APPENDIX

B

FISH BIODIVERSITY AND HABITAT ASSESSMENTS

FISH BIODIVERSITY AND HABITAT ASSESSMENTS IN THE CORNWALLIS RIVER & COLEMAN BROOK, NOVA SCOTIA

Report

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1. Introduction

This report provides a summary of the water quality, fish biodiversity, and habitat assessments conducted from April 2021 to December 2021 in the Cornwallis River and Coleman Brook by the Confederacy of Mainland Mi'kmaq (CMM) for the Nova Scotia Department of Public Works (NSDPW). The methods and results of the completed field studies are described for the Highway 101 interchange project near Cambridge, King's County.

1.1 Project Overview

NSDPW is planning an interchange development project off Highway 101 near Cambridge, King's County. The project will involve construction of a connector road between Black Rock Road and Cambridge Road, which will link Highway 101 to Trunk 1. Constructed roads will cross the Cornwallis River and Coleman Brook, requiring construction of a bridge and the placement of culverts. The interchange will remove over 2 hectares of wetland in the Cornwallis River watershed.

The Cornwallis River and Coleman Brook are extensively used for agriculture and recreation. Both watercourses have historically been a valuable resource to Mi'kmaw communities in the area as fishing and harvesting grounds. In consultation with Annapolis Valley First Nation (AVFN), the interchange location was selected to improve access to AVFN while minimizing environmental impacts and transference of AVFN land to the province. The goals of the interchange project are to provide economic opportunities for AVFN and to reduce the large volume of truck traffic on Trunk 1 from the nearby Michelin Tire Waterville Plant. The interchange would divert truck traffic from Trunk 1 to Highway 101, which would help improve traffic conditions and reduce road deterioration.

NSDPW contracted the Mi'kmaw Conservation Group (MCG) at the Confederacy of Mainland Mi'kmaq (CMM) to perform fish diversity and habitat surveys on Coleman Brook and the Cornwallis River before construction.

There is a data deficiency for recent environmental monitoring data in the area, which limits detection of environmental impacts from infrastructure projects such as this interchange. The objectives of this project are to assess fish biodiversity and habitat in the Cornwallis River and Coleman Brook, characterize water quality, and gain an understanding of overall ecosystem health.

2. Methods

Before starting fieldwork, the CMM conducted a desktop review of historic aquatic monitoring work in the Cornwallis watershed in search of baseline environmental conditions. Initial site selection was based on road access to the Cornwallis River and Coleman Brook, as well as proximity to the interchange's proposed impact zones. Eight access points were identified where the roads and waterways cross near the proposed interchange. Four access points were on the Cornwallis River and four were on Coleman Brook. The CMM conducted site surveys between 250 – 500 m upstream and downstream of each access point. Observations were recorded during the site surveys to identify substrate composition, undercut stream banks, and hazards. One of the proposed Coleman Brook sites was unsuitable for monitoring and a site on Killman Brook, a tributary of Coleman Brook, was an alternative site (Figure 2.1).

The results of the reconnaissance surveys were combined with the information collected from the historical data review to identify the sites for fish biodiversity surveys, water quality monitoring, and aquatic habitat assessments (Figure 2.1).

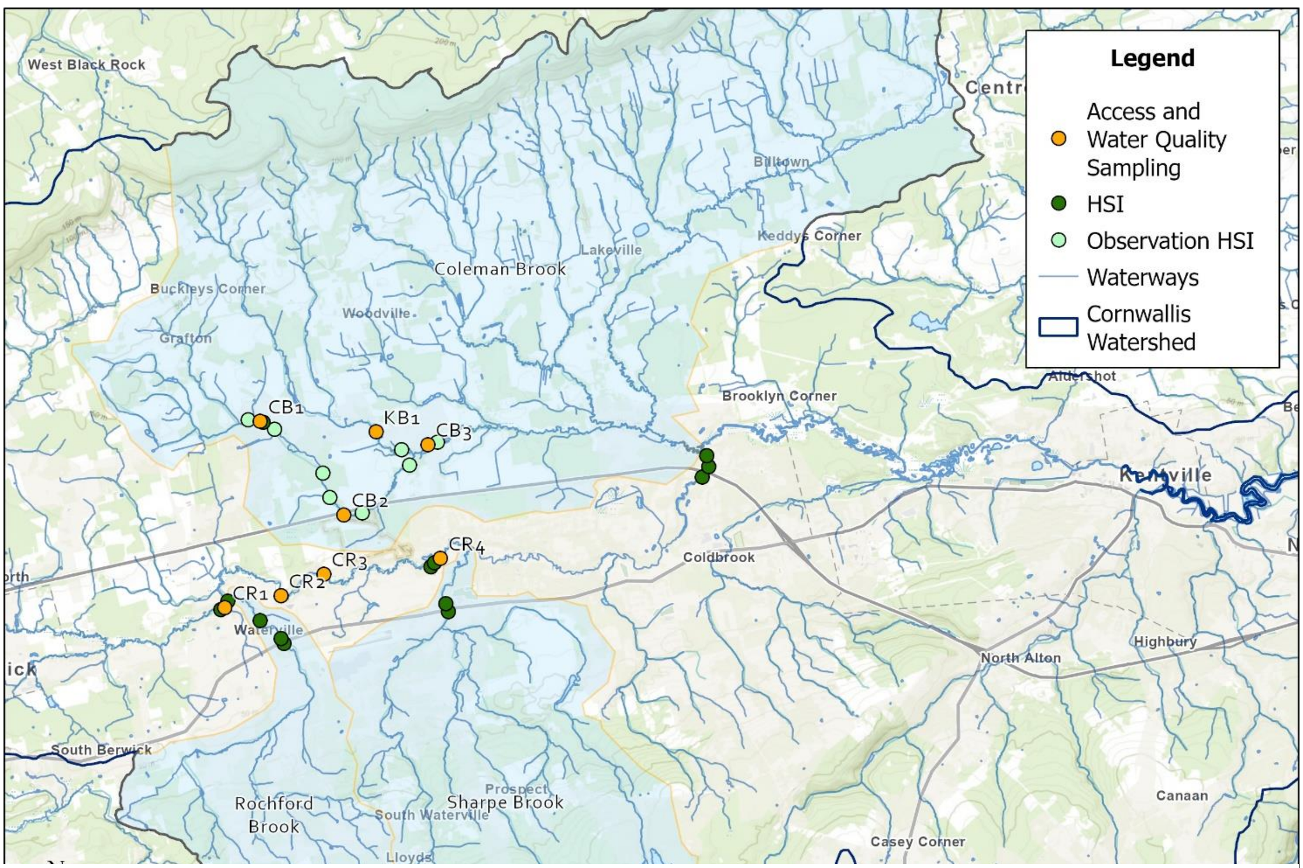

Figure 2.1. Project map showing stream access points in orange for the Cornwallis River (CR1, CR2, CR3, CR4) and Coleman Brook (CB1, CB2, CB3, KB1). Habitat Suitability Index (HSI) sites are in dark green and observational HSI sites are light green. Coleman Brook, Ratchford Brook, and Sharpe Brook watersheds are light blue, and the Cornwallis River watershed is a dark blue outline.

2.1 Fish Biodiversity Surveys

Fish sampling took place in June, September, and October. Due to high water levels, beach seine sampling was the primary survey method. At each seine net location, the field crew moved downstream in short sections of 25 to 40 ft, depending on stream structure and submerged obstacles, such as deadwood. Fish collected in the seine net were pulled onto the bank and placed into a cooler to be processed. More than one section was sampled if conditions around the watercourse allowed for safe access.

In June and October, at the CB1 location (see Figure 2.1), electrofishing was conducted with a HalTech backpack electrofishing unit with the voltage set to 350 V and the frequency set to 60 Hz. Before electrofishing, the water temperature was measured to ensure it was below 22°C for optimal fish recovery. At each site, CMM staff marked out approximately 100 meters along the shoreline. Electrofishing occurred within these 100 meters and staff moved upstream in a zig-zig pattern to maximize catch efficiency. Captured fish were placed in an open cooler half-filled with water to be processed.

In October, eel pots were used to fish at each of the eight access points. The traps were baited with king mackerel and placed in the watercourse overnight. The eel pots were retrieved on the next day to process the captured fish.

For all survey methods, fish were taken from the cooler or eel pot, the species was identified, and fish length was measured. All fish <10cm were recorded in a single length class, and fish ≥10cm were weighed and exact lengths were recorded. After data collection, all fish were released to the same site they were captured.

2.2 Water Quality Monitoring

Water quality data was collected 11 times between May and October at eight different sites. Four of the sites were on the Cornwallis River, three were on the Coleman Brook, and one was on the Killman Brook (Figure 2.1). A YSI Pro-Plus meter was used to measure temperature (°C), dissolved oxygen (mg/L), specific conductance (uS/cm), total dissolved solids (mg/L), salinity (ppt) and pH at each sampling location. Turbidity (NTU) was measured using a Lamotte portable turbidity meter. Both the YSI Pro-Plus and Lamotte turbidity meter were calibrated before use.

Onset HOBO data logger devices were deployed at all water quality monitoring sites. Data was retrieved in August at the Cornwallis River and Coleman Brook sites. At the time of retrieval, the logger battery at the CB1 site was found to be malfunctioning and was replaced on August 25th along with the initial deployment of a logger at site KB1 (Table 2.2.1). The loggers recorded water temperature every 10 minutes. During every water quality sampling event, the logger placement was checked to ensure they were fully submerged.

Site Name	Initial Deployment	Data Retrieval	Redeployment	Final Retrieval
CR1	May 17, 2021	August 18, 2021	August 18, 2021	December 1, 2021
CR2	May 17, 2021	August 18, 2021	August 18, 2021	December 1, 2021
CR3	May 17, 2021	August 18, 2021	August 18, 2021	December 1, 2021
CR4	May 15, 2021	August 18, 2021	August 18, 2021	December 1, 2021
CB1	May 15, 2021	August 18, 2021	August 25, 2021	November 18, 2021
CB2	May 17, 2021	August 18, 2021	August 18, 2021	November 18, 2021
CB3	May 17, 2021	August 18, 2021	August 18, 2021	November 18, 2021
KB1	August 25, 2021	N/A	N/A	November 18, 2021

Table 2.2.1. Deployment and retrieval dates of temperature loggers.

The average stream velocity was measured at all sites on August 18th and 25th using a Global Water Flow Probe. The probe was submerged in the watercourse for approximately 15 seconds while one reading was taken per second, and a continuous average was displayed on the device. Once the reading became steady, the average velocity of the stream was recorded. Due to a prolonged delivery time, the CMM did not receive the flow probe they intended to use until after project completion. The Global Water Flow Probe was borrowed for two days in August.

Average surface velocity was measured six times at each of the sites from June to October. To conduct the surface velocity measurements, five meters was measured along the streambank, then a float was placed at the upstream end of the measured section, and the time it took to travel the five meters was recorded. The distance was divided by the time to calculate the velocity in m/s. This process was repeated three times per site to determine the average velocity.

E. coli and total coliform samples were collected on June 29th and October 25th at each of the eight sites. Envirosphere Consultants Ltd. in Windsor, West Hants provided the 100mL, sterile, plastic, bottles used for sample collection. At each site, the 100mL sample bottles were filled using a triple-rinsed 500mL plastic bottle to ensure a controlled pour prevented losing preservatives in the sample bottle. The water samples were transported to the Envirosphere lab in a cooler bag with icepacks the same morning of collection, and analysis was completed by Envirosphere staff within 24 hours.

