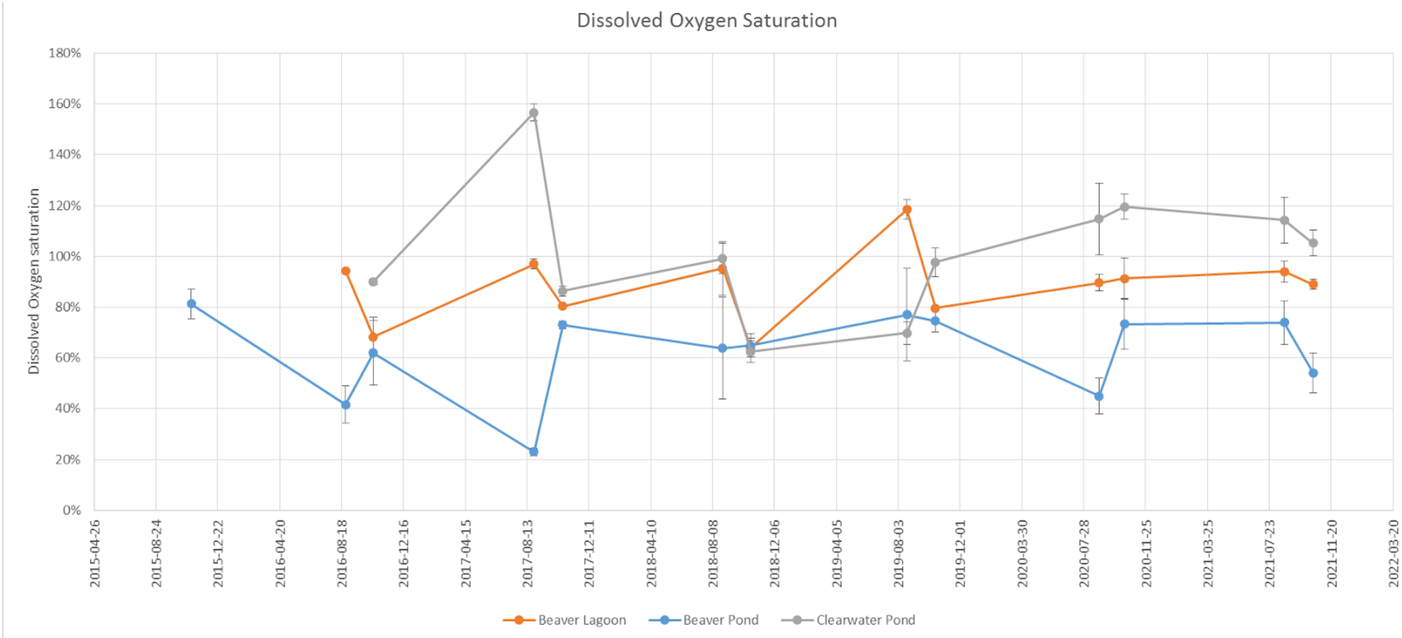

Figure 21. Dissolved oxygen (DO) recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) between 2015 and 2021.

vi) Chloride

Chloride is one of the important dissolved ions that can increase the electric conductivity of water ([11]Sawyer *et al.*, 2003). The measure of chloride (Figure 22) complements the data collected on conductivity by assessing the concentration of an ion that is of special interest in the study: the use of de-icing salts on the SWCRR may increase chloride concentration in adjacent wetlands.

Similar to the results obtained for conductivity, regression analysis for the Beaver Pond for the period between 2015 and 2021 revealed a significant increase in chloride over time (linear regression, d.f.=44 (Beaver Pond), $p<0.05$). During the same period, the reference wetland (Clearwater Pond) and the Beaver Lagoon have not shown any association between chloride and time (linear regression, $p>0.05$). Data from 2018 are incomplete and were not used in the statistical hypothesis testing.

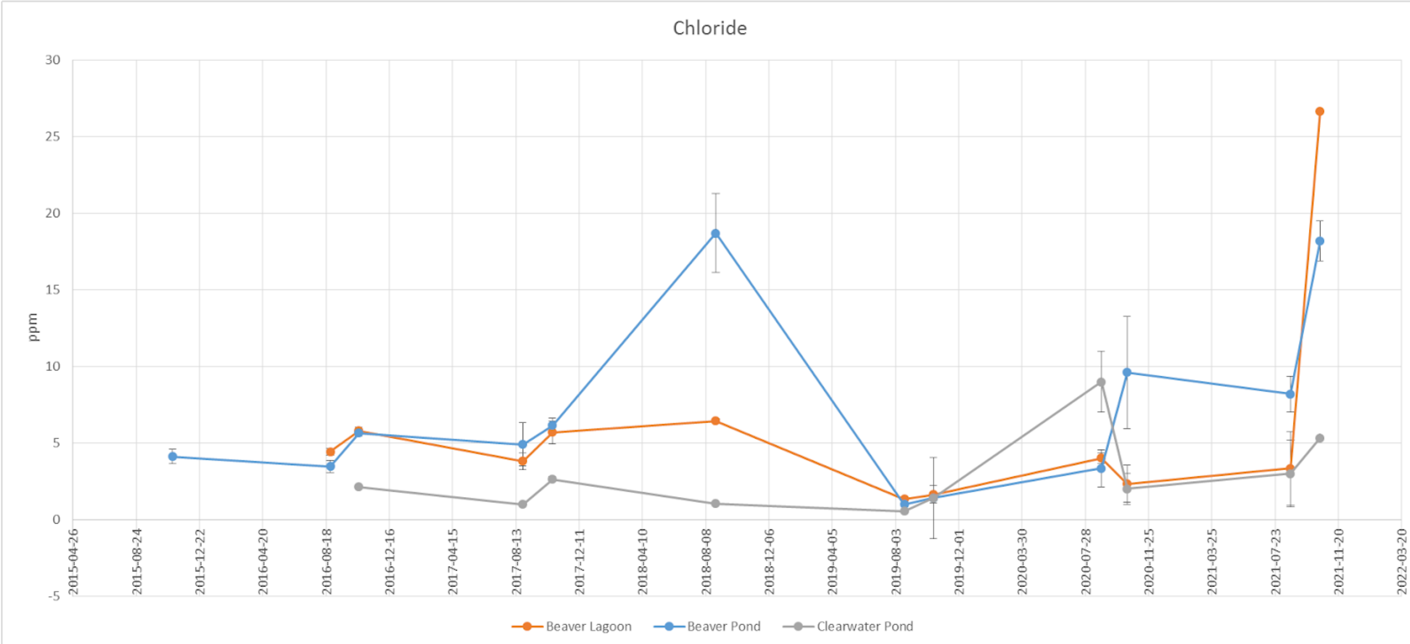

Figure 22. Chloride recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP) between 2015 and 2021.

vii) Nitrate

Nitrate levels have only been measured since 2019. Results in Table 16 show a marked increase in total nitrogen concentration in the two creeks that run into the Beaver Pond in 2020 and then a reduction by October 2021. *(Note: the test used also responds to nitrite in the water, normally very small in natural waters in comparison to nitrates)*.

Table 16. Nitrate concentrations recorded in 2020 and 2021

	Beaver Pond *(n = 5)*	**Beaver Lagoon** *(n = 3)*	**Clearwater Pond** *(n = 3)*	**Ravine Creek** *(n = 1)*	**Spring Brook** *(n = 1)*
Nitrate (mg/L N) ± SEM					
Aug. 19th/20th 2019	0.19 (±0.05)	0.03 (±0.1)	0.08 (±0.02)	0.14	0.05
Oct. 13th/14th 2019	0.12 (±0.04)	0.09 (±0.01)	0.10 (±0.02)	0.14	0.12
Aug. 17th 2020	0.31 (±0.11)	0.18 (±0.02)	0.15 (±0.01)	0.52	0.30
Oct. 15th 2020	0.58 (±0.09)	0.41 (±0.13)	0.17 (±0.07)	0.61	0.53
Aug. 21st 2021	0.59 (±0.08)	0.24 (±0.03)	0.43 (±0.05)	0.69	0.51
Oct. 16th 2021	0.08 (±0.03)	0.43 (±0.11)	0.30 (±0.04)	0.36	0.46

viii) Phosphorus

Phosphorus is one of the most important limiting nutrients in aquatic ecosystems ([11]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.

