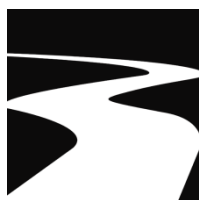# Fish Passage Restoration and Habitat Enhancement

Fish habitat enhancement in the Round Hill River sub-watershed

Prepared By:
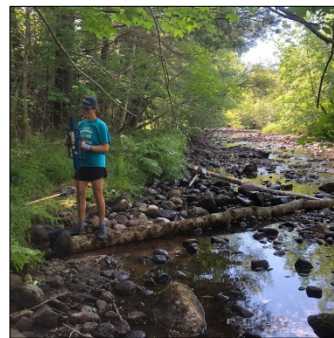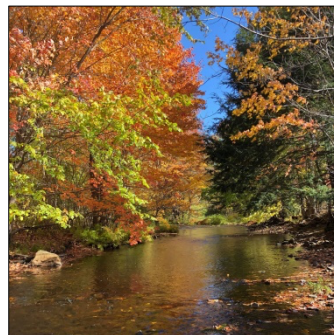
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December 2020

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Fish Passage Restoration and Habitat Enhancement

Fish habitat enhancement in the Round Hill River sub-watershed

Nova Scotia Salmon Association
Adopt A Stream

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List of Acronyms

AAS	Adopt A Stream
CARP	Clean Annapolis River Project
cm	Centimetre
DFO	Fisheries and Oceans Canada
g	Grams
HSI	Habitat Suitability Index
km^2	Kilometre squared
m	Meter
m^2	Meters squared
mg	Milligram
mm	Millimeter
NSE	Nova Scotia Environment
NSFHAP	Nova Scotia Fish Habitat Assessment Protocol
NSSA	Nova Scotia Salmon Association
μS/cm	microSiemens

Acknowledgements

Executive Summary

While threats to fish populations are numerous and diverse, degradation of freshwater habitats remains one of the most significant contributors to the observed decline of species. Much of this habitat loss has been attributed to modifications of the physical environment by human land-uses. The Round Hill River, not unlike many rivers in the Annapolis River watershed, is greatly affected by human alteration and land-use changes within the sub-watershed and as a result, ideal in-stream fish habitat is lost through channel modification, sedimentation and alterations to water quality. The Clean Annapolis River Project (CARP) has undertaken aquatic habitat connectivity assessment and restoration actions on the Round Hill River in the past, including the installation of restoration structures and assessments of major road watercourse crossing for fish passage. In the late 1990's, CARP installed various structures along the Round Hill River to enhance the physical characteristics of the watercourse, stabilize the banks to allow for re-establishment of riparian buffer zones and encourage salmonid spawning and rearing within the river. In recent years it was determined that many of these structures were too small and spaced too close together to be effective. CARP's recent work in the Round Hill River has been focused on removing, updating, and/or re-installing structures that are better suited for the layout of the river.

The objective of the 2020 project was to enhance in-stream habitat for Atlantic salmon, brook trout and other native aquatic species in the Round Hill River sub-watershed. Since 2012, CARP has been creating and implementing sub-watershed management plans to identify and manage ecosystem threats on a watershed scale in watercourses identified as priorities. As part of this process, CARP has been working towards improving in-stream habitat quality in the Round Hill River sub-watershed, one of the seven priority sub-watersheds identified. In total, 2604 m^2 of in-stream habitat was enhanced on the Round Hill River through the installation of 4 in-stream restoration structures. The completion of these enhancement activities in addition to historic data and future data collection will be used towards the completion of a sub-watershed management plan for the Round Hill River in future years.

1.0 Introduction

In Nova Scotia, the precipitous decline of fish populations that had historically widespread distributions is a well-documented issue (Parrish *et al.*, 1998; Klemetsen *et al.*, 2003; NSDAF, 2005; Ryan & MacMillan, 2016). While threats to fish populations are numerous and diverse, degradation of freshwater habitats resulting from human activities remains one of the most significant contributors to observed declines in native fish species, including sport fish that have provided valuable economic contributions to the province (Taylor *et al.*, 2010; DFO, 2006; Bohn & Kershner, 2002; Bardonnet & Baglinière, 2000). Much of this habitat loss has been attributed to modifications of the physical environment by human land-uses. Human influences and land-use changes surrounding a watercourse can lead to negative impacts such as erosion and sedimentation that damage aquatic ecosystems. Streams can become straightened and over widened which in turn can lead to greater erosion and sedimentation, thus reducing the thermal capacity of the watercourse, in-stream cover, food availability from vegetation, as well as appropriate flows for spawning (NSE, 2018). Remediation actions to address these threats include the removal of the fine sediments from the stream to reveal the natural cobble and gravel substrate as well as the installation of in-stream structures to help redirect the excess sand and silt while supporting natural stream processes, thus enhancing the aquatic habitat for various species including, but not limited to Atlantic salmon and brook trout.

Due to the region's history that includes the site of Canada's oldest existing European settlement, the rivers and streams of the Annapolis River watershed have a long history of human use, alteration and degradation, which has taken its toll on the freshwater ecosystems and the native aquatic species that inhabit them. In the early 1990's, the Clean Annapolis River Project (CARP) surveyed several tributaries to the Annapolis River, and in 2012 developed a list of seven priority sub-watersheds ideal for future fish habitat restoration work focused on the conservation of native fish populations, especially Atlantic salmon. As a historically known Atlantic salmon river, the Round Hill River watershed was identified as a priority sub-watershed based on historical water quality monitoring, past restoration activities, and observations and experiences of local community members. In the late 1990's, in-stream structures were installed by CARP to enhance the physical characteristics of the watercourse, and stabilize the banks to allow for re-establishment of riparian buffer zones to encourage salmonid spawning and rearing within the river.

The Fish Passage Restoration and Habitat Enhancement Project (formerly "Broken Brooks") was conceptualized and initialized by CARP in 2007. Fieldwork for the project has been ongoing since 2010 with the purpose of assessing and restoring aquatic habitat and connectivity within the Annapolis River watershed. As part of the

Broken Brooks program, CARP has been assessing watercourse crossings within the watershed in an attempt to identify which ones pose barriers to fish, and prioritize those which have been found to obstruct access to upstream habitats for remediation. In 2012, CARP adopted a sub-watershed assessment approach to allow for improved watershed management and planning. In 2015, the project name was changed to reflect the inclusion of in-stream habitat remediation and sub-watershed planning within the scope of the project. The focus of the 2020 season was on in-stream restoration work on the Round Hill River to concentrate flow and improve the quality of pool habitat for the spawning and rearing of salmonids and other native fish species. Additionally, monitoring was done along the Fales River to identify potential sediment input sources.

2.0 Methodology

The Round Hill River received restoration efforts by CARP during the summer of 1997 and again in 1998 to enhance and restore the aquatic habitat in this important sub-watershed. A total of 32 digger log structures with deflectors were installed with the intention to narrow the channel and reposition the boulder substrate to create deeper pools within the river. Bank stabilization was also conducted to address the over-sedimentation within the stream as a result of land-use changes (Halliday, 1998). In 2019, some of these structures were revisited to determine structural integrity in a small section of the river and those of which were undersized or deteriorating were removed.