Water samples were collected from all sites on October 7th. Samples were collected in two 100mL bottles and one 250mL plastic bottle provided by AGAT Laboratories in Dartmouth. One set of 100mL bottles contained a sulphuric acid preservative for nutrients analysis, and the other contained a nitric acid preservative for metals analysis. At each site, the 250mL bottle was first used to fill both 100mL bottles, and then used to collect another water sample. The water samples were transported in a cooler to the AGAT laboratory in Halifax for analysis on the same day as collection.

Stream discharge was not measured because of the delay in receiving appropriate equipment (i.e., water flow probe).

2.3 Habitat Assessments

Habitat Suitability Index (HSI) assessment sites were selected based on changes of in-stream and stream bank habitat, such as narrowing of the stream, a change in the surrounding vegetation, or a change in the geology of the stream; where there were road crossings, such as a culvert or bridge; and confluences with tributaries.

HSI data was collected on June 11th, 14th, and 15th from seven sites on the Cornwallis River, June 11th and 14th from five sites on Sharpe Brook and Ratchford Brook, and one site on Coleman Brook on June 15th (Figure 2.1).

Once a suitable location was chosen for an initial transect, water quality parameters were measured using a YSI Pro-Plus meter. The second and third transects were located upstream from the first transect at a distance calculated by the AAS Stream Width and Flow Calculator.

At each transect, dimensions of the stream were recorded using a tape measure and meter stick. “Fish Sticks” were used to estimate the instream cover for adult and juvenile fish cover both 50 cm above and below the transect line. The “Fish Stick” measuring for adult fish cover is 20 cm long with a 3/4” diameter and the “Fish Stick” for juvenile fish cover is 10 cm long with a 5/16” diameter.

Sediment composition of the stream was estimated using a 20-square quadrat placed ¼, ½ and ¾ of the way across the transect. Substrate composition was determined by recording the dominant substrate in each quadrat square (Appendix A). The embeddedness of the stream at each transect was estimated by lifting a rock in the thalweg and estimating the percent of fine substrate underneath.

Once the transects were completed, the riverbanks and riparian area were assessed for vegetation cover, erosion percentage, stable ground percentage, stream shade percentage, and ice scar height. If present, spawning habitat and pools located between transects were measured.

Data was entered into NSLC Adopt a Stream’s formula formatted Excel sheet and used to analyze the quality of fish habitat along the Cornwallis and Coleman waterways (Appendix B).

3. Results

3.1 Fish Biodiversity

Fish biodiversity surveys were completed three times in the Cornwallis River and Coleman Brook sites, once each during spring, summer, and fall. The spring surveys were completed on June 11th and 18th, the summer surveys on September 8th, and the fall surveys on October 25th and 26th. Beach seining was the most common survey method; however, electrofishing and eel pots were also used.

Spring Survey

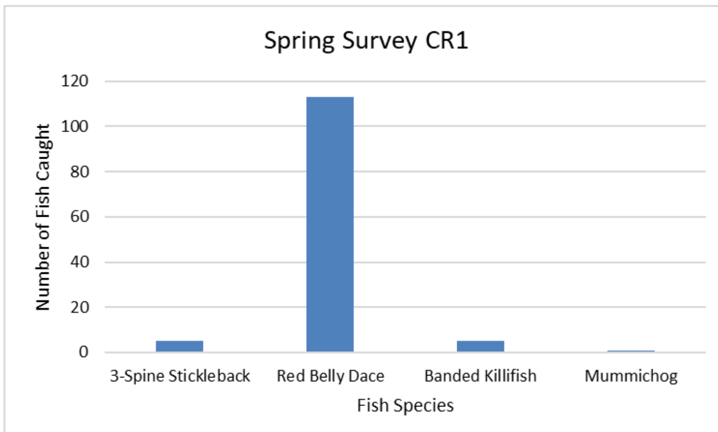

Figure 3.1.1. The number of each species of fish captured during the spring surveys at site CR1. 3-spine stickleback, red belly dace, banded killifish, and mummichog were captured using a beach seine.

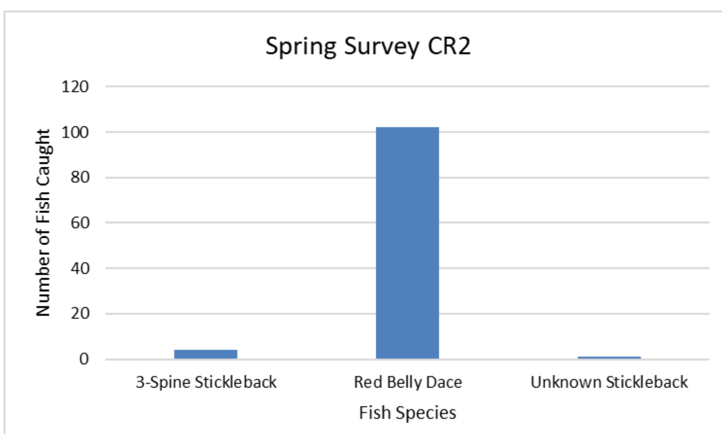

Figure 3.1.2. The number of each species of fish captured during the spring surveys at site CR2. 3-spine stickleback, red belly dace, and an unknown stickleback were captured using a beach seine.

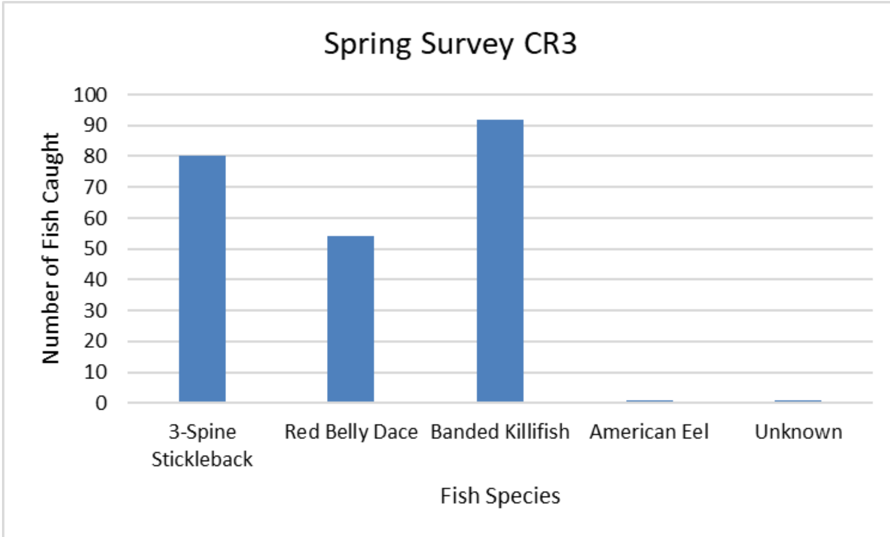

Figure 3.1.3. The number of each species of fish captured during the spring surveys at site CR3. 3-spine stickleback, red belly dace, banded killifish, American eel, and an unknown species were captured using a beach seine.

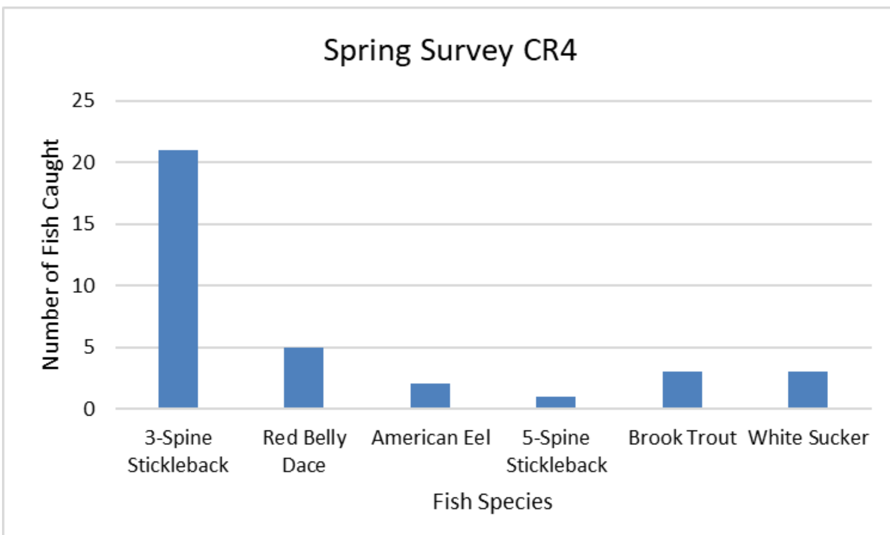

Figure 3.1.4. The number of each species of fish captured during the spring surveys at site CR4. 3-spine stickleback, red belly dace, American eel, 5-spine stickleback, brook trout, and white sucker were captured using a beach seine.

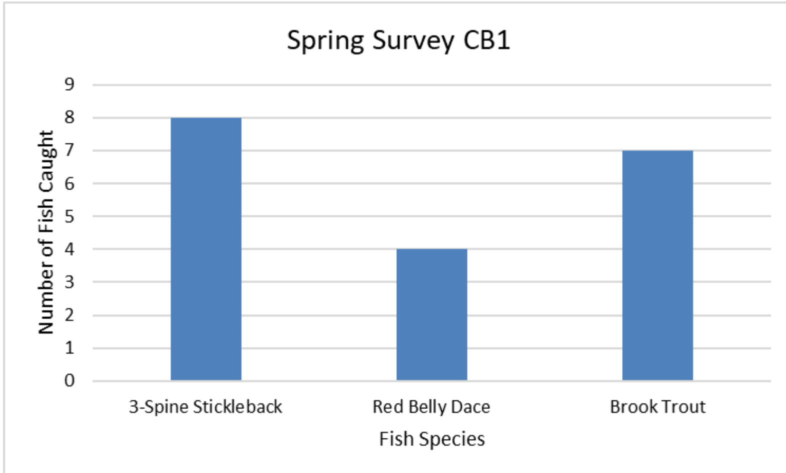

Figure 3.1.5. The number of each species of fish captured during the spring surveys at site CB1. 3-spine stickleback, red belly dace, and brook trout were captured via electrofishing.

Overview of Spring Survey Results

During the spring fish biodiversity surveys, 513 individual fish were caught. The species identified at the survey sites were 3-spine stickleback, red belly dace, banded killifish, mummichog, American eel, brook trout, and white sucker. At CR1, the most abundant species was red belly dace (n= 113; 91% of the total 124 fish), then 3-spine stickleback and banded killifish (each n=5; 4% of total), and mummichog was the least abundant (n=1; 1% of total). At CR2, red belly dace was again the most abundant (n= 95% of the total 107 fish), then 3-spine stickleback (n=4; 4% of total), and unknown stickleback was the least abundant (n=1; 1% of total). There was a more even species distribution at CR3, where banded killifish was most abundant (n= 92; 40% of the total 228 fish), followed by 3-spine stickleback (n=80; 35% of total), red belly dace (n=54; 24% of total), and American eel and an unknown species (each n=1; 1% of total). At CR4, 3-spine stickleback were the most abundant species (n=21; 60% of the total 35 fish), then red belly dace (n=5; 14% of total), white sucker (n=3; 9% of total), American eel and brook trout (each n=2; 6% of total), and the least abundant were brown trout and 5-spine stickleback (each n=1; 3% of total). At CB1, 3-spine stickleback was the most abundant (n=8; 42% of the total 19 fish), followed by brook trout (n=7; 37% of total), and the least abundant was red belly dace (n=4; 21% of total). Sites that were not surveyed due to unsafe conditions included CB2, CB3, and KB1.