No significant changes were detected between 2015 and 2021 in the phosphate concentrations (Table 17 and Figure 23), nor in any of the monitored wetlands prior to 2018. Data from 2018 are incomplete and were not used in the statistical hypothesis testing. Two peaks can be distinguished, in 2019 and 2021, which are observed in all sampling sites, including the control.

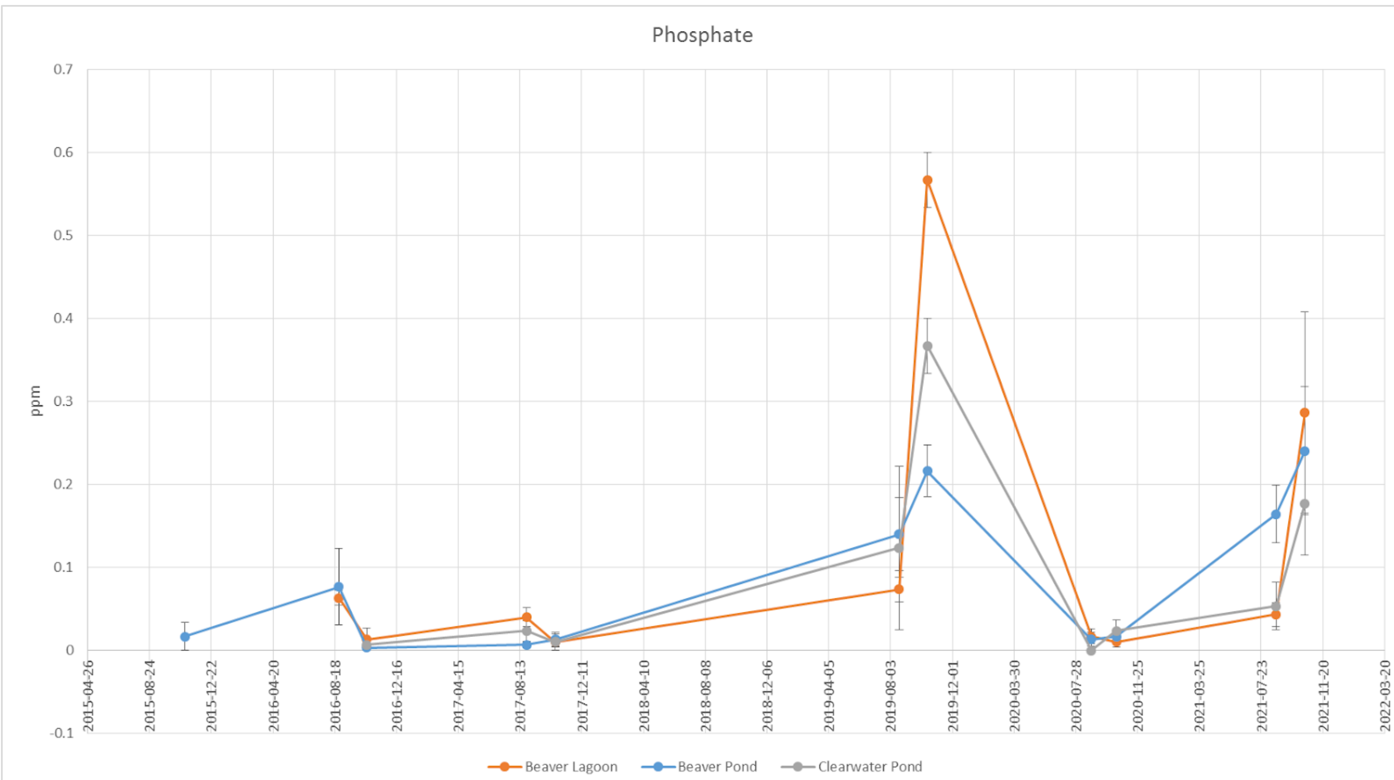

Figure 23. Phosphate recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) between 2015 and 2021.

Table 17. Phosphate concentrations 2015 to 2021.

Phosphate PO_4 (mg/L) ±SEM	Beaver Pond *(n=3, *n=5)*	Beaver Lagoon *(n=3)*	Clearwater Pond *(n=3)*	Ravine Creek *(n=1)*	Spring Brook *(n=1)*
Nov. 1st 2015	0.02 (±0.02)				
Aug. 26th 2016	0.08 (±0.05)	0.06 (±0.01)			
Oct 19th 2016	0.00 (±0.01)	0.01 (±0.01)	0.01 (±0.01)		
Aug. 26th 2017	0.01 (±0.00)	0.04 (±0.01)	0.02 (±0.01)		
Oct. 21st 2017	0.01 (±0.01)	0.01 (±0.02)	0.01 (±0.00)		
Aug. 27th 2018	0.14 (±0.08)	0.03 (±0.00)			
Oct. 21st 2018					
Aug.19th/20th 2019	0.14 (±0.02)*	0.07 (±0.06)	0.12 (±0.06)	0.79	0.23
Oct 13th/14th 2019	0.22 (±0.01)*	0.57 (±0.02)	0.37 ±0.02)	0.14	0.09
Aug. 27th 2020	0.01 (±0.01)	0.02 (±0.01)	0.00 (±0.00)	0.12	0.07
Oct 15th 2020	0.02 (±0.01)	0.01 (±0.01)	0.02 (±0.01)	0.10	0.04
Aug 21st 2021	0.16 (±0.03)	0.04 (±0.01)	0.05 (±0.03)	0.02	0.02
Oct 16th 2021	0.19 (±0.08)	0.29 (±0.12)	0.18 (±0.06)	0.06	0.03

b. Aquatic macroinvertebrates

In 2021 a total of 507 specimens were identified to 63 taxa for the habitats studied (BP, BL and CP, Tables 18 and 19). The 63 taxa identified represent the greatest taxonomic resolution achieved in 2021.

Table 18. Taxonomic classification for the aquatic macroinvertebrates sampled on August 21, 2021.

Aug, 21, 2021		Beaver Pond			Beaver Lagoon			Clearwater		
	Greatest Taxonomic Resolution Obtained	**BP1**	**BP2**	**BP3**	**BL1**	**BL2**	**BL3**	**CP1**	**CP2**	**CP3**
Mayflies	*Caenis* sp. (Stephens, 1835)	1					2			
	Centroptilum sp. (Eaton 1869)				3		1			
	Baetis						1			
	Isonychia						1			
Caddisflies	*Hydroptilidae*				1					
	Phryganeidae sp.				1		4			
	Phryganea									2
Dragonflies	*Aeshna* sp. (Fabricius, 1775)	1							1	2
	Calopteryx						1			
	Calopterydigae sp.								1	

	Enallagma sp. (Charpentier, 1840)	8					4		4	6
	Nehalennia				5	2				
True flies	*Anopheles earlei (*Vargas, 1943)				2		1			
	Ceratopogonidae sp.				1					
	Chironomidae sp.	1					1	1		
	Diamesinae					1	1			
	Psychodidae sp.	1								
	Tanypodina					1				
	Dixella				1				1	
Beetles	*Hydrophilidae sp.*								1	
	*Ilybius sp. (*Erichson, 1832)				1	1	1		1	
	Laccophilus sp. (Leach, 1815)									1
	Peltodytes	1								
True bugs	Corixidae	16	34	35	3		2	1	24	25
	Gerris sp.								2	
	Notonecta sp. (Linnaeus, 1758)			1	2	1	1			
Water fleas	*Chydoridae sp.*						1			
	Cladocera sp.				2					
	Daphnia						2			
	Polyphemus pediculus			1						
	Side crystallina					1				
	Simocephalus					1	3			
Bivalves	Pelecypoda					1				
	Sphaeriidae		1							
Scuds	*Gammarus lacustris* (G.O. Sars, 1864)					1	4			
	Hyalella azteca (Saussure, 1858)	1			11	8	56			2
	Ostracoda			3		29	10			
Gastropods	*Aplexa*				1					
	Physa sp. (Draparnaud, 1801)	8		3	4	2	2			
	Fossaria (Bakerilymnaea) bulimoides (I. Lea, 1841)							1	1	2
	Stagnicola sp. (Jeffreys, 1830)	1		2						
	*Probythinella lacustris (*F.C. Baker, 1928)							1		
	Promenetus umbilicatellus (Cockerell, 1887)			1		1		1	7	1
Leeches	*Erpobdella punctata*		1							