The 2020 field season built upon previous projects by CARP, in which efforts were focused on identifying, prioritizing and restoring fish habitat within the Fales River and Round Hill River sub-watersheds. In addition, in-stream restoration actions were completed to address over widening in the Round Hill River through the installation of in-stream structures.

2.1   In-Stream Habitat Enhancement

In 2020, a series of 4 new in-stream structures were installed to build upon past efforts and to establish a newer and more current layout to suit the natural changes that have occurred to the Round Hill River over the past 20 years.

The sites for restoration as well as the structures installed were selected through the guidance of Nova Scotia Salmon Association's (NSSA) Adopt A Stream Biologists. The sites were selected based on the width, gradient, and meandering pattern of the river. A straight and over widened section of the Round Hill River was

selected to receive in-stream restoration with the hopes to concentrate flow, narrow and deepen the channel, as well as re-establish its meandering pattern.

Figure 1. A straightened and over widened
section of the Round Hill River

2.1.1 Deflectors

Deflectors are in-stream structures that are used to help improve fish passage in wide, shallow streams by stabilizing the banks and consequently controlling erosion in addition to accentuating stream flow and keeping downstream of the structure free of sediment (NSE, 2018). The structures were constructed and installed according to NSSA Adopt A Stream design protocols (Figure 2), adapted from the DFO publication titled '*Ecological Restoration of Degraded Aquatic Habitat: A Watershed Approach*' (DFO, 2006).
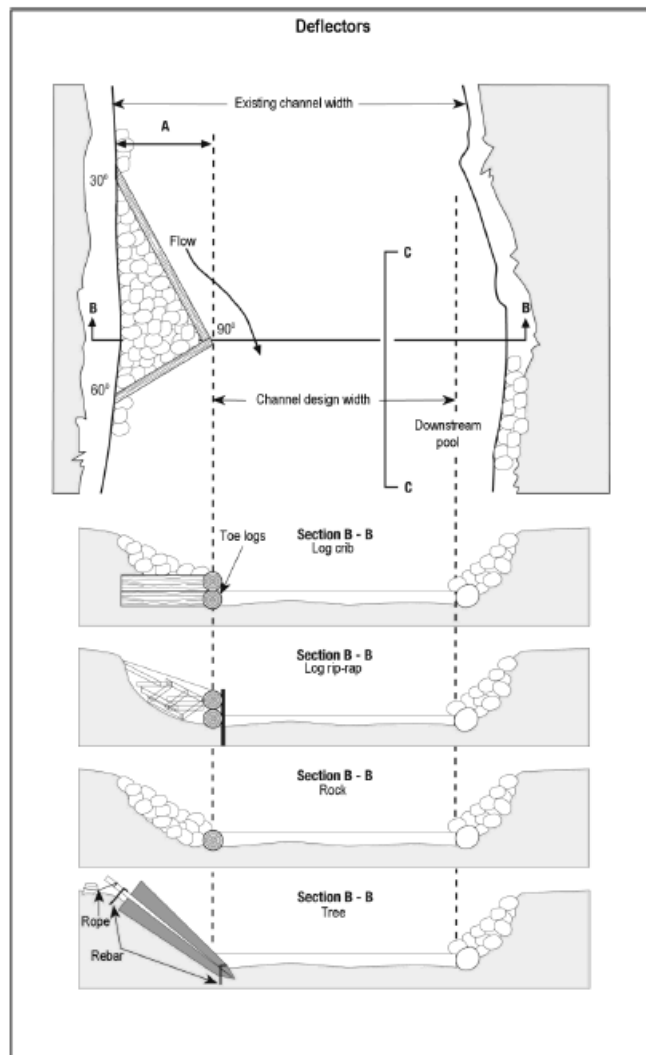
Figure 2. Conceptual drawing and guidelines for several types of deflectors (NSE, 2018)

All materials that were used for the construction of each deflector were sourced from their respective work sites and were installed using a variety of hand tools including saws, a pickaxe, log grabbers, a gas-powered drill, and an 8lb sledge hammer. The deflectors were created using hardwood logs from trees on site and placing them in a triangular shape with a 30° angle on the bank at the upstream end and a 60° angle on the bank at the downstream end, making a 90° angle where the two logs meet. The rock and boulder were cleared away from underneath the logs so they were able to lay flat on the riverbed. Using the gas-powered drill, holes were drilled through the logs, to then be secured in place using rebar. The deflectors were filled using cobble and boulder from within the river up to bankfull height to help

protect the bank from erosion. Refer to Appendix 6.11 for a detailed sketch of the structure design.