Summer Survey

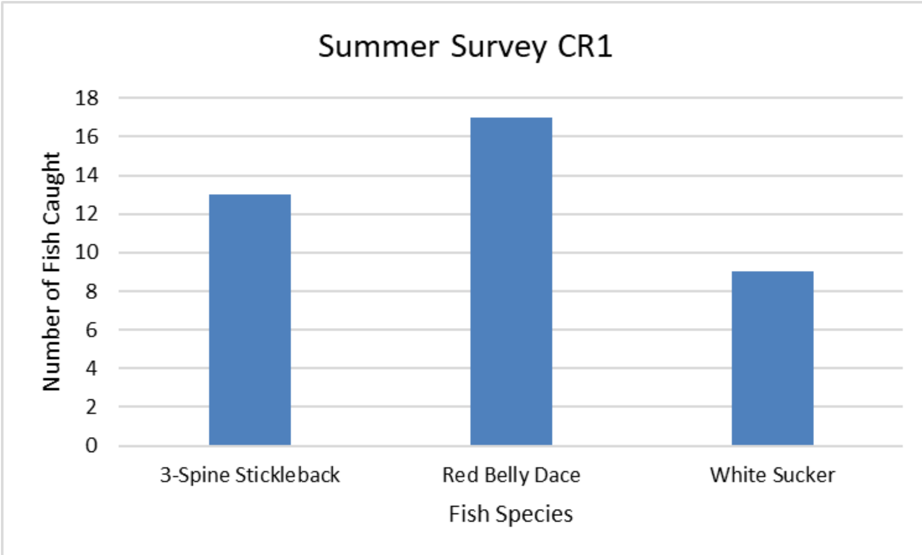

Figure 3.1.6. The number of each species of fish captured during the summer surveys at site CR1. 3-spine stickleback, red belly dace and white sucker were captured using a beach seine.

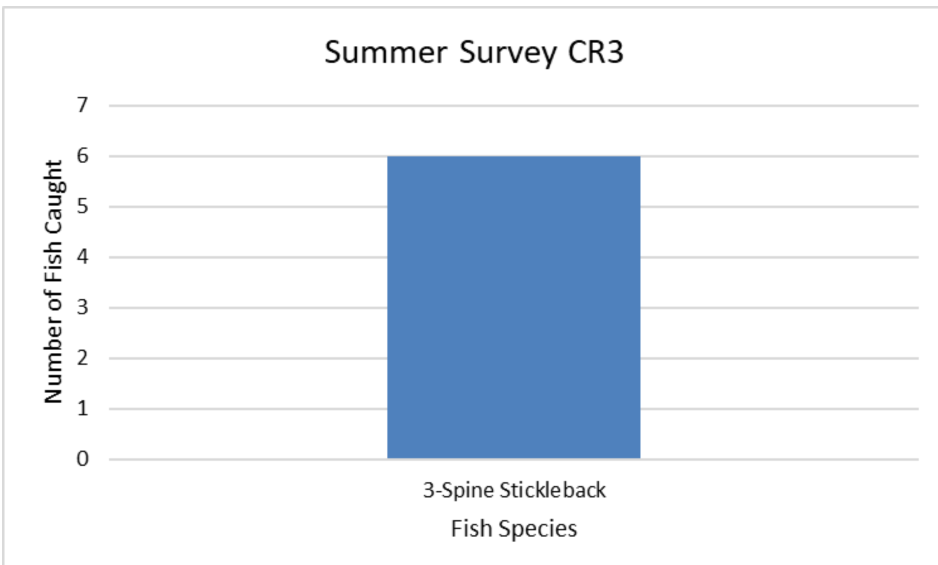

Figure 3.1.7. The number of each species of fish captured during the summer surveys at site CR3. 3-spine stickleback were captured using a beach seine.

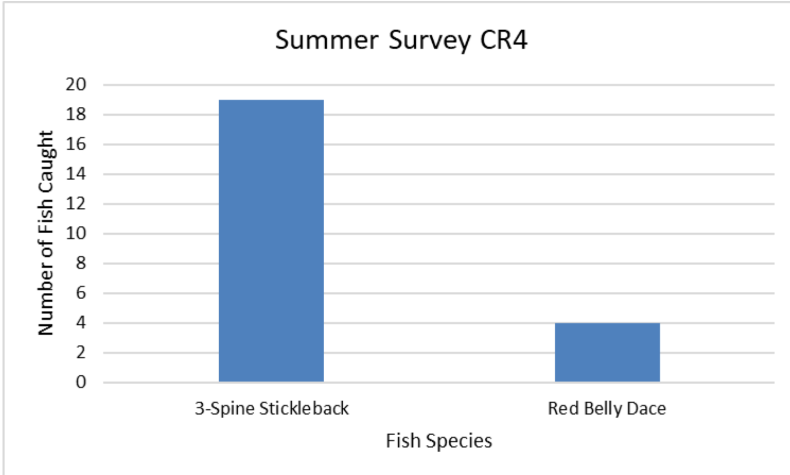

Figure 3.1.8. The number of each species of fish captured during the summer surveys at site CR4. 3-spine stickleback and red belly dace were captured using a beach seine.

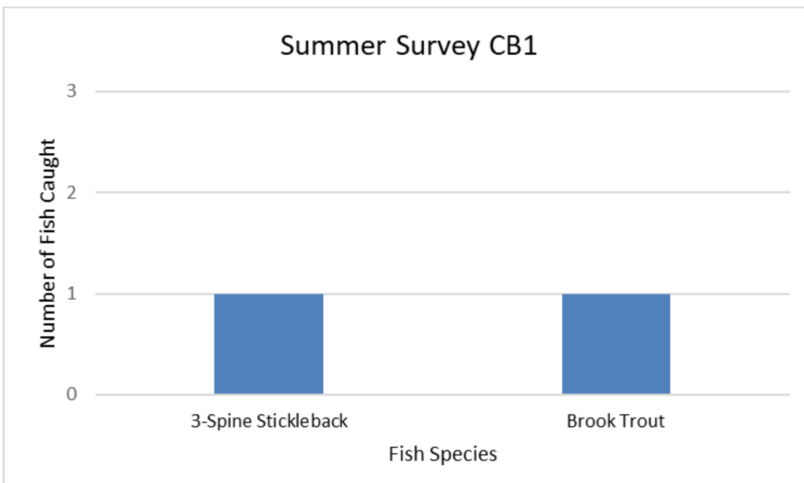

Figure 3.1.9. Fish caught during the summer surveys at site CB1 via electrofishing.

Overview of Summer Survey Results

During the summer survey, a total of 71 fish were caught, 86% less than the spring survey. The species captured during this survey were red belly dace, 3-spine stickleback, white sucker, and brook trout. At CR1, red belly dace was the most abundant (n=17; 43% of the total 40 fish), followed by 3-spine stickleback (n=13; 33% of total) and white sucker (n=9; 23% of total). The only species captured at CR3 was 3-spine stickleback. At CR4, 3-spine stickleback (n=19; 83% of the total 23 fish) and red belly dace (n=4; 17% of total) were the only species caught. Brook trout and 3-spine stickleback were equally abundant (each n=1; 50% of total) and were the only species caught at CB1. No fish were caught at sites CR2, CB2, CB3, and KB1.

Fall Survey

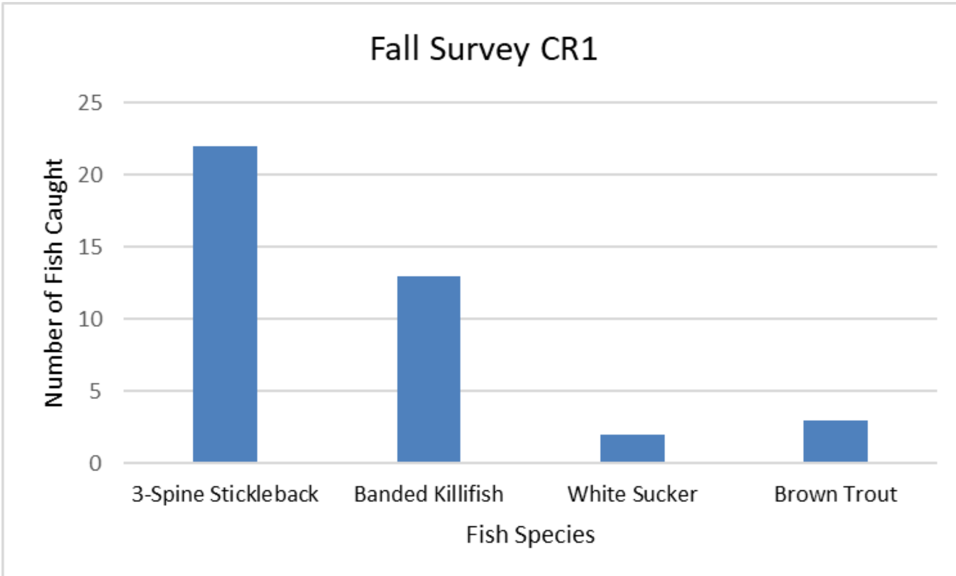

Figure 3.1.10. The number of each species of fish captured during the fall surveys at site CR1. 3-spine stickleback, banded killifish, white sucker, and brown trout were captured using a beach seine.

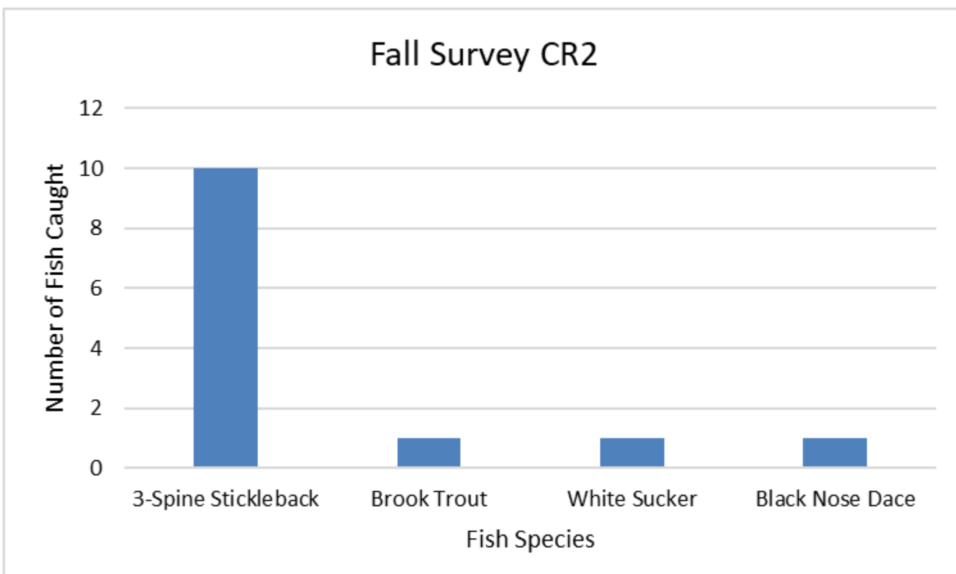

Figure 3.1.11. The number of each species of fish captured during the fall surveys at site CR2. 3-spine stickleback, brook trout, white sucker, and black nose dace were captured using a beach seine.