	Helobdella stagnalis			1						
	Theromyzon maculosum	1	1							
	Alboglossiphonia heteroclita	1								
Polychaeta	*Aeolosoma*					2				
Oligochaeta	*Naididae*			1		1				
Copepods	*Calanoida*					1				
	Orthocyclops				1	2	1			
	Cyclopoida					7	5			
	Paracyclops		1							
Acari	*Hydrachnidia*	1			1					

Table 19. Taxonomic classification for the aquatic macroinvertebrates sampled on October 16th, 2021.

Oct, 16, 2021		**Beaver Pond**			**Beaver Lagoon**			**Clear Water**		
	Greatest Taxonomic Resolution Obtained	**BP1**	**BP2**	**BP3**	**BL1**	**BL2**	**BL3**	**CP1**	**CP2**	**CP3**
Mayflies	*Caenis* sp. (Stephens, 1835)	1						1		3
	Callibaetis				1					
	Ephemerella						2			
Caddisflies	*Phryganeidae sp.*						1			
	Phryganea				2					
Dragonflies	*Aeshna* sp. (Fabricius, 1775)								1	
	Coenagrion									1
	Enallagma sp. (Charpentier, 1840)								1	
	*Ischnura sp. (*Charpentier, 1840)								1	1
True flies	Ceratopogonidae sp.				2				1	
	Chironomidae sp.		1							1
	Chironomini	1								
	Tanytarsini						1			
Beetles	*Laccophilus* sp. (Leach, 1815)	1								
	Peltodytes			3						
True bugs	Corixidae	5	2				1		1	
	Mesovelia mulsanti							1		
	Notonecta sp. (Linnaeus, 1758)		1							
Water fleas	*Daphnia*					1				
Bivalves	Pelecypoda									
	Sphaeriidae									

Scuds	*Gammarus lacustris* (G.O. Sars, 1864)				1		5			1
	Hyalella azteca (Saussure, 1858)				2	1	7			
Ostracoda	Cyrprididae								1	
	Ostracoda				1					
Gastropods	*Physa* sp. (Draparnaud, 1801)				1	1	3			
	Fossaria (Bakerilymnaea) bulimoides (I. Lea, 1841)					1				
	Stagnicola sp. (Jeffreys, 1830)				1					
	Probythinella lacustris (F.C. Baker, 1928)								1	
	Promenetus umbilicatellus (Cockerell, 1887)	1			1					
Leeches	*Helobdella stagnalis*		1							
Oligochaeta	*Naididae*	1								
Copepods	*Limnocalanus*									1
	Osphranticum									1
Acari	*Hydrachnidia*	9	1							

Table 20. Aquatic macroinvertebrates statistics (average ± SEM) (n=3)

Water body	Site	Assessment Date (2021)	Taxa Richness per Site/Sample	Simpson's Diversity Index (1-S) per Site/Sample	% of EPT Taxa
Beaver Pond	BP	August 22nd	9.0 (±2.3)	47.7% (±16.8%)	2.6% (±2.6%)
		October 18th	4.3 (±1.8)	49.0% (±24.6%)	4.8% (±4.8%)
Beaver Lagoon	BL	August 22nd	19.3 (±2.0)	77.9% (±5.0%)	13.5% (±6.8%)
		October 18th	6.3 (±1.5)	79.3% (±4.1%)	13.0% (±6.7%)
Clearwater Pond	CP	August 22nd	8.0 (±1.0)	69.8% (±6.7%)	3.7% (±3.7%)
		October 18th	5.3 (±1.7)	72.4% (±11.3%)	21.4% (±14.9%)

Taxa richness, Simpson's Diversity Index and % of EPT were calculated from the data (Table 20). The results are discussed under separate headings below.

i) Taxa Richness

Regression analysis of data from the Beaver Pond and Beaver Lagoon (Weaselhead sites), for the period between 2016 and 2021, does not reveal any significant association between taxa richness and time (linear regression, d.f.=10, $p>0.05$). For the same period, the data indicate a decrease in taxa richness for the reference site (Clearwater Pond) (linear regression, d.f. = 9, $p<0.05$).

These results suggest that the SWCRR Impact Study has not detected any significant trends of aquatic invertebrate taxa richness during this period on the studied wetlands. A decrease in the Clearwater Pond site richness (Figure 24), however, remains to be explained.

Figure 24. Taxa richness recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) from 2016 to 2021.

<u>ii) Simpson's Diversity Index</u>

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.

Regression analysis of data from the Beaver Pond and Beaver Lagoon (Weaselhead sites), for the period between 2016 and 2021, does not reveal any significant association between taxa diversity and time (linear regression, d.f.=10 Beaver Pond and Beaver Lagoon, d.f. = 9 Clearwater Pond, p>0.05). Following a drop in taxa diversity recorded in 2018, the diversity seems to have recovered for the Beaver Pond and Beaver Lagoon, and later declined again in the Beaver Pond 2021 (Figure 25).

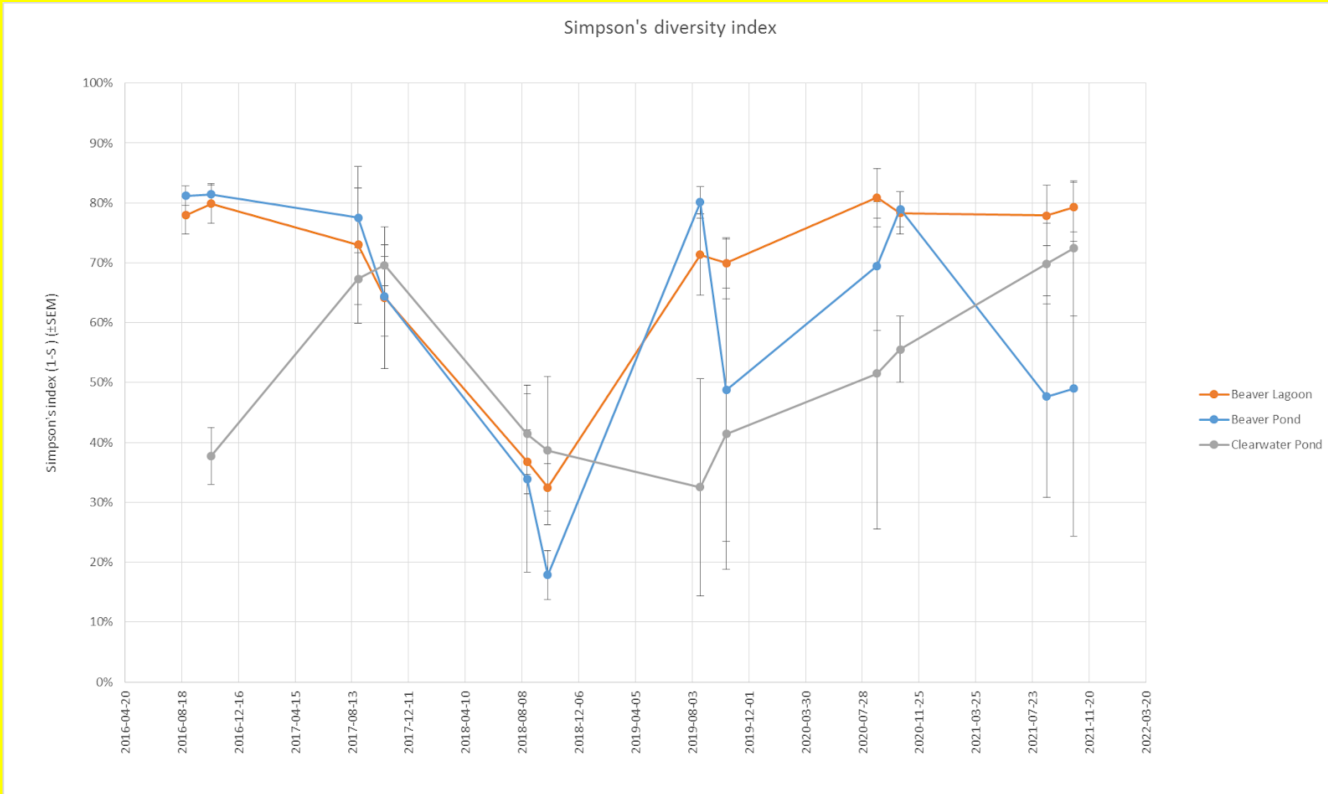

Figure 25. Simpson's diversity index recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) from 2016 to 2021.

iii) 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.