2.2   Restoration Monitoring

Over several decades, the Annapolis River watershed has been filling in with fine sediments from land-use impacts and bank erosion. Fine sediment accumulation (< 2 mm in size; Louhi *et al.*, 2008) has been widely recognized to pose detrimental effects to river ecosystems (Figure 3). Salmonid species prefer coarse gravel and stone bottoms for spawning and are particularly vulnerable to sediment accumulation (Hendry & Cragg-Hine, 2003; Klemensten *et al.*, 2003). Restoration monitoring was conducted in both the Fales River and Round Hill River sub-watersheds to help identify additional areas within the watersheds that would benefit from habitat restoration and enhancement activities.
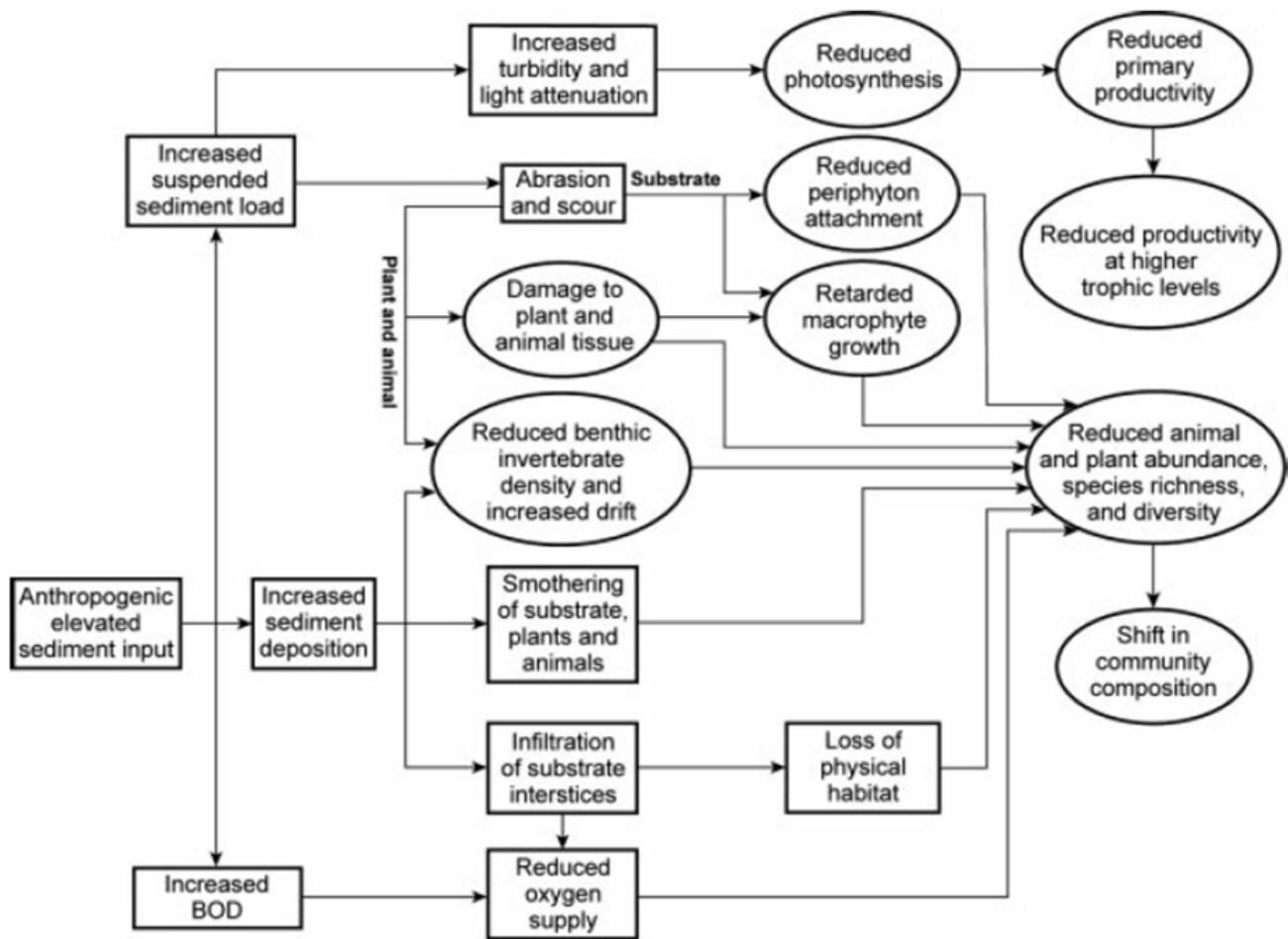
Figure 3. Negative impacts of anthropogenically enhanced sediment input (Kemp et al., 2011)

2.2.1 Habitat Suitability Index

The Habitat Suitability Index (HSI) is a tool that has been refined over many years as a method of evaluating the characteristics of a stream or river. Using habitat requirements and limiting factors for Nova Scotia's indicator species, these assessments help to determine whether the studied systems provide viable fish habitat. HSI assessments were completed in the 2020 field season along the Fales River and Round Hill River according to the updated (2019) Nova Scotia Fish Habitat Enhancement Protocol developed by Adopt A Stream and Clean Nova Scotia (NSFHAP, 2019). Refer to Appendices 6.3 and 6.4 for an example HSI data sheet and information on the data that is collected during a HSI assessment.

The data that was collected was entered into the NSFHAP online data entry sheet, which evaluates the data based on habitat suitability models for brook trout and Atlantic salmon. The 15 features assessed in the field methods are largely based on an HSI for brook trout (Raleigh, 1982) and have been adapted to include Atlantic salmon and to suit conditions in Nova Scotia. The program calculates important criteria for each species in a range from 0-1, where poor quality is given a value of less than 0.4, moderate quality has a value between 0.4 and 0.8, and good quality has a value of greater than 0.8 (Table 1). The program color codes these values, giving poor quality variables a red color, medium quality a yellow color, and good quality a green color. The results from the surveys will aid in interpreting the quality of habitat within the Fales River and Round Hill River sub-watersheds, as well as the potential for further enhancement to in-stream fish habitat. Refer to *'The Nova Scotia Fish Habitat Suitability Assessment: A Fields Methods Manual'* (NSFHAP, 2019) for full details of the assessment procedure and for more detail on each of the habitat suitability variables that are assessed for Atlantic salmon and brook trout habitat.

Table 1. Habitat suitability index and quality rating values for brook trout and Atlantic salmon habitat (NSFHAP, 2019).

Suitability Value	Quality of Habitat	Result
0.00 – 0.39	Poor	Will support none or small numbers of Atlantic salmon or brook trout.
0.40 – 0.80	Moderate	Will support some Atlantic salmon or brook trout.
0.81 – 1.0	Good	Will support many Atlantic salmon or brook trout.
1.00	Optimal	Optimum habitat to support Atlantic salmon or brook trout.

2.2.2 Sediment Monitoring

The focus of 2020 on the Fales River was to identify sediment input sources. This was done by taking sediment samples along the river; then based on those results, installing sediment traps in areas with high sediment accumulation. The sites for sediment sampling were selected by reviewing aerial photos of the river to determine areas with exposed soil, as well as locate tributaries and ditches leading into the river that may be transporting concentrated loads of sediment. Sites were also selected in areas along the river where SandWanding, a technique to remove fine sediment from the streambed, was completed in 2019.

The samples were taken by scooping sediment from the thalweg of the river and then drying the samples to remove any water content. Once the samples were dried, they were weighed and sieved into different substrate size classes to determine the percentage of fine sediment found within each sample.

Sediment traps were installed in locations along the river where samples showed the most fine sediment accumulation. The traps were made by cutting 10 cm diameter PVC pipe into 15 cm lengths. Nylon mesh netting was fitted over the pipe and held in place by a hose clamp. Rebar was used to secure the traps into the riverbed to assure they stayed in place for the length of the collection. The contents of the sediment traps were dried and weighed to determine the amount of sediment present.

Figure 4. CARP staff Brandi Veinot and
volunteer John Hill installing a sediment trap