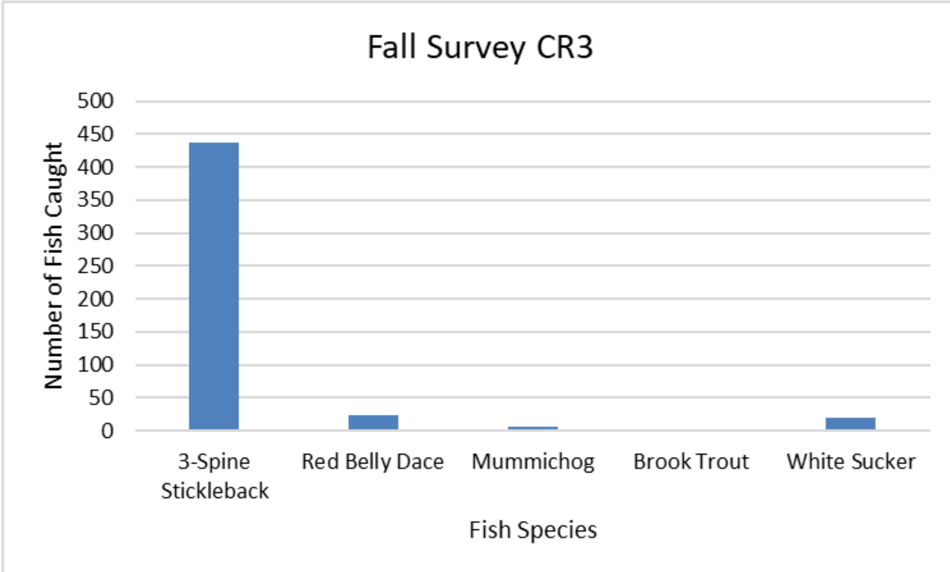

Figure 3.1.12. The number of each species of fish captured during the fall surveys at site CR3. 3-spine stickleback, red belly dace, mummichog, brook trout, and white sucker were captured using a beach seine except for one brook trout which was caught in an eel pot.

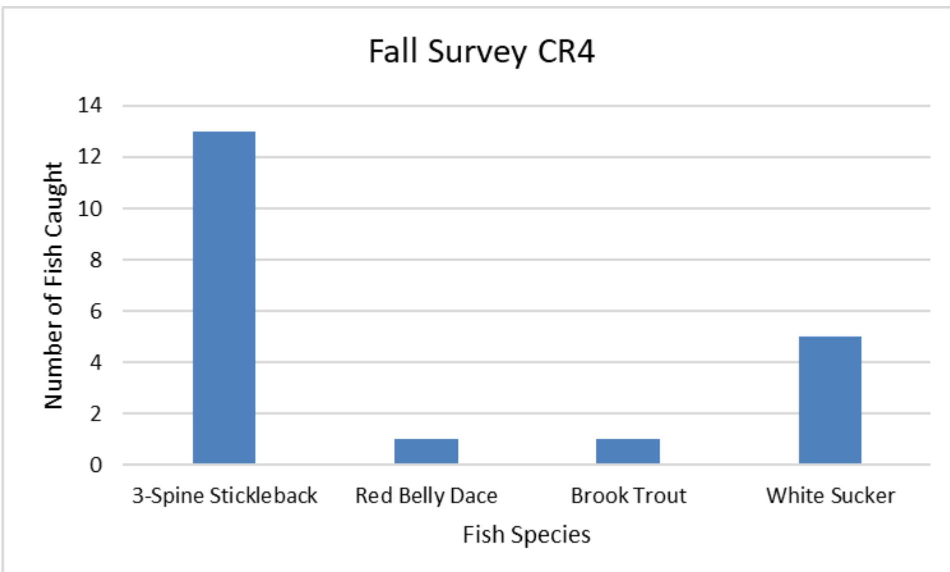

Figure 3.1.13. The number of each species of fish captured during the fall surveys at site CR4. 3-spine stickleback, red belly dace, brook trout and white sucker were captured using a beach seine except for one brook trout that was caught in an eel pot.

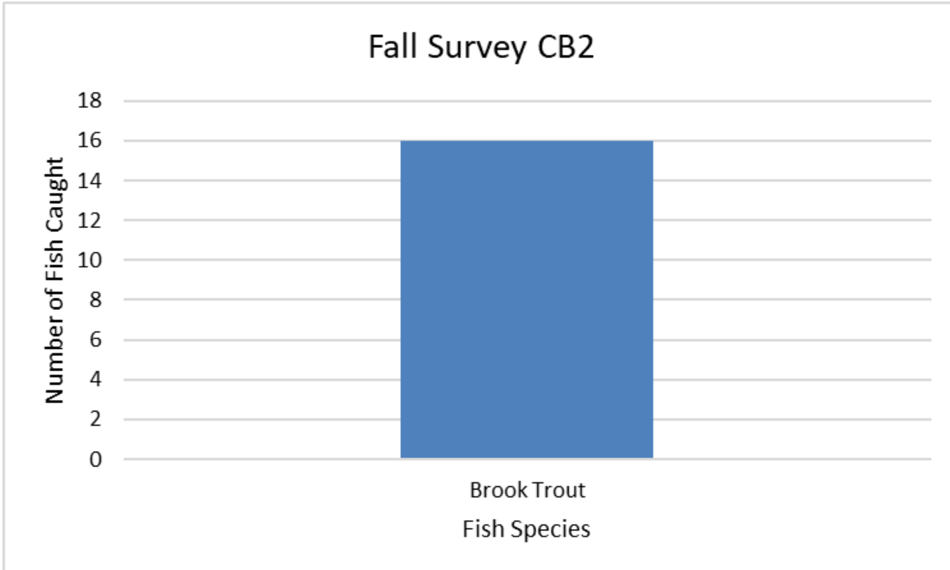

Figure 3.1.14. The number of brook trout captured in an eel pot during the fall surveys at site CB2.

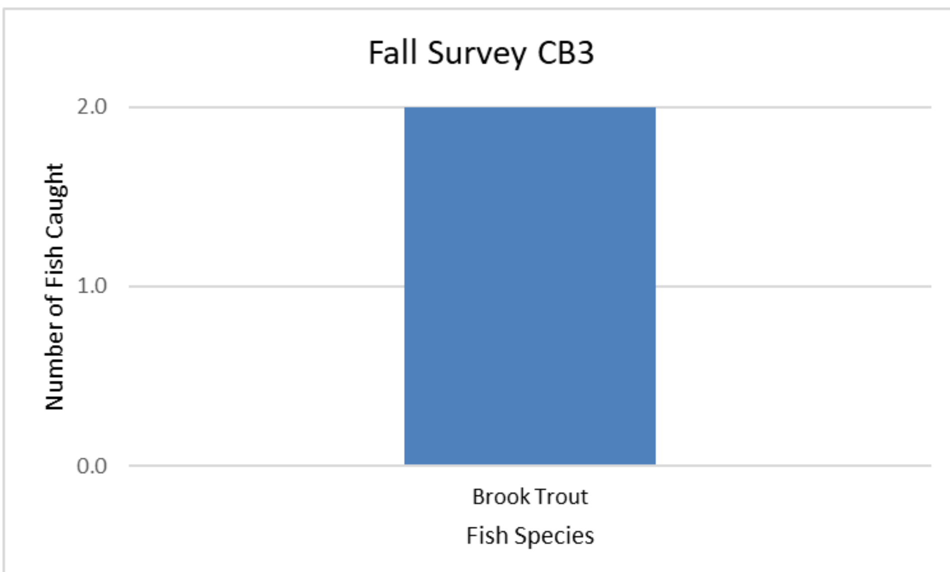

Figure 3.1.15. The number of brook trout caught in an eel pot during the fall surveys at site CB3.

Overview of Fall Survey Results

During the fall fish biodiversity surveys, 518 fish were caught, including 3-spine stickleback, banded killifish, white suckers, brown trout, brook trout, black nose dace, red belly dace, and mummichogs. The most abundant species at site CR1 was 3-spine stickleback (n=22; 55% of the 40 total fish) followed by banded killifish (n=13; 33% of total). Brown trout and white sucker were present in low numbers. At CR2, 3-spine stickleback were most abundant again (n=10; 77% of the 13 total fish). Black nose dace, brook trout, and white sucker were also present (each n=1; 8% of total). At CR3, 3-spine stickleback were the most abundant (n=437; 89% of the 489 total fish), with lower numbers of red belly dace (n=23; 5% of total) and white sucker (n=20; 4% of total). Low numbers of brown trout and mummichog were also present. The most abundant species at CR4 was 3-spine stickleback (n=13, 62% of the 21 total fish), followed by white sucker (n=5; 24% of total). Low numbers of brook trout, red belly dace, and an unknown species were present (each n=1; 5% of total). Brook trout was the only species caught at sites CB2 and CB3 (n=16 at CB2, n=2 at CB3). No fish were caught at CB1 or KB1.

Combined Fish Biodiversity Surveys

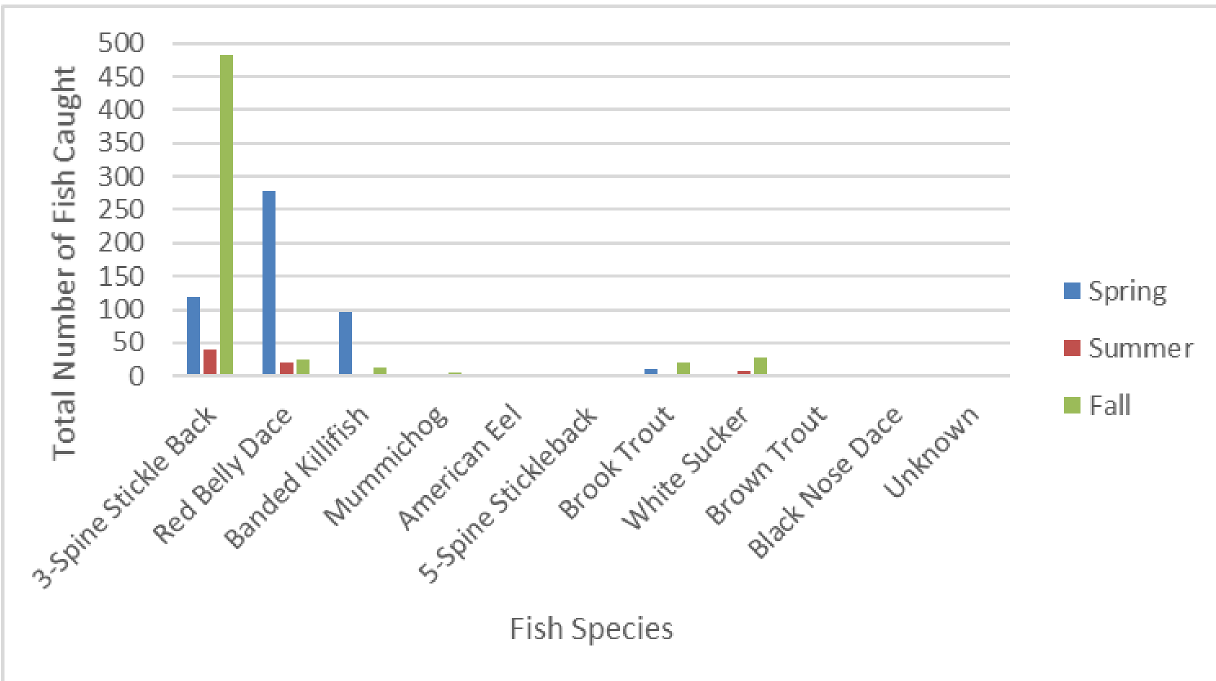

Figure 3.1.16. The total number of each species of fish captured from all sites in the Cornwallis River and Coleman Brook during the spring, summer, and fall surveys.

Overview of Combined Fish Biodiversity Surveys

Overall, the most abundant fish species found was the 3-spine stickleback (n=639; 55% of the study total 1165 fish), followed by red belly dace (n=323; 28% of total 1165 fish), killifish (n=111; 10% of total fish), white sucker (n=40; 3% of total fish), brook trout (n=30; 3% total fish), brown trout (n=7; 1% of total fish), mummichog (n=6; 1% of total fish), and less than 1% for 5-spine stickleback, American eel, black nose dace, and unknown species. Fish were most abundant in the fall surveys (n=581; 50% of study total 1165 fish), followed by the spring survey (n=513; 44% of total fish), and the least abundant was summer (n=71; 6% of total fish). Site CR3 had the highest number of fish caught (n=723; 62% of the study total 1165 fish), and site KB1 had the least, with no fish captured.