A regression analysis of data from the Beaver Pond, Beaver Lagoon (Weaselhead sites) and Clearwater Pond (reference wetland), for the period between 2016 and 2021, has not revealed any significant association between EPT taxa richness % and time (linear regression, d.f.=10 Beaver Pond and Beaver Lagoon, d.f. = 9 Clearwater Pond, $p>0.05$) (Figure 26). 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 usual values.

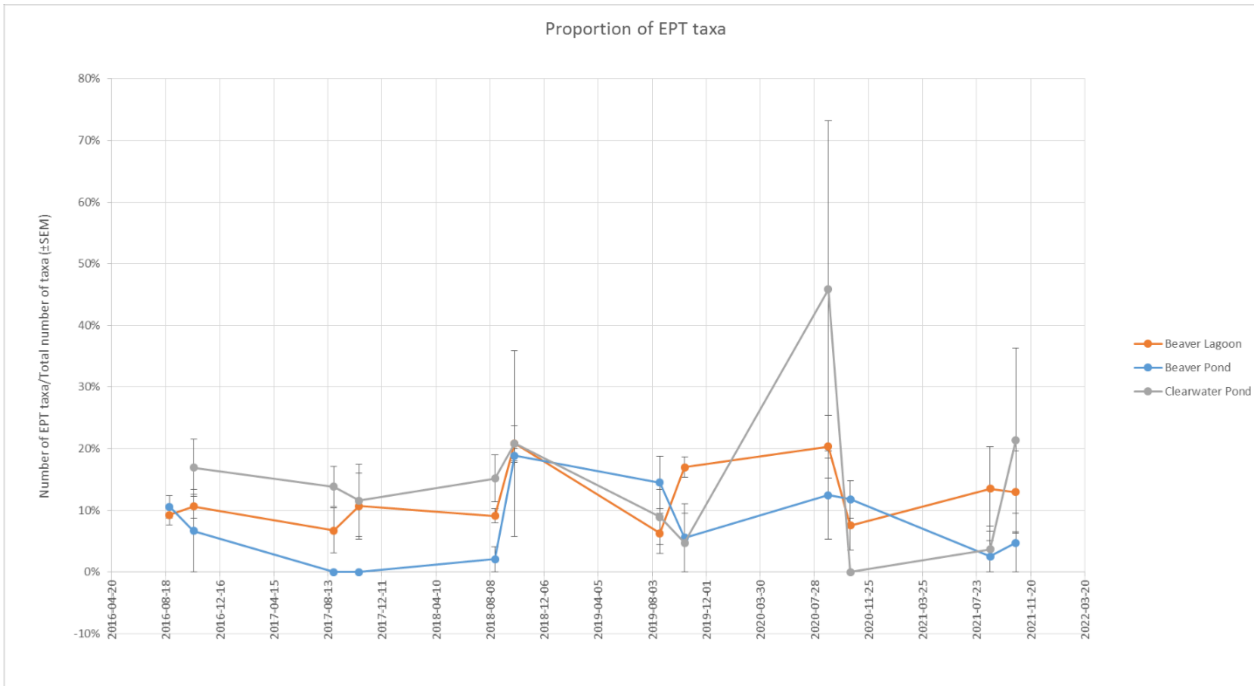

Figure 26. Proportion of EPT tax recorded in the monitored habitats (Clearwater Pond (CP), Beaver Lagoon (BL) and Beaver Pond (BP)) from 2016 to 2021.

c. Amphibians

Nocturnal amphibian call surveys were done at two locations in the Weaselhead from 2017 to 2021. Only boreal chorus frogs, *Pseudacris maculata* and wood frogs, *Lithobates sylvaticus* were detected (Figure 27; Tables 21 and 22). The locations match two used in 2012 and are close 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 at the completion of the 7 years of this study (2016 – 2022) results from the Weaselhead wetlands will be evaluated in the context of the results from this much larger study. Outcomes from this research[14] (Lee, T. et al. 2020) will help to decide if any changes in amphibian presence observed in the Weaselhead can be attributed to impacts associated with construction of the SWCRR, and guide potential restoration of movement corridors.

Figure 27. Locations of amphibian call surveys done in 2012 (green dots) and 2014 (purple dots) carried out for the EIA[1].(red line = boundary of construction zone; pink line = boundary of park;(blue line significance unknown). The 2017 to 2020 monitoring sites are indicated by white arrows.

Table 21. Boreal Chorus frogs heard during surveys conducted in 2012 to 2021; BP = Beaver Pond, OO = Old Oxbow *(2012 and 2014 data from Environmental Impact Assessment for the SWCRR, AMEC 2014[1]).*

	EIA 2012 *(no details of abundance)*		EIA 2014 *(no details of abundance)*		2017 *(no. of individuals heard)*		2018 *(no. of individuals heard)*		2019 *(no. of individuals heard)*		2020 *(no. of individuals heard)*		2021 *(no. of individuals heard)*	
Boreal Chorus frog	BP	OO	BP	OO	BP	OO	BP	OO	BP	OO	BP	OO	BP	OO
late April	present		present		0	0			0	0	0	0	0	0
early May					0	2	0	0	0	0	0	0	0	0
mid May	present		present		0	2	0	0			0	0		
late May	present		present		1	1			0	0	0	0	0	0
early June					0	1			0	0	0	0		

Mid June													0	0
late June					0	0					2	0		

Table 22. Wood frogs heard during surveys conducted in 2012 to 2021; BP = Beaver Pond, OO = Old Oxbow *(2012 and 2014 data from Environmental Impact Assessment for the SWCRR, AMEC 2014[1]).*

	EIA 2012 *(no details of abundance)*		EIA 2014 *(no details of abundance)*		2017 *no. of individuals heard)*		2018 *(no. of individuals heard)*		2019 *(no. of individuals heard)*		2020 *(no. of individuals heard)*		2021 *(no. of individuals heard)*	
Wood frog	BP	OO	BP	OO	BP	OO	BP	OO	BP	OO	BP	OO	BP	OO
late April	present		present		3	4			4	0	5	2	10-20	3
early May					2	0	4	0	3	0	10	2	0	0
mid May	present		present		0	0	0	0			0	0		
late May	present		present		0	0			0	0	0	0	0	0
early June					0	0			0	0	0	0		
Mid June													0	0
late June					0	0					1	0		

In addition to the above monitoring, following a spill of infill material from the construction site into the Beaver Pond in August 2019 and remedial action in November 2019, Alberta Environment and Parks (AEP) has ordered KGL to monitor amphibians in the Beaver Pond for two years. It was hoped that the results of this monitoring would be available for inclusion in this report in 2021 to be included in the 2021 Environmental Monitoring Report, but unfortunately these results will not be available until 2022.

d. Fish

Fish sampling is a way of monitoring the ichthyofauna diversity in key habitats in the Weaselhead (Beaver Pond and Beaver Lagoon). The third habitat monitored represents a reference site (Clearwater Pond) to which any observed changes in fish richness and diversity can be compared. In previous years of the impact study, each habitat had a minnow trap installed for one night baited with hot dogs, and dip netting carried out at the same location. A Fish Research License was obtained from 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. However, since 2018 we were continuously unsuccessful in catching fish using the minnow trap and the consensus was it was due to the traps mesh being larger than the minnows found in these habitats. Our previous sample methods were determined to be insufficient given the species present in the sample regions. In 2021 we decided to utilize only the dip net method, including fish caught in the three random scoops while catching aquatic invertebrates. Fish were removed from the sample, identified, measured, and released back to the water body immediately. The dip netting methodology was deemed to be more successful than the minnow trap. However, the difference in sample size may be attributed to lower water levels at the time of sampling and the patch distribution of the fish species. It is not assumed that the impact from the road statistically increased and influenced the number of fish in the wetlands.