3.0 Results

3.1 In-Stream Habitat Enhancement
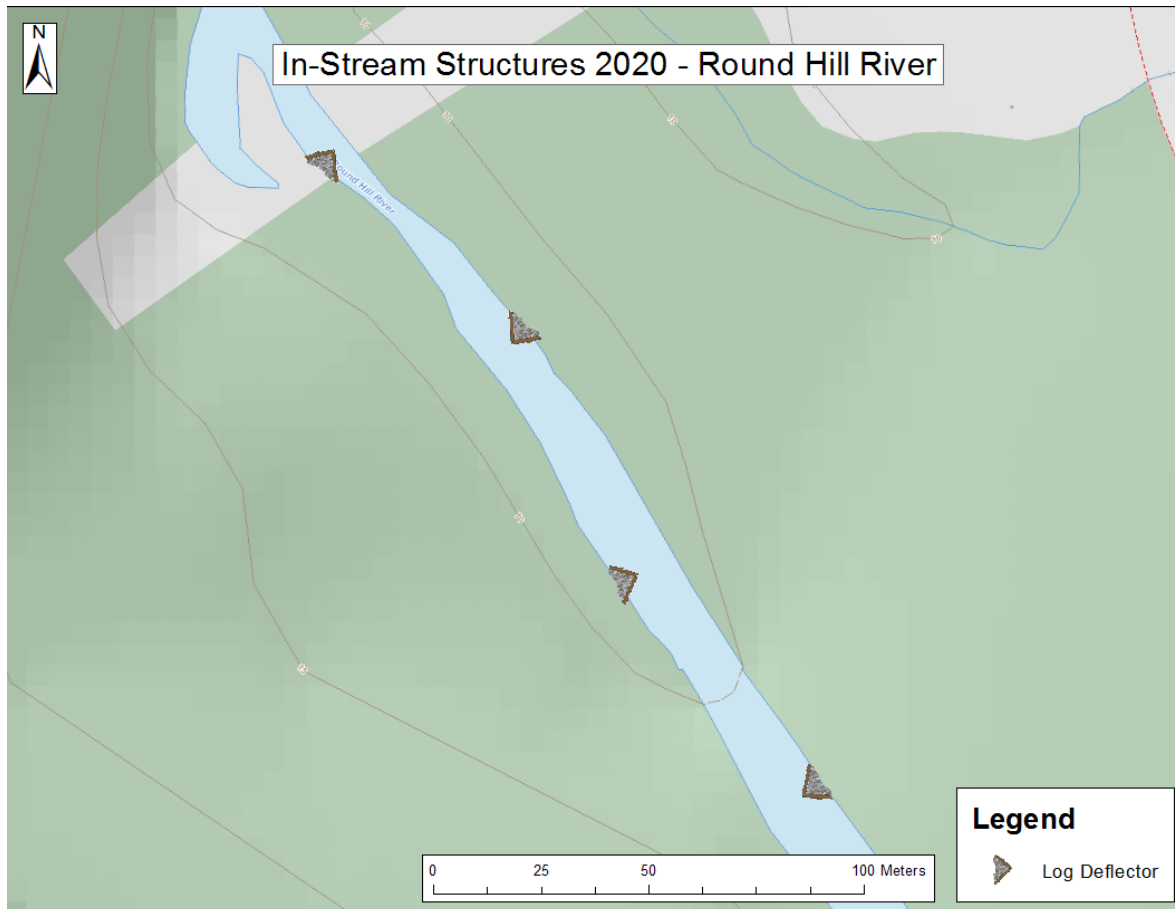
Figure 5. Site map of the 2020 completed restoration work on the Round Hill River

In-stream habitat enhancement work improved habitat productivity within a 240 m stretch of the Round Hill River restoring 2604 m^2 of fish habitat through the installation of 4 log deflectors.

Table 2. Summary of the 2020 in-stream fish habitat enhancement work

Restoration Site	Upstream		Downstream		In-stream Habitat Restored (m^2)	Restoration Work Completed
	Easting	Northing	Easting	Northing		
Round Hill River	309940	4960063	309837	4960377	2604	4 log deflectors

3.1.1 Deflectors

A series of 4 log deflectors were installed in the Round Hill River system in the 2020 field season (Figure 6). The deflectors were installed on alternating banks; the first being on the left, slightly upstream of a natural right pool.

Figure 6. CARP summer interns, Marina McBride and Abigail Bonnington, installing a log deflector

The deflectors were installed to help concentrate flow as well as narrow and deepen the channel of an area of stream over-widened by approximately 3 m. The cobble and boulder rock from within the stream that was used to fill the frame of the deflector assisted in stabilizing the bank in addition to accentuating the natural pool downstream from the new structure. These 4 log deflectors installed on the Round Hill River restored a linear length of approximately 240 m and an area of 2604 m^2.

Figure 7. Four log deflectors installed by CARP staff on the Round Hill River

3.2   Restoration Monitoring

Restoration monitoring took place in both the Fales River and Round Hill River sub-watersheds in the form of Habitat Suitability Index assessments and sediment input monitoring. HSI took place at 7 sites along the Fales River and 5 sites throughout the Round Hill River sub-watershed to assess the quality and presence of habitat for brook trout and Atlantic salmon. The Fales River also received monitoring to determine potential sediment input sources through the installation and monitoring of a series of sediment traps placed at 7 locations along the river.

Table 3. Habitat Suitability Index assessment location for 2020

HSI Site	Upstream		Downstream	
	Easting	Northing	Easting	Northing
Round Hill River Site 1	310124	4959734	310147	4959780
Round Hill River Site 2	309981	4958992	309476	4956784
Gibson Brook	318220	4954116	318220	4954128
East Branch	318522	4952674	318512	4952649
West Branch	308339	4956329	308335	4956381
Fales River Site 1	348292	4980491	348255	4980434
Fales River Site 2	348176	4980534	348192	4980494
Fales River Site 3	348059	4980599	347972	4980552
Fales River Site 4	348886	4980105	348827	4980148
Fales River Site 5	349266	4980183	349216	4980176
Fales River Site 6	349910	4980094	349862	4980121
Fales River Site 7	350788	4979174	350759	4979205

Table 4. Sediment monitoring locations for 2020

Sediment Monitoring Site	Easting	Northing	Activity
1	347605	4980595	Sample
2	347622	4980576	Sample and Trap
3	347676	4980429	Sample and Trap
4	347789	4980432	Sample and Trap
5	347870	4980501	Sample
6	348036	4980570	Sample
7	348075	4980594	Sample and Trap
8	348122	4980580	Sample
9	348178	4985051	Sample and Trap
10	348197	4980468	Sample
11	348612	4980167	Sample and Trap
12	348836	4980138	Sample and Trap

3.2.1 HSI Assessments

Figure 8. Volunteers and CARP staff completing HSI measurements on the Fales River (A) and the Round Hill River (B)

Through assessing representative variables and values of salmonid habitat features, Habitat Suitability Index assessments were completed in the Fales River and Round Hill River sub-watersheds to evaluate the quality of freshwater fish habitat. The sites were located in areas of recent restoration work, as well as locations where work hasn't taken place in recent years or at all.

The main stem of the Round Hill River, and the three of its tributaries that received HSI assessments, had relatively good results for brook trout and Atlantic salmon habitat criteria. The dominant substrate found in Round Hill was large cobble and boulder, which provides cover and resting areas for fish. The percentage of in-stream cover for both juvenile and adult fish scored high for this reason, but the results were quite poor for the spawning areas present as salmonids prefer to use smaller gravel substrate to spawn (Table 5 and Table 6).

The results on the Fales River showed overall moderate habitat quality for both brook trout and Atlantic salmon. Dominant substrate type in riffle-run areas, water depth, and percentage of in-stream cover for juveniles are categories that scored well in the index. The score for percentage of in-stream cover for adult brook trout and

Atlantic salmon was fairly poor in the Fales River; which may relate to the amount of sedimentation and fines (substrate <0.2 cm) present in the system.

It is important to note that the majority of these surveys were conducted during the fall of 2020. This means the comparison between air and water temperatures may not be fully useful. Monitoring air temperature and fluctuations in water temperature can indicate the ability of a river to stay cool during warm periods (NSFHAP, 2019). However, in the fall when both water and air tend to have cooler temperatures, this comparison becomes less useful and therefore limiting the reliability of these results (Table 10 and Table 11).