3.2 Water Quality Monitoring

Water Quality

Water quality parameters at CR1, CR2, CR3, CR4, CB1, CB2, and CB3 (Figure 2.1) were measured on 11 different days from May to October 2021. Water quality parameters at KB1 (Figure 2.1) were measured 9 times from June to October 2021 (Appendix C). The summary table below presents the range of monitoring results.

Site	Temp (°C)		DO (mg/L)		SPC (uS/cm)		TDS (mg/L)		Salinity (ppt)		pH		Turbidity (NTU)	
	min	max	min	max	min	max	min	max	min	max	min	max	min	max
CR1	8.00	22.70	8.39	9.90	150.30*	416.30	97.50	271.05	0.06	0.20	6.86*	8.34	2.81	12.80
CR2	8.40	22.60	7.93*	10.64	132.81	379.80	86.45	247.00	0.06	0.18	7.02*	7.97	3.27	16.40
CR3	8.40	21.90	6.93	12.33	127.83	398.20	82.55	258.70	0.06	0.19	6.60*	7.51	2.76	10.69
CR4	8.80	21.20	7.44*	11.45	118.23	376.20	76.70	244.40	0.06	0.18	6.74*	7.56	1.73	11.40
CB2	8.90	24.00	6.10*	11.28	167.08	310.20	108.55	201.50	0.08	0.19	6.87*	7.80	2.80	19.20
CB1	8.70	20.10	6.99*	11.01	173.67	320.97	113.10	205.40	0.08	0.15	6.56*	7.84	1.80	9.42
CB3	8.10	19.10	6.50*	10.99	139.25	352.10	90.35	229.45	0.07	0.17	6.68*	7.62	1.61	25.30
KB1	8.90	20.30	5.60*	11.17	265.63	412.50	122.20	267.80	0.13	0.20	6.95*	7.93	5.39	11.40

Table 3.2.1. Minimum and maximum values of water quality parameters at all sampling sites.

Asterisks beside values in the 'min' columns indicate that a lower value was recorded during sampling, however, this value does not accurately represent the low range of the parameter in the watercourse. All values, including outliers, are listed in Appendix C. The outlying values may be caused by equipment malfunctions or inconsistencies in sampling procedure. For example, pH values measured at all sites on July 9th fell between 2.43 and 2.78. These values were outliers, and the next lowest recorded pH value was used to fill the table. The pH levels measured on all other sampling days all fall within the Canadian Council of Ministers of the Environment (CCME) guidelines for the protection of aquatic life (CCME, 1987d).

Dissolved oxygen levels across all sites were considered suitable for cold water ecosystems according to the CCME guidelines for the protection of aquatic life (CCME, 1999a). The lowest values at CB2 and KB1 may be a result of the morphology of these sites, where the watercourses are flat and slow moving, without high flow or riffle-type habitat to help buffer dissolved oxygen levels (see Stream Velocity).

Total dissolved solids were consistent across all sites, with the highest values recorded at CR1 and KB1. Specific conductance, total dissolved solids, and salinity values showed a gradual increase across all sites from May to October (Appendix C).

The normal range of NTU in environmental samples can vary between 0 to 1000 NTUs (CCME, 1999b). Turbidity measurements at all sites were low, with much higher values recorded on September 8th and October 7th. On September 2nd, 76.5 mm of rain was recorded at the Kentville CDA CS weather station (Environment and Climate Change Canada, 2021). Runoff and more turbulent flow in the following days may have contributed to higher turbidity readings. However, only trace amounts of precipitation recorded during the week before sampling on October 7th, with a total of 0.6 mm of precipitation recorded from October 1st to 7th.

Temperature

HOBO logger data was continuously collected from May 15th at CB1 and CR4 and May 17th at CB2, CB3, CR1, CR2, and CR3 until August 18th. HOBO logger data was continuously collected from August 18th at CB2, CB3, CR1, CR2, CR3, and CR4 and August 25th at CB1 and KB1 until November 18th at CB1, CB2, CB3, and KB1 and December 1st at CR1, CR2, CR3, and CR4.

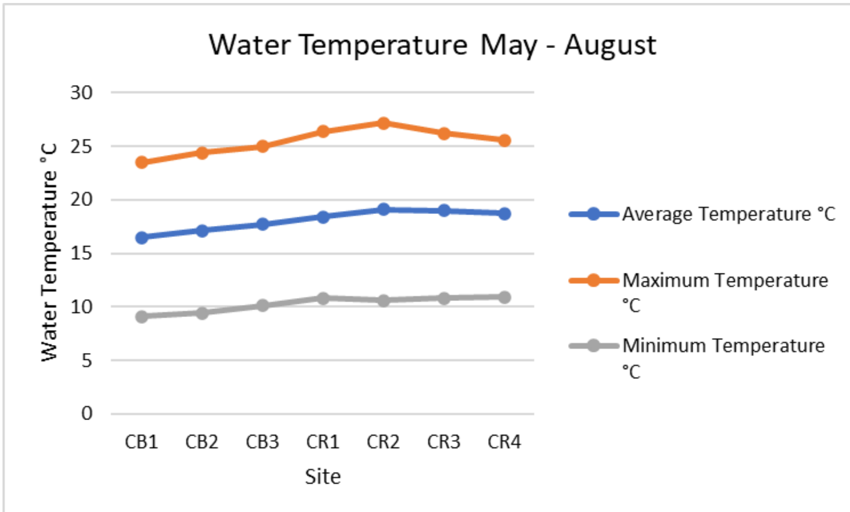

Figure 3.2.1. The average, maximum, and minimum water temperatures of each site in the Cornwallis River, Coleman Brook, and Killman Brook from May to August.

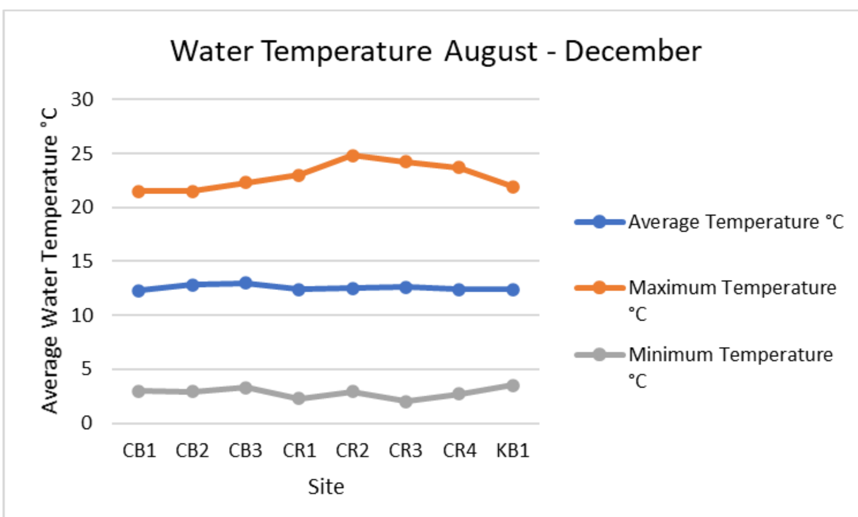

Figure 3.2.2. The average, maximum, and minimum water temperatures of each site in the Cornwallis River, Coleman Brook, and Killman Brook from August to December.

All average temperatures for each site were higher from May to August than they were from August to December. Sites CR2 and CR3 had the highest average temperature overall and site KB1 had the lowest temperature overall.

Velocity

The highest surface velocities were recorded at CR1, CB1, and CR4, although there were outlying values recorded on June 25th for CR1 and on October 7th for CB1. Lowest surface velocities were recorded at CB2 and KB1. The remaining three monitoring sites, CR2, CR3, and CB3, held consistent surface velocities across all monitoring dates.

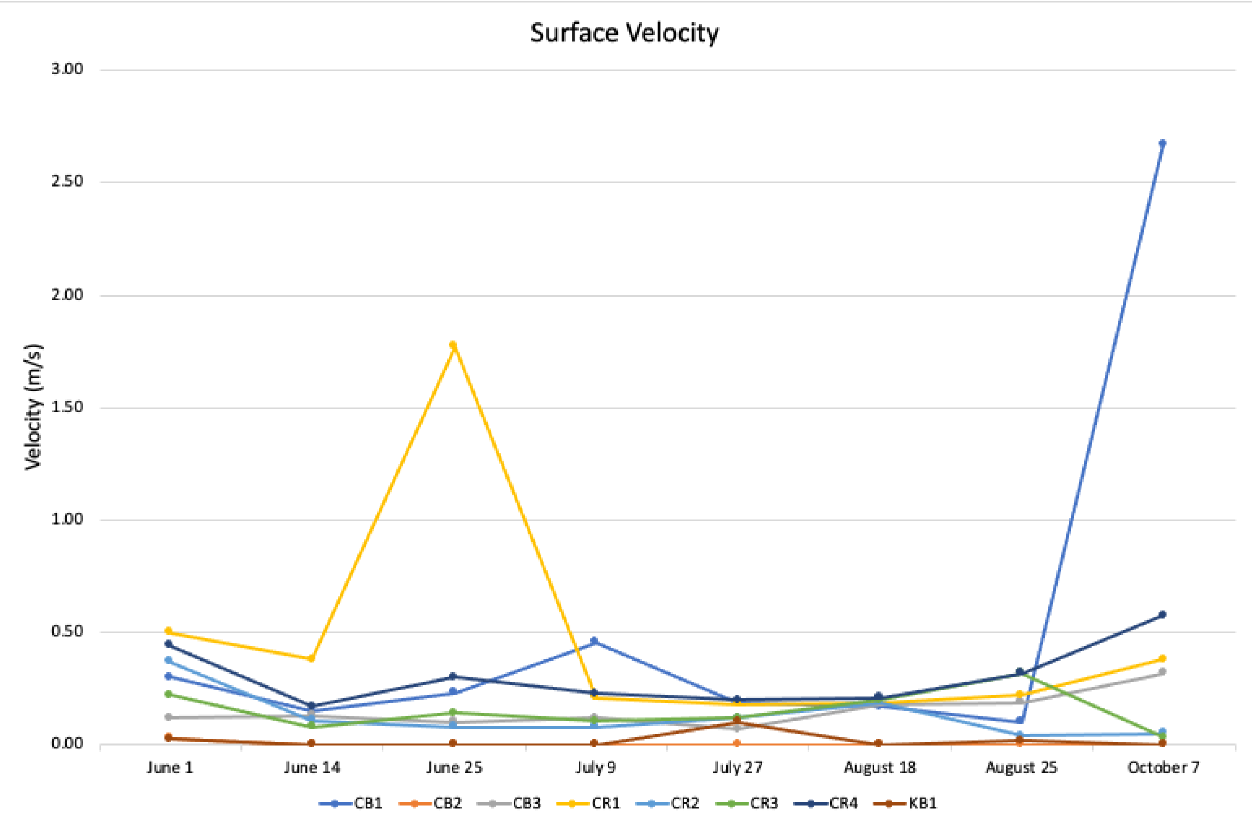

Figure 3.2.3. Surface velocity at water quality monitoring sites.

The highest average stream velocity was recorded at CR3 and CR4, the two most downstream sites on the main channel of the Cornwallis River. The CR1, CR2, CB1, and CB3 locations have a moderate average velocity. CR1 and CR2 are the upstream Cornwallis River sites, CB1 is the most upstream site on the Coleman Brook, and CB3 is the farthest downstream site on Coleman Brook. CB2 and KB1 have very low average stream velocity compared to the rest of the sites.