The locations of the random scoops align with the same sites and methodology described for aquatic invertebrate sampling on August 21 and October 16, 2021.

Results are given in Table 23 below:

Table 23. Fish caught in minnow traps and caught with dip nets while collecting invertebrate samples, 2017- 2021 ***(*Note: students participating in Society's education programs regularly found brook stickleback in the Beaver Pond in 2017 and 2018).***

Location	20th Oct. 2017	8th Nov. 2018	14th Oct. 2019	15th Oct. 2020	21st Aug. 2021	16th Oct. 2021
Beaver Pond	11 fathead minnows *(Pimephales promelas)*	No fish caught	5 brook stickleback *(BP1)* *(Culaea inconstans)* (sizes: 2.6, 3.3, 3.5, 2.5, 2.0 cm)	1 brook stickleback *(BP 3)* *(Culaea inconstans)* (size: ?)	2 brook stickleback (BP 3) (*Culaea inconstans)* (size: 1.7, 2.1cm)	27 brook stickleback (BP1) (*Culaea inconstans)* (sizes: 1.3-3.2cm) (3.2, 3.3, 1.3, 2.6, 3.1, 1.5, 1.7, 2.9, 3.0, 2.6, 1.8, 2.6, 2.5, 1.4, 1.5, 2.4, 1.5, 2.0, 1.6, 1.4, 1.7, 1.6, 1.4, 1.7, 1.6, 1.4, 1.7, 1.6, 1.4, 1.6, 1.7, 1.4, 1.6 cm)
Beaver Lagoon	No fish caught	No fish caught	No fish caught	No fish caught	No fish caught	No fish caught
Clearwater Pond	19 white suckers *(Catostomus commersonii)*	No fish caught	No fish caught	2 brook stickleback *(CP 2)* (sizes: 2.0 and 3.0 cm)	No fish caught	1 brook stickleback (CP 2) (size: 3.5 cm) 1 unknown sp. Likely brook stickleback or fathead minnow, dorsal line observed may indicate *Chrosomus* (dace) (CP 1) (size: 1.8cm)

FINAL CONSIDERATIONS

The *Environmental Monitoring Report 2021* is an important step in the evaluation of the mitigation measures adopted during the construction phase and opening of the SWCRR. The road was opened October 1, 2020.

1) **Impact on wetlands**

One mitigation measure required by KGL's contract with Alberta Transportation is to *'install and maintain appropriate erosion and sediment control methods to prevent sediments from disturbed areas from being transported into watercourses.*' (p. 124, [9]Schedule 18 of DBFO agreement). So far, the measures adopted during the construction phase of the project have proved to be ineffective on some occasions. Two separate spills of sediment into the Beaver Pond occurred in 2018, one directly from the adjacent construction site and one via a creek, 'Spring Brook' that feeds into the wetland ([13]Environmental Monitoring Report 2018, WGPPS). Another spill of 'coarse infill' (pers. comm. Chris Pipher KGL Environmental Management Team) directly into the Beaver Pond in August of 2019 occurred. Again, in July 2020 sediment entered the Beaver Pond via a feeder creek (Figure 31) as a result of a failure of erosion control in the SWCRR construction zone following heavy rain. Most recently an erosion control measure failure occurred July 2, 2021, as detailed below. This spill occurred after the opening of the road and therefore had potential for carrying road contaminants into the wetlands.

Concern Regarding Drainage and Stabilization Mitigation:

On July 2, 2021, a major rain and hail event occurred, which is common in spring and summer, and was recorded by Environment Canada to have been 24.6mm of precipitation. This event resulted in an overwhelming volume of water running off the impermeable pavement surface of the ring road where it would have previously been absorbed by the former wetlands, forest, and meadow systems. The SWCRR design is intended to capture road runoff and direct it along a drainage system to the stormwater ponds for filtering before entering the river. This mitigation effort had not been completed to design specification when the rain event occurred, and major erosion of drainage channels occurred (Figure 28). The existing mitigation measures intended to direct runoff in the ditch through a culvert to the west side of the SWCRR (and from there to the stormwater ponds) also failed, resulting in a large amount of water with significant velocity running over a temporary berm and into Spring Brook, taking mixed and woody vegetative debris with it. The Beaver Pond, which Spring Brook feeds (Figure 16 to view the bypass drainage for Spring Brook) was heavily inundated with silty water, potentially carrying road contaminants. This event may have contributed to the increase in chloride and other pollutants found in the wetlands water quality assessments by both our Society and Hemmera Envirochem Inc. ([10]Wetland 06 Water Monitoring Report Southwest Calgary Ring Road Project). In addition the failure of the drainage systems resulted in the temporary closing of the SWCRR on July 2, 2021 as the road was overcome with water.

KGL Constructors, A Partnership
Wetland Assessment and Impact Report – Southwest Calgary Ring Road, Wetland 06

Appendix B
Project No. 102871-02

Photo 7 Western culvert berm after rain event.

Photo 5 Channel erosion within ditch alignment.

Figure 28. Silt inundation of culvert and ditch erosion after rain event. Taken from WAIR - Hemmera Inc.

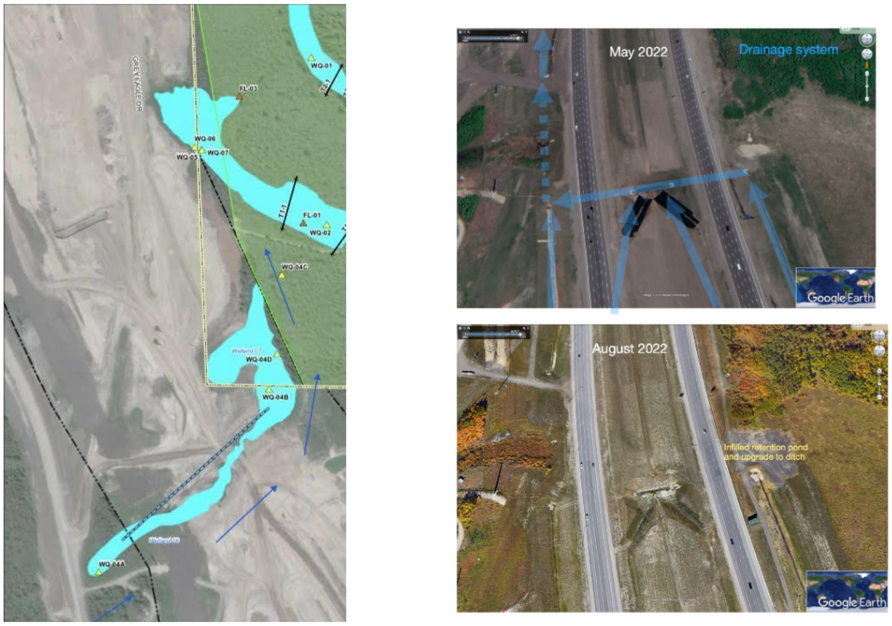

Figure 29. More detailed view of bypass drainage for Spring Brook (northern culvert) intended to maintain surface flow across the Transportation Utility Corridor into the Beaver Pond (Left image from WAIR – Hemmera Envirochem Inc., right images from Google Earth*)*

KGL and Hemmera staff made the following notes from their site visit on July 5, 2021, summarizing the event as noted in the WAIR – Hemmera Envirochem Inc. ([17]Wetland Assessment and Impact Report – Southwest Calgary Ring Road, Wetland 06. August 11, 2021):

KGL and Hemmera staff were onsite July 5, 2021, and recorded the following observations with photos included in **Appendix B**:

- The open highway ditch was heavily eroded prior to the July rain event (Hemmera 2021a) and worsened during the rain event.
- Riprap installed at the inlet of the culvert as part of the temporary berm was transported downstream and erosion was visible to the top of the bank.