Table 5. Habitat suitability criteria results for brook trout

		% In-stream Cover (Juvenile)	% In-stream Cover (Adult)	Dominant Substrate Type in Riffle-Run Areas	Average Size of Substrate in Spawning Areas	% Fines in Spawning Areas	% Fines in Riffle-Run Areas	% Substrate Size Class for Winter Escape
Fales River	Site 1 2020/06/30	1.00	0.51	0.60	0.00	0.63	0.97	0.94
	Site 2 2020/06/30	0.83	0.07	0.60	0.00	0.08	0.99	1.00
	Site 3 2020/07/03	0.91	0.30	0.60	0.00	0.54	0.98	1.00
	Site 4 2020/10/15	0.68	0.08	0.60	0.00	0.00	0.92	1.00
	Site 5 2020/10/15	0.71	0.14	0.60	N/A	N/A	1.00	1.00
	Site 6 2020/10/15	1.00	0.57	1.00	N/A	N/A	1.00	1.00
	Site 7 2020/10/16	1.00	0.50	0.30	0.00	0.00	1.00	1.00
Round Hill River sub-watershed	Site 1 2020/10/9	1.00	0.45	0.30	0.00	0.00	1.00	1.00
	Site 2 2020/10/13	1.00	0.94	0.30	0.00	0.00	1.00	1.00
	Gibson Brook 2020/10/13	1.00	0.44	0.60	N/A	N/A	0.94	0.67
	East Branch 2020/10/20	1.00	1.00	0.30	N/A	N/A	1.00	1.00
	West Branch 2020/10/20	1.00	1.00	0.30	N/A	N/A	1.00	1.00

Table 6. Habitat suitability criteria results for Atlantic salmon

		% In-stream Cover (Juvenile)	% In-stream Cover (Adult)	Dominant Substrate Type in Riffle-Run Areas	Substrate for Spawning and Incubation	% Fines in Spawning Areas
Fales River	Site 1 2020/06/30	1.00	0.51	0.60	0.11	0.00
	Site 2 2020/06/30	0.83	0.07	0.60	0.14	0.00
	Site 3 2020/07/03	0.91	0.30	0.60	0.20	0.54
	Site 4 2020/10/15	0.68	0.08	0.60	0.70	0.00
	Site 5 2020/10/15	0.71	0.14	0.60	N/A	N/A
	Site 6 2020/10/15	1.00	0.57	1.00	N/A	N/A
	Site 7 2020/10/16	1.00	0.50	0.30	0.41	0.00
Round Hill River sub-watershed	Site 1 2020/10/9	1.00	0.45	0.30	0.78	0.54
	Site 2 2020/10/13	1.00	0.94	0.30	0.00	0.00
	Gibson Brook 2020/10/13	1.00	0.44	0.60	N/A	N/A
	East Branch 2020/10/20	1.00	1.00	0.30	N/A	N/A
	West Branch 2020/10/20	1.00	1.00	0.30	N/A	N/A

*Scores with results listed as N/A, contain data that was not documented during the time of assessment and therefore their scores could not be computed.

3.2.2 Sediment Monitoring
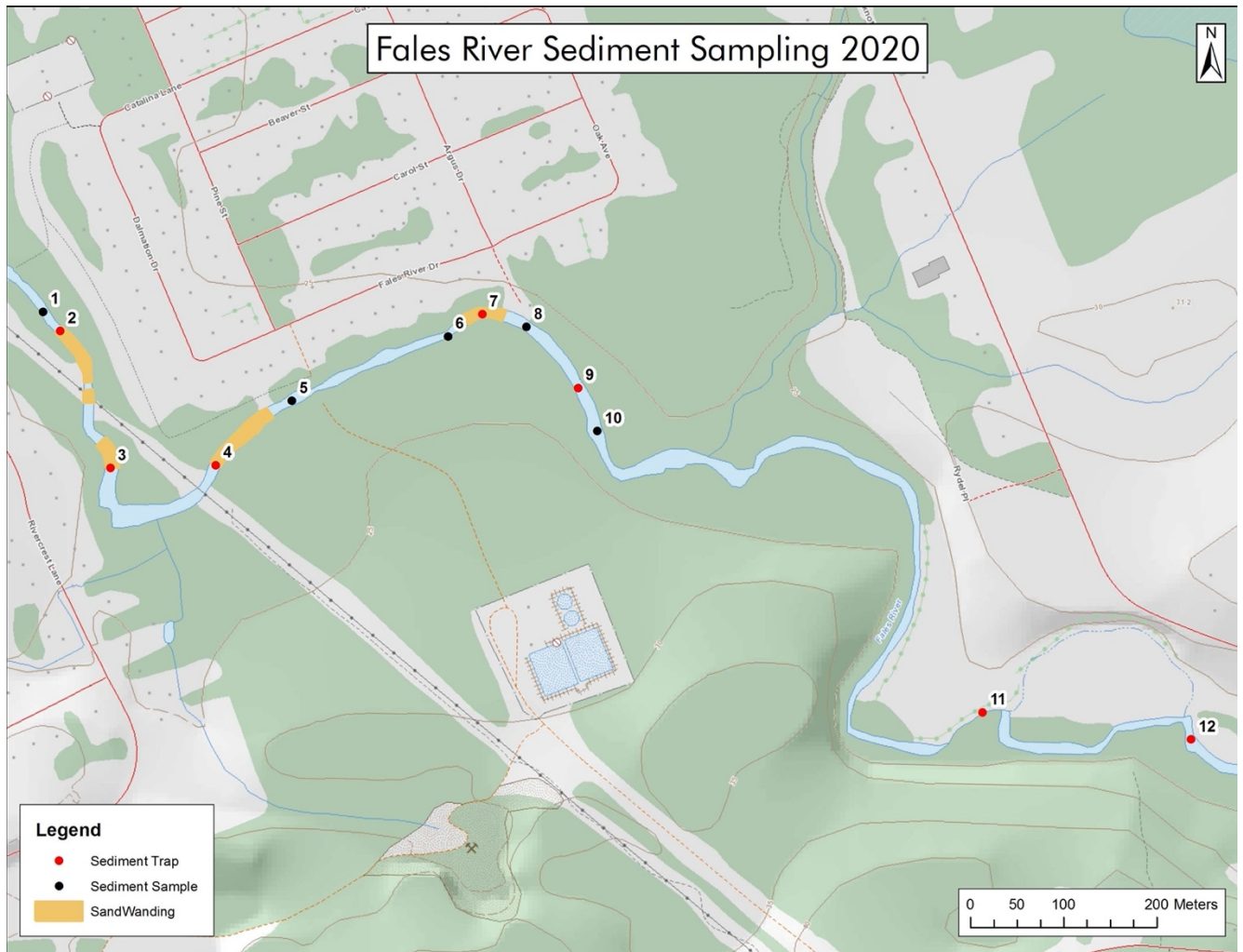
Figure 9. Site map of sediment trap and sediment sampling locations on the Fales River

Sediment sampling occurred at 12 sites along the Fales River. Sites 2, 3, 4 and 7 which are located in areas of recent SandWanding, had some of the largest recorded percentages of silt and fine sediment. Site 9 was identified as having the most sand content, and is located downstream of a newly created ATV trail which may be a contributing factor to sediment input on the river. Sediment traps were installed at these five sites, along with sites 11 and 12. Based on the results, site 12 appeared to have the lowest percentages of fine sediment and was therefore being monitored as a control site (Table 7).