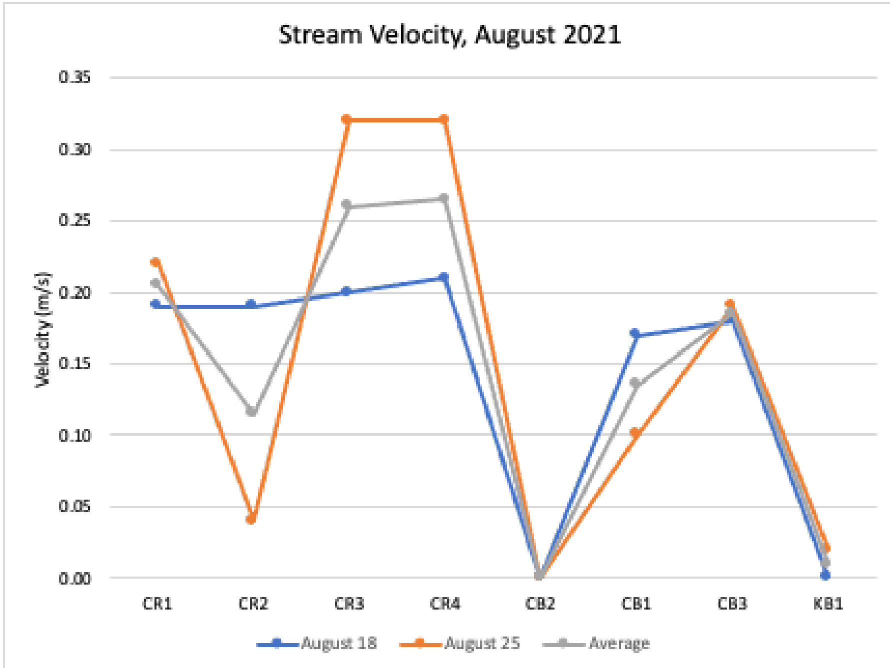

Figure 3.2.4. Average stream velocity at water quality monitoring sites.

E. coli and Total Coliforms

Agriculture is one of the dominant land-use types in the Cornwallis watershed. Although there are forested buffers along stretches of the Cornwallis River and Coleman Brook, fields and livestock pasture extend right to the watercourse at many locations, providing pathways for coliforms to enter the water.

Generally, E. coli levels were much higher in June compared to October, with the highest levels recorded in the Coleman Brook and Killman Brook. The range in E. coli levels across all sites was greater in June compared to October. Similarly, total coliform counts were higher in June compared to October. The difference is likely due to warmer temperatures promoting colony growth in June.

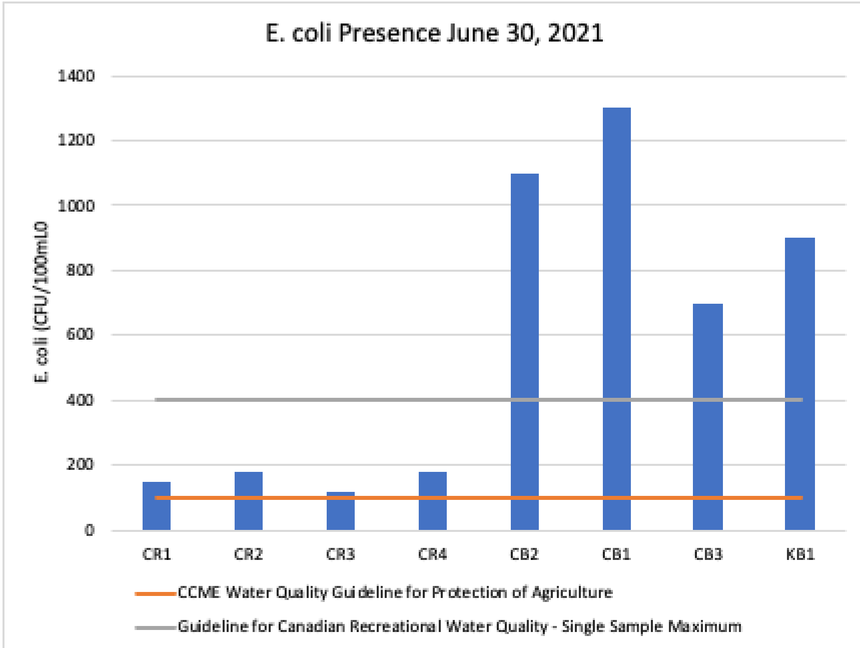

Figure 3.2.5. Summer counts of E. coli colony forming units compared to federal guidelines (Health Canada, 2012, CCME 1987b).

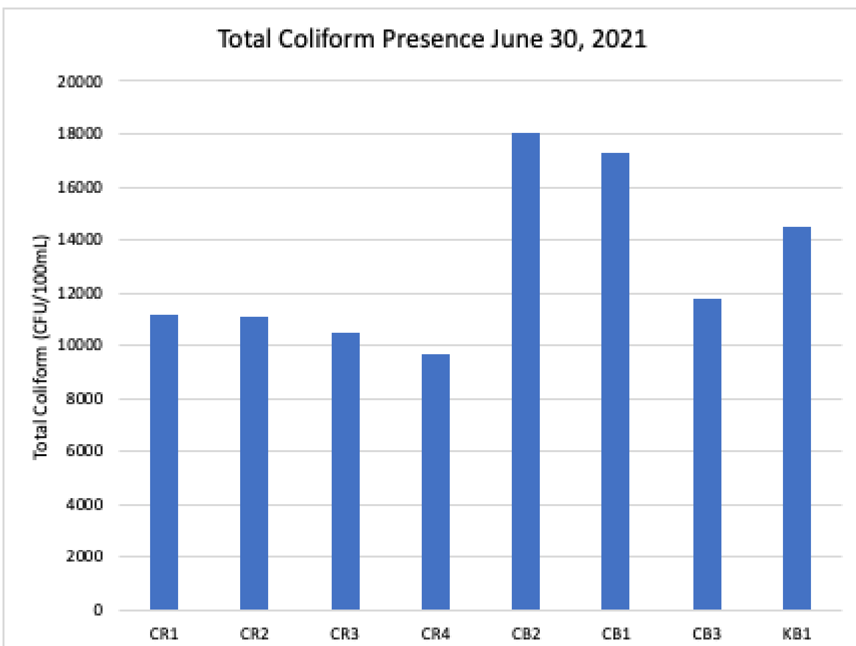

Figure 3.2.6. Summer counts of total coliform colony forming units.

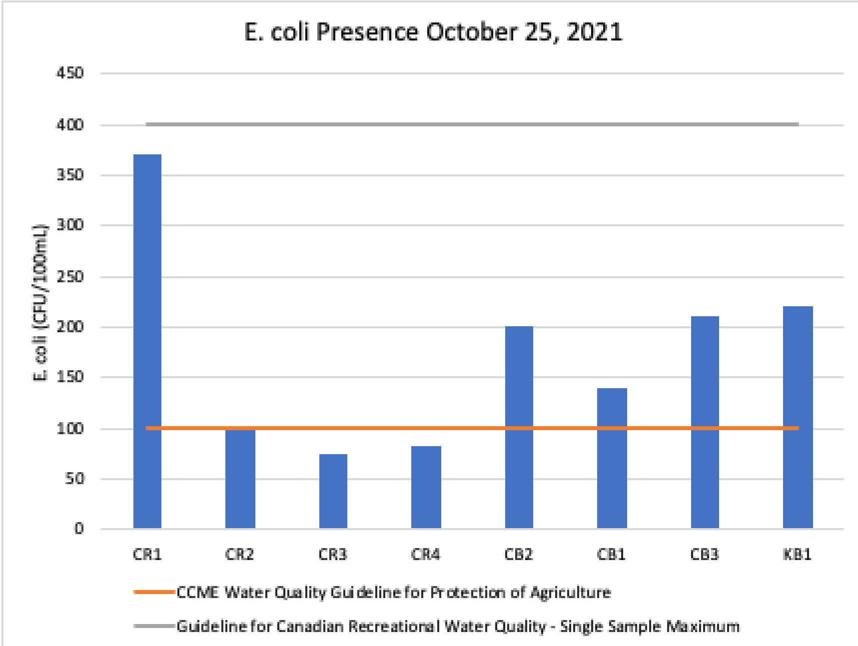

Figure 3.2.7. Autumn counts of E. coli colony forming units compared to federal guidelines (Health Canada, 2012, CCME 1987b).

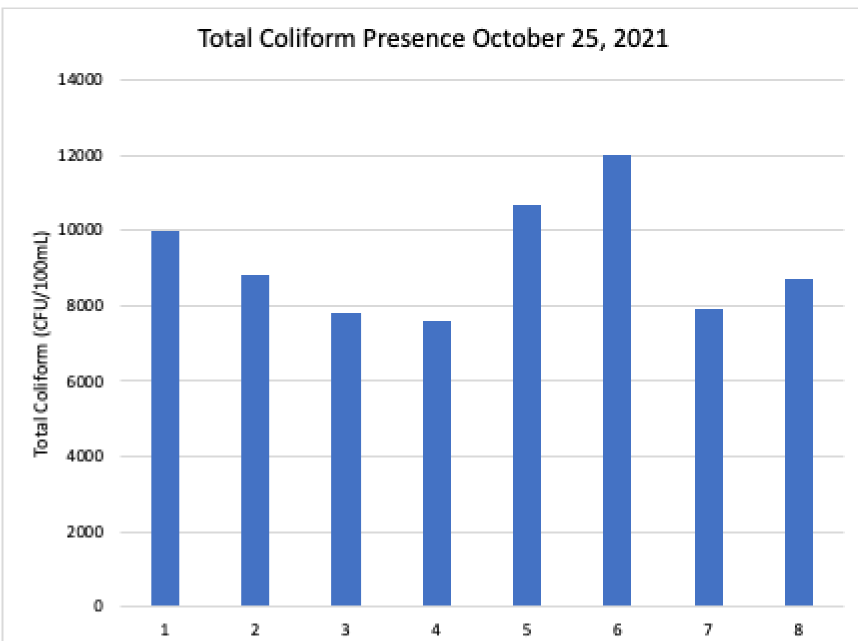

Figure 3.2.8. Autumn counts of total coliform colony forming units.

AGAT Laboratories Chemical, Nutrient, and Metals Analysis

Generally, the values for each parameter did not have a large range across sites. Higher nutrient values were associated with the CR1 and CR2 locations, which may be due to the proximity of livestock and the Waterville treatment facility. Values were higher at CR1 and KB1 for many of the metal parameters compared to the rest of the sites. Select parameters of interest are discussed below.

Parameter	Unit	RDL	CR1	CR2	CR3	CR4	CB1	CB2	CB3	KB1
Chloride	mg/L	1	78	33	38	34	21	21	20	15
Sulphate	mg/L	2	65	45	43	39	9	9	47	92
Ammonia as N	mg/L	0.03	0.12	1.17	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Total Phosphorous	mg/L	0.02	0.38	0.18	0.2	0.18	0.06	0.07	0.06	0.08
Total Aluminum	ug/L	5	650	79	88	158	75	90	160	564
Total Iron	ug/L	50	1990	564	510	512	189	351	452	912

Table 3.2.2. Select water quality parameters at sampling sites. RDL stands for reported detection limit.

Values for chloride were low compared to the CCME guidelines of 640 mg/L for short-term concentration and 120 mg/L for long-term concentration (CCME, 2011). Sulphate values were similarly low with highest reported values at CR1 and KB1, which may be a result of fertilizer use near these sites.

The highest ammonia value at CR2 is likely a result of effluent from the water treatment facility but does not appear to impact downstream sites CR3 and CR4 as values drop below the detection limit at these sites.