Hemmera
An Ausenco Company
August 2021
Page | 3
210811_SWCRR_WAIR_Final_v2.0.docx

KGL Constructors, A Partnership
Wetland Assessment and Impact Report – Southwest Calgary Ring Road, Wetland 06 Project No. 102871-02

- Sediment accumulation within and around the surrounding inlet of the culvert indicated that culvert was likely compromised by sediment deposition and flow was impeded from being transported beneath the active roadway.
- Water accumulation within the holding pond and visual flow pathways (i.e., downed vegetation) indicated water overtopped the north portion of the holding pond and continued to flow to Wetland 06.
- Little to no sediment deposition was observed on the downed vegetation.

Figure 30. KGL and Hemmera staff observations (WAIR – Hemmera Envirochem Inc.) from July 5, 2021

In addition to the drainage ditch and the temporary berm intended to direct the water to the culvert, an earlier temporary holding pond to capture runoff was overwhelmed in the rain event. This holding pond has since been filled in and at the time of writing this report in April 2022, now exists as a field of mud, as hydroseeding efforts appear to have failed in the drought over the 2021 summer and fall months.

Alberta Erosion & Sediment Control conducted an Inspection on July 8, 2021, and did suggest that a "possible storage pond will need to be constructed" and it is suggested in addition to the sediment catchment pond that existed at the time of the inspection ([17]WAIR – Hemmera Envirochem Inc.). The area poses a risk for significant increased turbidity in Spring Brook and the Beaver Pond should a major rain event happen and again overwhelm the berm and drainage measures (Figure 31).

Photo 8 Holding pond downstream of culvert (T2).

Figure 31. The holding pond after the rain event on July 2, 2021, while the adjacent photo taken on April 19, 2022 shows a large area of un-vegetated mud. Photo 8 from Hemmera's WAIR.

In addition to the Spring Brook flooding, another location on the west end of the Beaver Pond, where previous sediment spills have occurred, also had heavy erosion and some sediment deposits. The turbidity was recorded on July 5, 2021, in the Beaver Pond by Hemmera to be 102 NTU, in contrast to their regular measurements in Spring and Summer being 1.1 - 7.4 NTU ([17]WAIR – Hemmera Envirochem Inc.). In response to this, the catchment pond installed in November 2019 adjacent to the wetland was filled in and replaced with an erosion control installation on the slope. (Figure 32 and 33).

Photo 2 Sediment fence along side temporary sump (holding pond) adjacent to Wetland 06.

Photo 1 Sediment plume observed in Wetland 06.

Figure 32. View of Beaver Pond and increased turbidity on July 5, 2021 (WAIR - Hemmera Envirochem Inc.)

Figure 33. Hemmera WAIR photo 12 shows the installation of the erosion control matting in the summer of 2021. The following image was taken April 19, 2022 of the erosion control matting and fencing.

Our Spring Brook monitoring site (Figure 15) was dramatically altered from this flooding event as debris and trees are nearly blocking access to the site (Figure 32). Bank erosion was noted in the [17]WAIR – Hemmera Envirochem Inc. Fortunately it is still accessible, but drastically different and could result in stream shifts. However, the deep groove in the landscape which channels Spring Brook to the pond will help to maintain the location of the stream.

Figure 34. View of Spring Brook after the flood on September 6, 2021. Photo by Stewart Rood

It was expected that the ring road will influence a shift in runoff patterns due to the capacity of absorption being impeded by the pavement, however these results indicate significant changes beyond what was anticipated. Corrective actions were made by KGL after this event to improve mitigation. These actions included raising and improving the armouring of the culvert berm, repairing the heavily eroded drainage channel by recontouring to stabilize the ditch line, and applying erosion control blankets as well as reseeding. This work was completed July 30, 2021. Hemmera is optimistic that these efforts will be adequate and KGL will continue to monitor the remediation of this area until 2023. Because of the repeated failure of sediment and erosion control measures throughout this project, the Society believes it will be pertinent that these locations continue to be monitored and mitigation measures improved where necessary following any future mitigation failures.

While ditch erosion and further sediment loading to the Beaver Pond is likely, some areas are seeing reasonable plant establishment while other areas have reduced coverage and non-native species establishing, including some noxious weeds.

On April 19, 2022, staff from the City of Calgary and AEP met with Lisa Dahlseide and Maureen Luchsinger of the Society to investigate the new drainage and stabilization system installed to prevent serious events like the one on July 2, 2021 from happening again (Figure 35).

Figure 35. April 19, 2022, visit to inspect drainage and stabilization improvements.

The water is expected in this design to take a hard 90 degree turn to drain into the culvert which directs it to the storm water ponds on the west side of the SWCRR. Another major rain event may result in the water overtopping the berm, running through the un-vegetated field north of it and carrying that sediment again into Spring Brook, further eroding the channel and dropping debris along it and eventually depositing the sedimentation and silt into the sensitive Beaver Pond, Wetland 06.

The Society recommends that KGL improve this design to ensure it is adequate given local hydrological data, and consider raising the berm height and armouring, as well as increasing the catchment space at the mouth of the culvert. Culverts appear too small to carry large volumes of water and may need upgrading. We also recommend replacing the sediment catchment pond located north of the berm in alignment with Alberta Erosion & Sediment Controls suggestion in their inspection report ([17]WAIR – Hemmera Envirochem Inc.).

2) **Water quality parameters**

Chloride concerns:

Regression analysis for the Beaver Pond for the period between 2015 and 2021 revealed a significant increase in chloride over time, as well as conductivity. The Beaver Lagoon had a noted increase in Chloride in 2021, however it has not yet been correlated to any pattern over time (Figure 22). As this was the first water quality testing since the opening of the road, this was expected, yet remains a disappointing reality related to road infrastructure in Alberta. The province is responsible for de-icing the roads and providing safe driving conditions. They use Calcium Chloride treated sand and Sodium Chloride (salt) as well as a mix of stockpile salt treated sand, depending on road conditions ([18]Alberta Transportation Website). The July 2021 spill into the Beaver Pond was the first road runoff spill to happen in the park. That water was intended to be directed to the storm ponds for filtration, but that did not happen due to the failure of the stormwater system in place. This event likely increased the Chloride in the wetlands. The Elbow River site had 0 mg/l chloride in the August sample but was higher at 30 mg/l in October (raw data available on request). High chloride levels affect aquatic invertebrates and species at all trophic levels having severe costs to freshwater ecosystems.

EPT indicators:

EPT represents pollution intolerant species of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). While the regression analysis of data has not revealed any significant statistical association between EPT taxa richness % and time, we remained concern about the absence of Caddisfly larvae found in the Beaver Pond. They were a species that consistently existed there prior to the construction sediment spills. On September 7, 2021, a group of students were conducting an educational pond study and discovered one individual caddisfly (Figure 36). This is a positive indication.

Figure 36. Caddisfly larvae discovered September 7, 2021, in the Beaver Pond

3) **Impact on noise**

It is apparent from our analysis of the data that the opening of the SWCRR increased noise levels in the park (Table 6 and Figure 6). It is an environmental concern in that the dB recorded may end up exceeding the provincial standards and require responsive sound wall mitigation. Traffic was significantly reduced in 2021 with the impact of COVID 19 lockdowns and work from home orders. Thus, as the economy continues to open up again, traffic is increasing along with the impact of noise on the park inhabitants.