Twenty-one sediment traps were created using PVC pipe and nylon netting. The traps were installed at 7 locations along the Fales River, with 3 traps installed at each site; one on the left, right, and middle of the channel. The contents of the sediment

traps were collected weekly for a total of four weeks. The sediment trap results indicated that site 11 had the highest inputs of fine sediment. Located in close proximity to site 11 is a new development that is currently under construction and is suspected to be one of the potential sources of sedimentation along the river. This data, along with the rest of the results collected, will aid in the identification of input sources and future work needed to address sedimentation in the Fales River sub-watershed.

Table 7. Summary of Fales River sediment sample results for 2020

Site	% Coarse Gravel (>16mm)	% Fine Gravel (16mm-2.8mm)	% Sand (2.8mm-0.063mm)	% Silt, Clay (<0.063mm)
1	47.15	25.82	26.95	0.08
2	44.25	20.42	35.17	0.16
3	6.96	66.12	26.68	0.24
4	32.66	38.10	29.03	0.22
5	38.91	20.75	40.21	0.13
6	34.45	31.00	34.45	0.10
7	42.04	36.78	21.02	0.16
8	48.44	36.33	15.14	0.09
9	0	12.74	87.08	0.18
10	32.61	36.69	30.57	0.13
11	9.08	30.26	60.51	0.15
12	72.71	18.18	9.09	0.03

Table 8. Summary of Fales River sediment trap results for 2020 (results displayed in grams)

	Site 2	Site 3	Site 4	Site 7	Site 9	Site 11	Site 12
2020/09/30	10.85	6.24	9.27	8.99	5.7	63.27	8.56
2020/10/08	5.23	2.88	1.49	1.28	3.12	33.39	N/A
2020/10/23	4.56	2.55	3.44	3.32	4.67	10.92	6.47
2020/10/30	8.03	1.63	2.92	2.98	10.16	11.01	12.48

*Results listed as N/A, contain data that was not documented during the time of assessment.

4.0 Recommendations

Recommendations are based on the 2020 field season as well as previous work through the Fish Passage Restoration and Habitat Enhancement program.

A) In-stream habitat enhancement:
   Continue restoration work on the Round Hill River including additional installations of in-stream enhancement structures. The 2020 deflectors should be revisited, and future actions should be identified for structures further upstream.

   An Atlantic salmon and salmon habitat conservation plan for the Round Hill River sub-watershed to optimize habitat restoration efforts in future years of the Fish Habitat program should be developed. This document would be used to help develop a strategy to optimally enhance the productivity of fish habitat within the Round Hill River and its tributaries.

   Future in-stream restoration projects should be identified and developed for other priority sub-watersheds within the Annapolis River watershed (South River, Black River, etc.).

B) Restoration Monitoring:
   Continue monitoring sediment inputs on the Fales River to identify sources of sedimentation. Monitoring is best to take place during the spring and summer months as leaves tend to clog the sediment traps in the fall.

   Targeted outreach and collaboration to landowners/mangers/users at sites where land-based activities have been identified as significant sources of sediment pollution.

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6.0 Appendices

6.1 Fales River and Round Hill River Sub-Watersheds
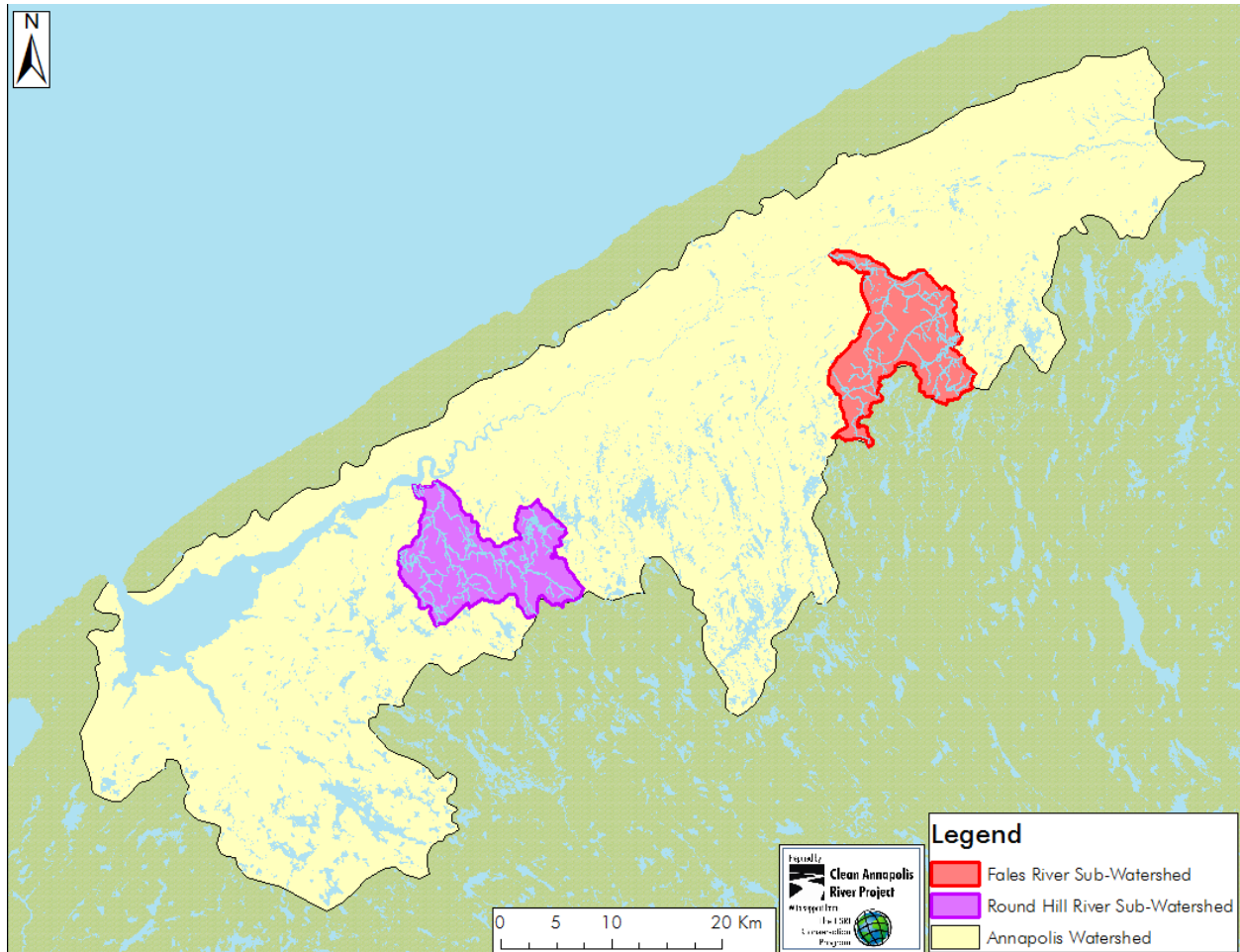
Figure 10. Location of the Fales River and Round Hill River sub-watersheds within the greater Annapolis River watershed