According to total phosphorus guidelines for long term concentration, sites CR1, CR2, and CR4 may be considered hyper-eutrophic with values over 0.10 mg/L. CR3, CB1, CB3, CB3, and KB1 are classified as eutrophic, in the range of 0.035 mg/L to 0.10 mg/L (CCME 2004). More than one measurement would be required to classify the productivity at these locations.

Long term concentration guidelines for the protection of aquatic life are 100 ug/L for aluminum and 300 ug/L for iron (CCME, 1987a, 1987c). The measured values for these parameters exceed the guidelines at many sampling locations. Soils in the area may have depleted minerals due to a regional history of acid rain, which could contribute to a lower buffering capacity and high concentration of these metals in the watercourse.

3.3 Aquatic Habitat Assessment (HSI)

The aquatic habitat assessment was divided into three sections, the Coleman Brook, the Cornwallis River, and Cornwallis River tributaries. As shown in the tables below, one site was surveyed on the Coleman Brook, seven sites were surveyed on the Cornwallis River, and five sites were surveyed in Cornwallis River tributaries.

The suitability index ranges between 0 and 1 for each category. A value less than 0.4 is considered poor quality and is highlighted in red, 0.4-0.8 is moderate quality and is highlighted in yellow, and values over 0.8 represent good quality and are highlighted in green. The tables below show the suitability index values for brook trout and Atlantic salmon habitat in the three assessment sections.

Coleman Brook

The freshwater habitat on the Coleman Brook was assessed at one location near CB1. Overall, the habitat provided good quality for brook trout and Atlantic salmon, although there was a lack of pool habitat, defined thalweg, and appropriate substrate in riffle-run areas. The limited data suggests good potential for productive trout and juvenile Atlantic salmon habitat at this location.

According to observational HSI data, the habitat downstream of this location becomes swampier, with thick stands of alder providing stream shade and fish cover. On the reach of the Coleman Brook south of Highway 101 by CB2, the main channel is poorly defined, with slow water flow and evidence of beaver activity.

From Highway 101 to Cambridge Road, stream shade on the Coleman Brook decreases and floodplains widen. Streambank vegetation is mainly made up of grasses and shrubs. The depth of the watercourse increases significantly near CR3. Fine sediment is the dominant substrate type from CR1 to CR3.

Table 3.2.2. Brook trout habitat suitability in Coleman Brook.

Percent Pools	Pool Class Rating	Percent Instream Cover Juvenile	Percent Instream Cover During Late Growing Season Adult	Dominant Substrate Type in Riffle-Run Areas	Average Percent Vegetation Along the Streambank	Average Percent Rooted Vegetation and Stable Rocky Ground Cover	Average Maximum Water Temperature	pH	Spawning Present	Average Size of Substrate in Spawning Areas	Percent Fines in Spawning Areas	Percent Fines in Riffle-Run Areas	Percent Substrate Size Class for Winter Escape	Average Thalweg Depth During the Late Growing Season	Percent Stream Shade
0.30		1.00	1.00	0.30	1.00	1.00	1.00	1.00				0.00	0.00	0.75	0.93

Table 3.2.3. Atlantic salmon habitat suitability in Coleman Brook.

% Pools	Pool Class Rating	% Instream Cover (fry)	% Instream Cover (parr)	Dominant Substrate Type in Riffle-Run Areas	Avg % Vegetation Along the Streambank	Avg % Rooted Vegetation and Stable Rocky Ground Cover	Summer Rearing Temp During Growing Season	pH	Spawning Present	Substrate for Spawning and Incubation	% Fines in Spawning Areas	Fry Water Depth	Parr Water Depth	Stream Order	% Stream Shade
0.12		1.00	1.00	0.30	1.00	1.00	1.00	1.00				1.00	1.00		0.93

Cornwallis River

HSI data from sites on the Cornwallis River indicate that freshwater habitat for brook trout and Atlantic salmon is degraded, with minimal pool habitat of poor quality, minimal fish cover and spawning areas, lack of stream shade, and poor substrate quality in riffle-run sections.

The suitability index for average percent rooted vegetation and stable rocky ground is generally low, which means there is good potential for erosion, especially when considering the high percentage of fine substrate in the Cornwallis River. However, the average bankfull widths at all seven HSI sites are less than the calculated bankfull width, indicating that the banks are not over-widened at these locations.

Despite the lack of stream shade and instream cover at these sites on the Cornwallis River, the water temperature suitability index values were good when the HSIs were completed in June. The suitability index for average maximum water temperature and summer rearing temperature during growing season may be lower in late summer when water levels are lower and daytime temperatures increase.

Floodplains are generally greater than 10m on either side of the river between the farthest upstream and farthest downstream HSI locations. Streambank vegetation is dominated by grasses and shrubs. The Cornwallis River meanders for the entire reach of the study area. There is a well-defined main channel with some oxbow formations.

Table 3.2.4. Brook trout habitat suitability in the Cornwallis River.

Percent Pools	Pool Class Rating	Percent Instream Cover Juvenile	Percent Instream Cover During Late Growing Season Adult	Dominant Substrate Type in Riffle-Run Areas	Average Percent Vegetation Along the Streambank	Average Percent Rooted Vegetation and Stable Rocky Ground Cover	Average Maximum Water Temperature	pH	Spawning Present	Average Size of Substrate in Spawning Areas	Percent Fines in Spawning Areas	Percent Fines in Riffle-Run Areas	Percent Substrate Size Class for Winter Escape	Average Thalweg Depth During the Late Growing Season	Percent Stream Shade
0.39	0.60	1.00	1.00	0.30	1.00	0.33	1.00	1.00	no			0.19	0.81	0.50	0.37
0.38	0.60	1.00	0.17	0.30	1.00	0.25	1.00	1.00	no			0.00	0.25	0.98	0.33
0.30	0.30	1.00	0.12	0.60	1.00	0.69	0.98	1.00	no			0.89	1.00	0.76	0.37
0.30	0.30	0.00	0.00	0.30	1.00	0.77	0.99	1.00	no			0.00	0.22	0.48	0.37
0.30	0.30	0.00	0.00	0.60	1.00	0.69	1.00	0.99	no			1.00	1.00	0.92	0.37
0.30	0.30	0.00	0.00	0.30	1.00	0.77	1.00	1.00	no			0.00	0.28	1.00	0.44
0.30	0.30	1.00	0.43	0.60	1.00	0.97	1.00	1.00	no			1.00	0.00	1.00	0.30

Table 3.2.5. Atlantic salmon habitat suitability in the Cornwallis River.

% Pools	Pool Class Rating	% Instream Cover (fry)	% Instream Cover (parr)	Dominant Substrate Type in Riffle-Run Areas	Avg % Vegetation Along the Streambank	Avg % Rooted Vegetation and Stable Rocky Ground Cover	Summer Rearing Temp During Growing Season	pH	Spawning Present	Substrate for Spawning and Incubation	% Fines in Spawning Areas	Fry Water Depth	Parr Water Depth	Stream Order	% Stream Shade
0.27	0.60	1.00	1.00	0.30	1.00	0.33	1.00	1.00	no			1.00	1.00		0.37
0.25	0.60	1.00	0.17	0.30	1.00	0.25	1.00	0.94	no			1.00	1.00		0.33
0.12	0.30	1.00	0.12	0.60	1.00	0.69	1.00	1.00	no			1.00	1.00		0.37
0.12	0.30	0.00	0.00	0.30	1.00	0.77	1.00	1.00	no			0.69	0.93		0.37
0.12	0.30	0.00	0.00	0.60	1.00	0.69	1.00	1.00	no			0.80	1.00		0.37
0.12	0.30	0.00	0.00	0.30	1.00	0.77	1.00	1.00	no			0.91	1.00		0.44
0.12	0.30	1.00	0.43	0.60	1.00	0.97	1.00	0.91	no			1.00	1.00		0.30

Cornwallis River Tributaries

Three sites were surveyed on Ratchford Brook, and two sites were surveyed on Sharpe Brook. Both tributaries have similar morphology, flowing north towards the Cornwallis River from headwaters on the South Mountain. The two tributaries provide good stream shade, instream cover, and streambank vegetation. The limited pool habitat is poor quality, and there are few spawning areas. Substrate in riffle-run areas is more suitable for brook trout and Atlantic salmon compared to the sites surveyed on the Cornwallis River. Generally, the tributaries surveyed were less susceptible to erosion based on the suitability index of percent rooted vegetation and stable rocky ground cover.

Trees were the dominant vegetation along Sharpe Brook. The average bankfull width was wider than the calculated bankfull width at both HSI sites, indicating that streambanks may be over-widened at these locations. The suitability index for dominant substrate was good in this tributary, with a mix of gravel, cobble, and boulder.

Grasses are the dominant vegetation along Ratchford Brook, with a less dominant mix of trees and shrubs. The average bankfull width was wider that the calculated bankfull width at only one of the three sites surveyed. The dominant substrate suitability index was lower at this tributary than Sharpe Brook due to a much higher percentage of fine substrate.

Table 3.2.6. Brook trout habitat suitability in Cornwallis River tributaries.

Percent Pools	Pool Class Rating	Percent Instream Cover Juvenile	Percent Instream Cover During Late Growing Season Adult	Dominant Substrate Type in Riffle-Run Areas	Average Percent Vegetation Along the Streambank	Average Percent Rooted Vegetation and Stable Rocky Ground Cover	Average Maximum Water Temperature	pH	Spawning Present	Average Size of Substrate in Spawning Areas	Percent Fines in Spawning Areas	Percent Fines in Riffle-Run Areas	Percent Substrate Size Class for Winter Escape	Average Thalweg Depth During the Late Growing Season	Percent Stream Shade
0.30	0.30	1.00	0.13	0.30	1.00	0.85	1.00	1.00	no			0.00	0.06	0.40	1.00
0.30	0.30	1.00		0.60	1.00	0.77	1.00	1.00	no			0.47	0.08	0.40	1.00
0.30	0.30	1.00	1.00	0.60	1.00	0.77	1.00	1.00	no			0.82	1.00	0.51	0.72
0.30	0.30	1.00	0.44	1.00	1.00	0.92	1.00	1.00	no			1.00	1.00	0.27	1.00
0.78	0.60	1.00	0.18	1.00	1.00	0.85	1.00	0.96	yes	0.00	0.03	0.99	1.00	0.76	1.00

Table 3.2.7. Atlantic salmon habitat suitability in Cornwallis River tributaries.