4) Impact on wildlife movement

The *'Calgary Captured'* cameras recorded medium to large mammals in the Weaselhead, including species such as moose (Figure 35) and bear that require ranges far larger that the ~250ha Weaselhead for their needs. These animals are likely to have been using habitat to the west of the SWCRR as land to the east, outside of the park is fully developed. Monthly monitoring by Golder and Associates showed little evidence of wildlife using the designated wildlife passages to cross under the SWCRR and reports of animals seen on or near the highway suggest they may instead be crossing over it. Reluctance to go under the bridges may be because of the active construction noted by Golder on, under, or adjacent to the bridges, and because vegetation is still sparse in areas. Wildlife use may also have been missed in some months when conditions were not conducive to tracking.

Reports of deer, coyotes, and moose on the roadsides and of several wildlife collisions were received by the Society in the months following the road opening in October 2020. Wildlife fencing intended to prevent access to the SWCRR and to direct animals to the wildlife passages (Figure 39) unfortunately was not installed in 2020 despite the road opening to traffic in October.

Figure 37. Aug 2020. Two moose browsing caught on *Calgary Captured* camera #63, see Figure 11 for location.

Wildlife fencing installation began December 1, 2021 ([19] KGL Construction Schedule) and and is continuing to be installed as of May, 2021. Unfortunately, it does not extend across the complete expanse to functionally direct wildlife to the intended corridor for movement under the bridge overpasses (Figure 38). A gap approximately 8 feet wide exists west of the Beaver Pond where the fence approaches the retaining wall, and it is possible that similar gaps are on the north end of this green wall as well. The fence does not extend to the ground with several areas high enough to allow small mammals such as a fox to easily get under. There is no underground wire to prevent digging, but there is a mesh along the roadside of the fence, likely installed to help stabilize the soil preventing erosion. The mesh is not attached to the bottom of the fence, so it does not impede wildlife movement under the fence. Any gaps and build flaws in the installed wildlife fencing will likely reduce its effectiveness in preventing wildlife movement over the highway and directing animals towards the wildlife corridor. Further investigation to determine the shortcomings in the wildlife fencing build is required to ensure the safety of drivers using the SWCRR and animals that cross into and out of the park.

Figure 38. West of the Beaver Pond and south of the retaining wall a visible gap exits highlighted by the yellow arrow.

Another concern regarding the fencing is that the mesh used at the base does pose a significant risk for wildlife to get caught in it. Similar plastic, non-biodegradable meshes exist along the extent of the road and are trapped under sediment from the multiple sediment flows. All of these factors again pose a risk to wildlife getting caught in it. We recommend KGL remove it all or allow the Society to access the TUC to remove it. This work will require soil disturbance and efforts to reduce invasive plant establishment must be made.

Similarly, temporary fencing is still in place in a number of locations and appears to be buried under sediment from erosion in some of these locations as well (Figures 32, 33, 38, 39 and 40). It will be important to confirm that temporary erosion fences and other construction remnants are fully removed on project completion. A photo by Golder in June shows water levels facing east from the north bank of the river beside the bridge and temporary fencing in view on the south of the river.

Figure 39. View looking Northwest over the SWCRR showing the wildlife corridors in May 2021 showing construction using heavy equipment along the realignment corridor. Photo taken by Golder during the May 2021 track survey.

Figure 40. View facing east from the north bank of the river showing water levels at the Elbow River realignment and temporary fencing on the south side of the river. Photo taken by Golder during the June 2021 track survey.

Wildlife Reports: KGL's monthly wildlife report continued to have this statement highlighted in the left column throughout 2021 "Mitigations developed to reduce barriers to wildlife movement during construction are implemented and functioning as intended." This is of concern as there is evidence that the wildlife corridor was not functioning as intended, specifically during the construction phase when it was not significantly utilized, and post construction revegetation is not completed and therefore has not supported all wildlife movement from our available knowledge. We are hopeful that wildlife will start adapting to and using it, but the statement continuously made during construction is false and leads readers who may just be scanning that document into believing that the mitigation efforts were effective, when indeed they were not and require significant improvement. We have requested that this statement be removed or modified, but the request was not fulfilled. We have also requested that Alberta Transportation work in partnership with experts such as Drs. Tony Clevenger and Adam T. Ford to improve their wildlife movement mitigation efforts and standards during construction.

5) **Impacts of the SWCRR on hydrology in the Weaselhead**

These environmental monitoring studies have emphasized impacts of the SWCRR Project on water quality and the aquatic and riparian ecosystems. The Project also has substantial impacts on patterns of water quantity, or hydrology. The roadway system substantially altered the watersheds for the Spring Brook and Ravine Creek, which outflow into the west and east portions of the Beaver Pond. The areas of those prior watersheds that are now the roadway and the adjacent embankments have drains that collect the surface runoff and divert this water into the settling ponds, reducing the contribution to the Beaver Pond.

The Beaver Pond naturally fluctuates seasonally in response to summer weather and especially precipitation, as we confirmed in the 2019 Environmental Monitoring Report. The pond level also varies across dry versus wet years and the summer of 2021 was very warm and dry. The combination of a warm and dry year, and the reduced watershed drainage reduced the flows into the Beaver Pond, which partially dried up over the summer of 2021 (Figure 41). A new beaver dam was constructed at the point where Ravine Creek enters the Beaver Pond. This may have also contributed to the lower water levels observed. These factors would substantially influence the aquatic and riparian conditions.