6.2   Design Sketch of In-Stream Restoration Structure

Flow

7 m

Structure: Log deflector
Site: Round Hill River, Round Hill NS
Location: 309835, 4960206

Add an additional 0.5 m to both logs and bury into bank to secure logs

Rock from downstream pool used to fill deflector (helps to enhance pool) and fill up to bank

4 m

Flow

7 m

5 m
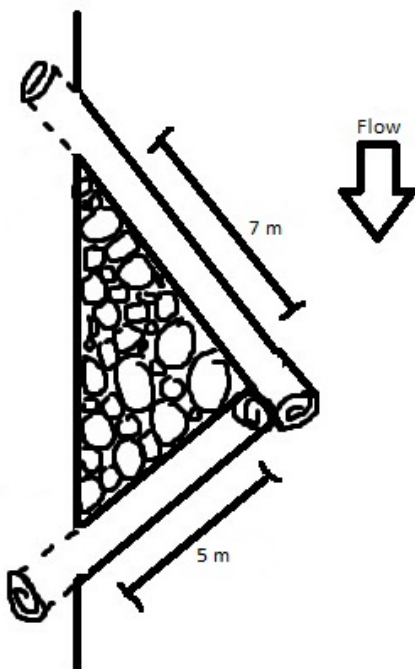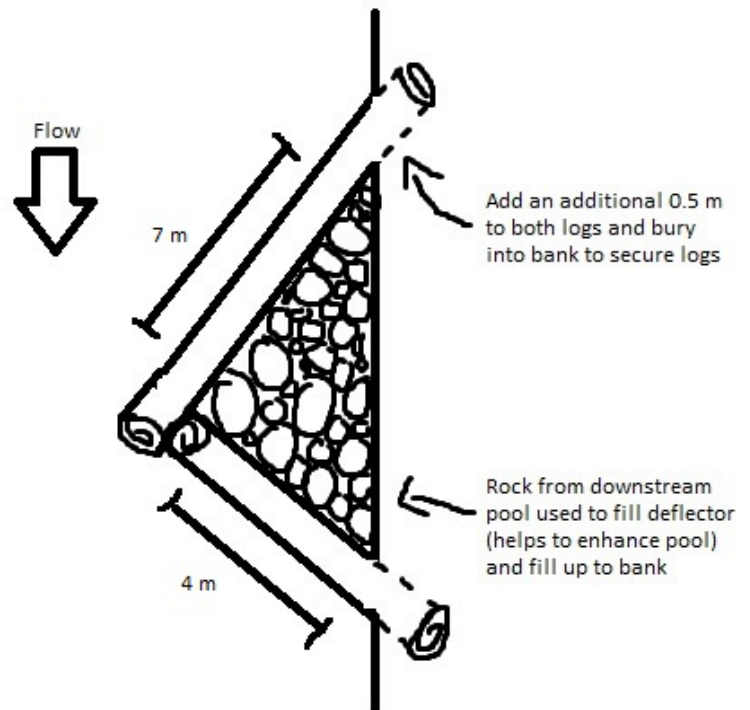
Structure: Log deflector
Site: Round Hill River, Round Hill NS
Location: 309872, 4960162

Structure: Log deflector
Site: Round Hill River, Round Hill NS
Location: 309912, 4960111
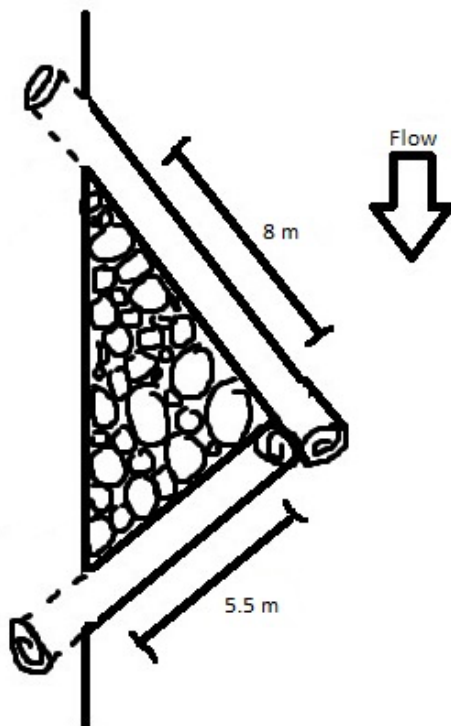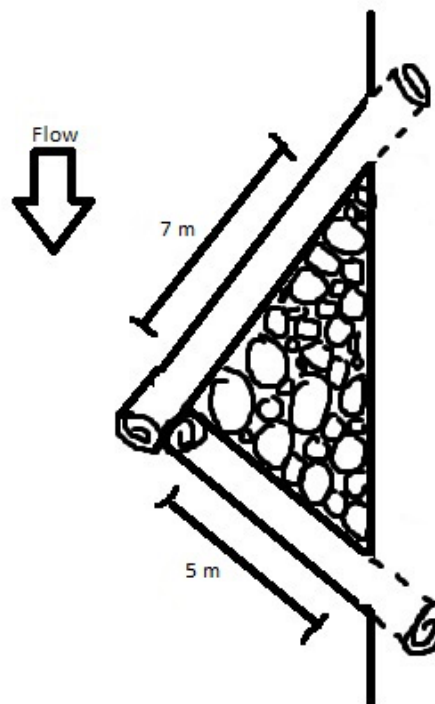
Structure: Log deflector
Site: Round Hill River, Round Hill NS
Location: 309940, 4960063

6.3   Habitat Suitability Index (HSI) Data Sheet – NSFHAP

NSFHAP Field Sheet #:

River Name: _____ Watershed Code: _____ Date: _____ Time: _____ Crew: _____

Site Boundary Coordinates in DMS (degrees/min/sec): Downstream _____°_____'_____"N _____°_____'_____"W Upstream _____°_____'_____"N _____°_____'_____"W

Watershed Area (km²): _____ Calculated Bankfull Width (m): _____ Transect Spacing (m): _____ Site Length (m): _____ Stream Order: _____

Air Temp (°C): _____ Water Temp: _____ pH: _____ Conductivity (S/m): _____ TDS (mg/L): _____ DO (mg/L): _____