% Pools	Pool Class Rating	% Instream Cover (fry)	% Instream Cover (parr)	Dominant Substrate Type in Riffle-Run Areas	Avg % Vegetation Along the Streambank	Avg % Rooted Vegetation and Stable Rocky Ground Cover	Summer Rearing Temp During Growing Season	pH	Spawning Present	Substrate for Spawning and Incubation	% Fines in Spawning Areas	Fry Water Depth	Parr Water Depth	Stream Order	% Stream Shade
0.12	0.30	1.00	0.13	0.30	1.00	0.85	1.00	1.00	no			1.00	0.70		1.00
0.12	0.30	1.00		0.60	1.00	0.77	1.00	1.00	no			1.00	0.99		1.00
0.12	0.30	1.00	1.00	0.60	1.00	0.77	0.90	1.00	no			1.00	0.66		0.72
0.12	0.30	1.00	0.44	1.00	1.00	0.92	0.77	1.00	no			1.00	1.00		1.00
0.95	0.60	1.00	0.18	1.00	1.00	0.85	0.80	1.00	yes	0.64	0.03	1.00	1.00		1.00

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Appendix A

Table 1. Substrate types and associated sizes

Substrate	**Size (cm)**
Fines (sand, clay, silt)	<0.2
Gravel	0.2-6.4
Cobble	6.4-25.6
Boulder	>25.6

Appendix B

Table 1. Freshwater Fish Habitat Suitability Index field sheets

NSFHAP Field Sheet #:

River Name: ______________ Watershed Code: ___________ Date: _____________ Time: _______ Crew: ______________

Site Boundary Coordinates: D/S ______________ _________________ U/S _________________ _________________

Site Bankfull Width: _________ Site Length: _________ Transect Spacing: ___________ Stream Order: _________

Air Temp: ___________Water Temp: ___________ pH: ________ Conductivity: _______ TDS: _______ DO: _______

Channel Cross-sections										
	Floodplains		Height and Widths			Wetted Depths				
	Average Left Width	Average Right Width	Bankfull Width (m)	Bankfull Height (m)	Wetted Width (m)	1/4 of Width (cm)	2/4 of Width (cm)	3/4 of Width (cm)	Thalweg (cm)	Thalweg Location (m)
T1										
T2										
T3										

Substrate and Cover																					
				¼ Width					1/2 Width					¾ Width							
	GPS Coordinates		Habitat Type	Fines	Gravel	Cobble	Boulder	Bedrock	Fines	Gravel	Cobble	Boulder	Bedrock	Fines	Gravel	Cobble	Boulder	Bedrock	% Embedded	Instream Cover for Juveniles (# of fish)	Instream Cover for Adults (# of fish)
T1																					
T2																					
T3																					

Riverbanks and Riparian Area								
	% Trees	% Shrubs	% Grass	% Bare Soil	% Eroding	% Stable Ground	% Stream Shade	Ice Scar Height
Left Bank								
Right Bank								
Vegetation Index:					Avg:	Avg:		

Table 2. Freshwater Fish Habitat Suitability Index field sheets

Pool Measurements									
Transect #	Max Depth (cm)	Depth of Pool Tail (cm)	Est. Low Flow Max Depth (cm)	Average Length (m)	Average Width (m)	Final Pool Area (m²)	% Pool Cover	Percentage of Pools	Pool Class Rating

Pictures	
#	Description

Avg. Substrate Size in Spawning Areas (*Brook trout*) (cm): ___________________

Avg. Substrate Size in Spawning Areas (*Atlantic salmon*) (cm): _______________

% Fines (*Brook trout Spawning*): _______________________

% Fines (*Salmon Spawning*): _________________________

Point Bar Presence/Condition: ________________________

Rock Grab: ☐ 3 Minute Kick: ☐

Net Type/Mesh Size: _____/____

% EPT: ______ %Chironomids: ___

Common Name				Tally
Midges				
Snails, Limpets				
Sow Bugs				
Aquatic Earthworm				
Beetles				
Mayflies				
Fishflies, Alderflies				
Stoneflies				
Caddisflies				

Notes and Section Sketch: Indicate right and left banks, tributaries and inflows, flow direction, and general river form description

Appendix C

CR1

Date	Temp (°C)	DO (mg/L)	SPC (uS/cm)	TDS (mg/L)	Salinity (ppt)	pH	Turbidity (NTU)
10-May-21	8.00	9.79	150.30	97.50	0.06	6.86	N/A
01-Jun-21	15.20	8.91	319.50	208.65	0.15	7.12	N/A
14-Jun-21	17.20	8.69	333.36	216.45	0.16	7.43	4.77
25-Jun-21	17.30	8.47	286.19	188.50	0.16	7.47	4.91
09-Jul-21	18.70	8.39	356.16	231.40	0.17	2.76	2.81
27-Jul-21	19.30	N/A	387.14	N/A	0.17	7.55	N/A
18-Aug-21	20.70	9.60	325.70	211.25	0.16	8.34	10.45
25-Aug-21	22.70	9.40	381.40	200.16	0.18	7.76	5.33
08-Sep-21	15.10	N/A	4.05	171.60	0.13	7.12	12.80
07-Oct-21	10.70	9.36	416.30	271.05	0.20	7.54	8.24
25-Oct-21	9.40	9.90	401.80	261.30	0.19	7.10	7.46

CR2

Date	Temp (°C)	DO (mg/L)	SPC (uS/cm)	TDS (mg/L)	Salinity (ppt)	pH	Turbidity (NTU)
10-May-21	8.40	8.79	132.81	86.45	0.06	7.43	N/A
01-Jun-21	14.70	9.50	262.05	170.30	0.13	7.39	N/A
14-Jun-21	16.70	7.93	282.36	183.95	0.14	7.44	3.27
25-Jun-21	17.00	8.67	302.41	196.30	0.14	7.59	4.46
09-Jul-21	18.10	6.71	314.90	204.75	0.16	2.54	2.25
27-Jul-21	19.20	N/A	311.51	N/A	0.13	7.39	N/A
18-Aug-21	20.20	8.10	341.50	221.65	0.16	7.97	3.41
25-Aug-21	22.60	9.20	343.70	222.95	0.16	7.71	5.43
08-Sep-21	17.80	4.29	223.10	144.95	0.11	7.02	16.40
07-Oct-21	10.70	10.64	350.00	227.50	0.17	7.57	4.54
25-Oct-21	9.20	10.00	379.80	247.00	0.18	7.15	6.27

CR3

Date	Temp (°C)	DO (mg/L)	SPC (uS/cm)	TDS (mg/L)	Salinity (ppt)	pH	Turbidity (NTU)
10-May-21	8.40	9.69	127.83	82.55	0.06	6.60	N/A
01-Jun-21	15.00	7.94	272.44	177.45	0.13	7.28	N/A
14-Jun-21	16.90	9.69	291.26	189.80	0.14	7.30	2.76
25-Jun-21	17.40	8.26	320.29	208.00	0.15	7.34	3.29
09-Jul-21	18.20	6.93	318.69	207.35	0.15	2.43	2.93
27-Jul-21	19.40	N/A	319.13	N/A	0.14	7.46	N/A
18-Aug-21	19.50	7.20	348.00	226.20	0.17	7.37	3.80
25-Aug-21	21.90	8.60	354.50	230.10	0.17	7.49	4.71
08-Sep-21	18.10	N/A	229.50	138.90	0.11	7.05	10.69
07-Oct-21	11.60	12.33	351.90	228.80	0.17	7.51	3.50
25-Oct-21	9.30	10.80	398.20	258.70	0.19	6.93	6.24

CR4

Date	Temp (°C)	DO (mg/L)	SPC (uS/cm)	TDS (mg/L)	Salinity (ppt)	pH	Turbidity (NTU)
10-May-21	9.00	9.21	118.23	76.70	0.06	6.74	N/A
01-Jun-21	15.20	9.74	278.78	181.35	0.13	7.40	N/A
14-Jun-21	17.60	10.92	283.23	184.60	0.14	7.43	1.73
25-Jun-21	17.80	8.58	310.85	202.15	0.15	7.30	3.40
09-Jul-21	18.30	7.44	298.96	194.35	0.14	2.68	3.95
27-Jul-21	19.70	N/A	303.75	N/A	0.13	7.43	N/A
18-Aug-21	19.20	8.40	332.10	215.80	0.16	7.56	2.68
25-Aug-21	21.20	8.30	335.40	217.75	0.16	7.50	4.24
08-Sep-21	16.40	3.99	217.60	N/A	0.10	6.69	11.40
07-Oct-21	11.50	11.45	334.10	217.10	0.16	7.52	5.88
25-Oct-21	8.80	8.90	376.20	244.40	0.18	7.21	5.46

CB2

Date	Temp (°C)	DO (mg/L)	SPC (uS/cm)	TDS (mg/L)	Salinity (ppt)	pH	Turbidity (NTU)
10-May-21	8.90	10.72	167.08	108.55	0.08	6.87	N/A
01-Jun-21	14.10	8.83	211.79	137.15	0.10	7.44	N/A
14-Jun-21	16.30	9.37	266.84	173.55	0.13	7.36	4.79
25-Jun-21	14.00	11.28	265.35	172.90	0.13	7.54	2.84
09-Jul-21	16.40	7.15	267.19	173.55	0.13	2.50	3.53
27-Jul-21	24.00	N/A	191.66	N/A	0.19	7.27	N/A
18-Aug-21	16.20	6.10	288.20	186.55	0.14	7.24	2.80
25-Aug-21	19.00	8.10	280.10	182.00	0.13	7.80	3.37
08-Sep-21	15.80	4.20	240.90	155.65	0.11	7.28	19.20
07-Oct-21	10.40	10.39	286.10	185.90	0.14	7.63	6.70
25-Oct-21	8.90	10.00	310.20	201.50	0.15	7.08	3.00

CB1

Date	Temp (°C)	DO (mg/L)	SPC (uS/cm)	TDS (mg/L)	Salinity (ppt)	pH	Turbidity (NTU)
10-May-21	8.70	11.01	173.67	113.10	0.08	6.56	N/A
01-Jun-21	14.00	6.99	211.29	137.15	0.10	7.55	N/A
14-Jun-21	17.00	9.48	262.28	170.95	0.13	7.73	3.14
25-Jun-21	14.40	9.46	263.81	171.60	0.13	7.78	1.80
09-Jul-21	16.60	8.61	215.95	140.50	0.10	2.43	5.34
27-Jul-21	18.70	N/A	320.57	N/A	0.14	7.84	N/A
18-Aug-21	16.60	7.90	290.60	189.50	0.14	7.40	2.74
25-Aug-21	20.10	9.00	294.70	191.10	0.14	7.48	2.45
08-Sep-21	16.60	5.29	255.70	166.40	0.12	7.51	9.42
07-Oct-21	10.40	10.43	290.00	188.50	0.14	7.53	2.67
25-Oct-21	9.20	9.10	316.40	205.40	0.15	7.09	2.34

CB3

Date	Temp (°C)	DO (mg/L)	SPC (uS/cm)	TDS (mg/L)	Salinity (ppt)	pH	Turbidity (NTU)
10-May-21	8.10	10.99	139.25	90.35	0.07	6.68	N/A
01-Jun-21	14.40	8.70	259.55	169.00	0.12	7.47	N/A
14-Jun-21	17.50	9.79	336.27	218.40	0.16	7.62	3.29
25-Jun-21	15.20	6.95	295.39	191.75	0.14	7.39	4.80
09-Jul-21	17.30	7.87	315.97	205.40	0.15	2.78	5.75
27-Jul-21	19.10	N/A	317.81	N/A	0.14	7.63	N/A
18-Aug-21	17.50	6.50	323.50	209.60	0.16	7.17	7.44
25-Aug-21	19.00	8.80	286.90	182.00	0.14	7.74	1.61
08-Sep-21	15.20	4.04	206.90	134.55	0.10	7.12	11.60
07-Oct-21	10.70	9.86	329.30	213.20	0.16	7.59	25.30
25-Oct-21	9.10	8.50	352.10	229.45	0.17	7.02	6.60

KB1

Date	Temp (°C)	DO (mg/L)	SPC (uS/cm)	TDS (mg/L)	Salinity (ppt)	pH	Turbidity (NTU)
01-Jun-21	13.70	11.17	265.63	172.90	0.13	7.47	N/A
14-Jun-21	15.90	10.31	376.18	244.40	0.18	7.93	6.08
25-Jun-21	16.00	8.07	320.98	208.65	0.15	7.49	5.39
09-Jul-21	16.60	7.49	361.26	235.95	0.17	2.68	6.17
27-Jul-21	20.30	N/A	318.60	N/A	0.14	7.70	N/A
18-Aug-21	17.50	5.60	345.10	224.25	0.17	7.09	8.71
25-Aug-21	19.60	6.80	326.30	211.99	0.16	7.43	9.70
08-Sep-21	14.80	4.03	188.20	122.20	0.09	7.11	7.56
07-Oct-21	10.40	9.54	388.80	252.85	0.19	7.58	11.40
25-Oct-21	8.90	8.10	412.50	267.80	0.20	6.95	6.48