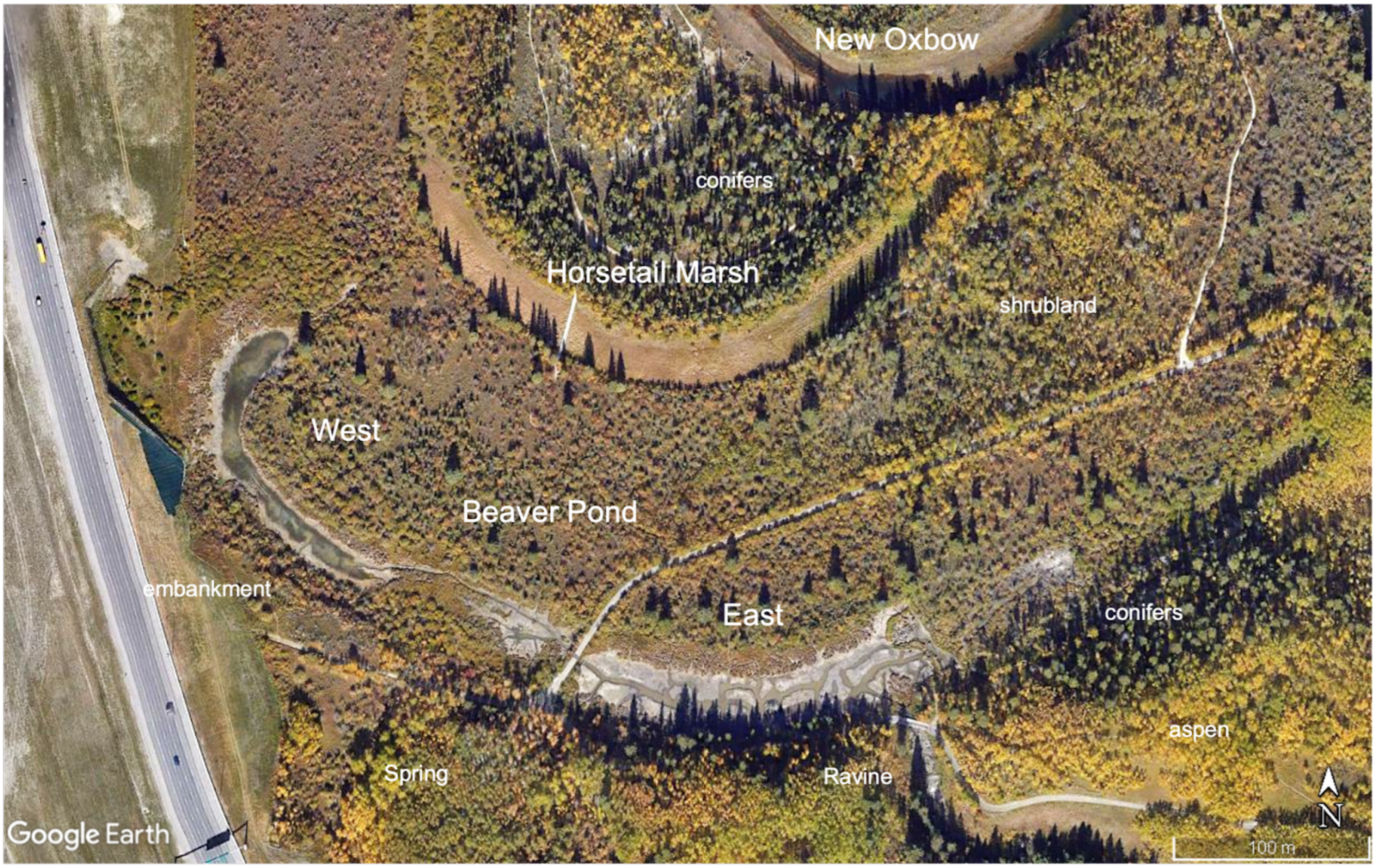

Figure 41. An aerial view of the Beaver Pond and adjacent features following the warm and dry summer of 2021.

Figure 41 is taken in late-August, when the autumn senescence reveals the woodland types. The Beaver Pond has dropped substantially, revealing the beaver canals in the east portion.

The realignment and straightening of the Elbow River channel (Figure 3) will also substantially alter the hydrology through the floodplain system at Weaselhead. The unnatural channel position is fixed with the bridge pillars and bank armoring, which may be increased as the river works to re-establish some sinuosity. The alignment somewhat provides a flume that is likely to extend the meander lobe immediately downstream. Over time the channel may further extend eastward and there could be some reconnection of the abandoned channel to the New Oxbow (Figure 3). This could increase the surface and groundwater flow to the southern zone, where the Horsetail Marsh/Old Oxbow and Beaver Pond occur.

6) **Raising of water levels in Glenmore Reservoir**

The City of Calgary improved the Glenmore Dam with restoration efforts completed by September 2020. Water levels were raised by 1.5m resulting in significant changes happening to the riparian vegetation and banks along the reservoir and Weaselhead Flats. This is an additional factor that will influence our aquatic invertebrate data due to terrestrial plants submerged at sample sites. The raised reservoir results in substantial flooding of the willow wetland on the Elbow River Delta (Figure 3). The inundation and especially submergence will probably result in mortality of the willows, dogwood and other riparian shrubs (Figure 42).

Figure 42. A southwest-facing overlook of the Elbow River Delta in Weaselhead Flats, with the pathway bridge on the right.

The delta includes an extensive and ecologically rich network of channels and islands that are covered with willows and other riparian shrubs. As part of the City of Calgary flood mitigation program, Glenmore Dam was raised, and Glenmore Reservoir displays greater fluctuation. The higher reservoir floods parts of the delta system and this will probably kill the willows in lower positions (Sept. 3 2021, Stewart Rood). While these alterations are independent from the SWCRR Project, the timing is coincidental and there will probably be cumulative impacts from the roadway and reservoir projects.

While there are a number of confounding factors, as discussed above, greater clarity and the elucidation of any potential patterns and correlations in the data will likely be found in the conclusion of this study. There is one final year of data collection before the conclusion of this study.

ACKNOWLEDGEMENTS

The collection of data for this report was generously supported by the Land Stewardship Centre of Canada, Alberta Ecotrust and The Calgary Foundation.

The authors would like to thank the Board and members of the Weaselhead/Glenmore Park Preservation Society for their support of this project, and the following for their help, advice, and assistance in carrying out the many hours of fieldwork involved:

Sarah Nevill	Stewart Rood	Tannis Vegso
Teresa Lynch	Georgia Blum	Rachel Ward
Matthew Wallace	Vlad Franco-Valias	Chelsea Cooper
Rebeccah Schwab	Katrine Konopnicki	Michael Johnson
Lisa Dahlseide	Gavin McKinnon	Alexandra Neill
Dylann Golbeck	Ethan Denton	Thomas Pryde
Zachary Mager	Evan Lewis	Brian Chmielewski
Cassiano Caue Possas Porto	Margaret Bates	Jarod Gall
Maureen Luchsinger	Jenna Cross	

REFERENCES

[1]Environmental Impact Assessment for the Southwest Calgary Ring Road (2006, updated Dec. 2014). AMEC Environment and Infrastructure (submitted to Alberta Transportation, Edmonton, Alberta)

[2]Alberta Environment and Parks: Alberta Wild Species Status List 2020; retrieved from https://extranet.gov.ab.ca/env/wild-species-status/default.aspx

[3]Sullivan, B.L., C.L. Wood, M.J. Iliff, R.E. Bonney, D. Fink, and S. Kelling. 2009. eBird: a citizen-based bird observation network in the biological sciences. *Biological Conservation* 142: 2282-2292.

[4]McClure, C. J. W., Ware, H. E., Carlisle, J. D., Barber, J. R. (2013). An experimental investigation into the effects of traffic noise on distributions of birds: Avoiding the phantom road. *Proceedings of the Royal Society B: Biological Sciences* 280(1773): 20132290.

[5]USDA Plants Database https://plants.sc.egov.usda.gov/wetinfo.html wetland classification for Great Plains region

[6]Alberta Weed Control Act 19/2010); retrieved from http://www.qp.alberta.ca/documents/Regs/2010_019.pdf

[7] Kahal, N., Lee, T., Clevenger, T., (2017, April). City of Calgary: Wildlife Camera Monitoring**.** *Miistakis Institute*

[8] Kahal, N., Lee, T., Creetch, T. (2020, October). Calgary Captured Year One Analysis: Technical Report. *Miistakis Institute*

[9]Agreement to design, build, finance and operate southwest Calgary ring road Schedule 18: Technical Requirements; available at https://open.alberta.ca/publications/agreement-to-design-build-finance-and-operate-southwest-calgary-ring-road

[10]Hemmera Envirochem Inc. (2021, February). *Wetland 06 Water Monitoring Report Southwest Calgary Ring Road Project*. http://www.swcrrproject.com/about/environmental-management/

[11]Sawyer, C. N., McCarty, P. L., Parkin, G. F. (2003); *Chemistry for Environmental Engineering and Science.* New York, NY: McGraw-Hill.

[12]Ohio River Valley Water Sanitation Commission: turbidity for Riverwatchers available online at www.orsanco.org/wp-content/uploads/2016/10/turbidity.pdf)

[13]Enivironmental Monitoring Report 2018, WGPPS; available online at http://theweaselhead.com/wp-wh/assets/Report-2018-final.pdf

[14] Lee, T., Sanderson, K., Colquhoun, N.L. (2020) Amphibians at Risk: An analysis of wetland habitat and corridors needed to secure amphibian populations in Calgary. *Miistakis Institute*

[15] Canadian Council of Ministers of the Environment. (2020). *Water Quality Guidelines for the Protection of Aquatic Life Freshwater, Marine.* Https://Ccme.Ca/. https://ccme.ca/en/summary-table

[16] *Calgary Ring Road – Photo Gallery*. (2020). Http://Www.Swcrrproject.Com/Media-Centre/Photo-Gallery/. http://www.swcrrproject.com/media-centre/photo-gallery/

[17]Wetland Assessment and Impact Report – Southwest Calgary Ring Road, Wetland 06. August 11, 2021. Hemmera Envirochem Inc.

[18]Alberta Transportation. www.transportation.alberta.ca/2150.htm

[19] KGL Construction Schedule. https://ahsl.ca/wp-content/uploads/2021/12/KGL_TWO-WEEK-WORK-ACTIVITY-SCHEDULE-002.pdf