Channel Cross-sections

	Floodplains		Height and Widths			Wetted Depths				Thalweg	Slope
	Left Width (m)	Right Width (m)	Bankfull Width (m)	Bankfull Height (cm)	Wetted Width (m)	1/4 of Width (cm)	1/2 of Width (cm)	3/4 of Width (cm)	Thalweg depth (cm)	Location (m)	% Slope between riffles
T1											
T2											
T3											

Substrate and Cover

	GPS Coordinates	Habitat Type	¼ of Width					½ of Width					¾ of Width					% Embedded (% Fines under surface)	10 cm Instream Cover (# of fish)	20 cm Instream Cover (# of fish)
			Fines	Gravel	Cobble	Boulder	Bedrock	Fines	Gravel	Cobble	Boulder	Bedrock	Fines	Gravel	Cobble	Boulder	Bedrock			
T1																				
T2																				
T3																				

Riverbanks and Riparian Area

	% Trees	% Shrubs	% Grass	% Bare Soil	% Eroding	% Stable Ground	% Stream Shade	Ice Scar Height
Left Bank								
Right Bank								

Pool Measurements

Transect #	Max Depth (cm)	Depth of Pool Tail (cm)	Average Length (m)	Average Width (m)	% Pool Cover

Pictures

	upstream	downstream
T1		
T2		
T3		

#	Description

Spawning Areas

	Area		Substrate Size			Embeddedness
	Length (m)	Width (m)	Rock #1 (cm)	Rock #2 (cm)	Rock #3 (cm)	% fines under surface
Salmon						
Brook Trout						

Rock Grab: ☐		3 Minute Kick: ☐ Net Type/Mesh Size: _____ / ___			
Common Name	Rock #1	Rock #2	Rock #3	Total
Midges				
Snails, Limpets				
Sow Bugs				
Aquatic Earthworm				
Beetles				
Mayflies				
Fishflies, Alderflies				
Stoneflies				
Caddisflies				

Point Bars

Transect	Present	Angle	Vegetation	Comments
T1	Y or N	Gradual or sharp	None, grasses, shrubs, trees	
T2	Y or N	Gradual or sharp	None, grasses, shrubs, trees	
T3	Y or N	Gradual or sharp	None, grasses, shrubs, trees	

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

6.4　Habitat Suitability Index (HSI) Assessment Parameters – NSFHAP

Table 9. Variables assessed during Habitat Suitability Index assessments

Variable	Units	Description
Air Temperature	Celsius	The temperature of the air on the day of the assessment
Average Pool Length	m	Length of pool parallel to the flow
Average Pool Width	m	Width of pool perpendicular to flow
Bankfull Height	m	Height of elevation of the bankfull above the water surface
Bankfull Width	m	Horizontal distance between banks on opposite sides of the stream
Bedrock	%	Hard, solid rock often beneath surface materials such as soil and sediment
Boulder	%	Substrate measuring >25.6 cm
Channel		Area of the river within the bankfull, including potentially dry areas during low water and riverbanks, but not the floodplain
Cobble	%	Substrate measuring 6.4-25.6 cm
Conductivity	μS/cm	The ability of a solution (water) to carry an electrical current
Crest of Riffle		Area at the most downstream end of a pool or most upstream end of a riffle where a slow, deep section of river becomes a shallow and fast section. See also 'tail of pool'.
Date		The date on which the assessment was completed
Depth of Pool	cm	Depth of pool at the deepest section
Depth of Pool Tail	cm	Depth of water in the pool tail
Design Width	m	See also 'site bankfull width'
DO	mg/L	The amount of oxygen dissolved in the water
Embeddedness	%	Degree that boulder, cobble and gravel substrate is surrounded by finer sand and silt. Measured as percentage of fines underneath rocks.
Estimated Low Flow Max Depth	cm	How much of the pool will be covered in low flows

Final Pool Area	m²	Total area of pool measured during the assessment
Floodplain	m	Relatively flat area of land adjacent to a river channel which gets submerged when water levels are high.
Field Crew		The assessors collecting the data
Fines	%	Sand or silt measuring <0.2 cm
Gravel	%	Substrate measuring 0.2-6.4 cm
Ice Scarring	m	Signs of damaging ice movement observed as scarring on riparian trees and shrubs
In-stream Cover (Adults)		Unembedded cover (substrate, aquatic vegetation, large woody debris, undercut banks, etc.) below the water surface that can shelter/hide a 10 cm long dowel (representing a juvenile fish)
In-stream Cover (Juveniles)		Unembedded cover (substrate, aquatic vegetation, large woody debris, undercut banks, etc.) below the water surface that can shelter/hide a 20 cm long dowel (representing an adult fish)
Meander Sequence (Full)		The meandering or sinuous pattern many rivers follow that feature steps, pools, riffles, and runs. A full meander sequence usually has two pool, riffle, and run areas in low gradient rivers and steps, pools and runs in higher gradient rivers.
Percentage of Pools	%	Calculated by determining the total area of each transect covered by pools
pH		The acidity of the water in the watercourse
Photos		The photos taken of the assessment site
Point Bars		Areas where sediment is deposited on the inside of bends. Record the presence, slope and vegetation type
Pool		Deep, slow section of river used by salmonids for cover and resting
Pool Class Rating		Pools can be classified as having an A, B or C rating based on depth and amount of cover
Pool Cover	%	Amount of pool bottom that is hidden by water colour, depth, or high surface velocities
Riffle		A shallow (<10 cm) and fast section of river that occurs between pools

Riparian Vegetation	%	Percentage of ground covered by trees, shrubs, grasses and sedges, and bare ground within 10 m of the banks edge
Riverbank Stability	%	Percentage of rooted vegetation and stable rocky substrate that protect riverbanks from erosion
Rock Grab Sampling		Cobble sized rock from a riffle is selected from the stream and the invertebrates/organisms on the bottom of the rock are counted and identified
Run		A moderately deep section, somewhat slower than a riffle, that occurs in varying locations in a river pattern
Site Bankfull Width	m	Proper stream width determined mathematically before entering the field. The formula is based on watershed area and annual precipitation. See also 'design width'
Site Length	m	6 channel width lengths or site bankfull width x 6
Spawning Areas (Brook Trout)		Spawning occurs in areas of groundwater upwelling which contains 2.5-6 cm gravel substrate
Spawning Areas (Atlantic Salmon)		Spawning occurs in areas of downwelling, such as the tail of pools or above a digger log which contains 2-9.5 cm g-cobble substrate
Step-Pool		Series of staircase-like pools, which usually occur in steeper channels
Stream Name		The name of the watercourse where the assessment is taking place
Stream Order		Measure of the relative size of a stream. The smallest streams in a watershed have the lowest numbers and the largest streams closest to the ocean have the highest numbers.
Stream Shade	%	Canopy cover created by riparian vegetation
Tail of pool		Area at the most downstream end of a pool or most upstream end of a riffle where a slow, deep section of river becomes a shallow and fast section. See also 'crest of riffle'.
TDS	mg/l	Total dissolved solids, the measurement of the combined content of all inorganic and organic substances in its suspended form

Thalweg	Depth: cm Location: m	Deepest section in a channel cross-section, and the area where the water will be found during low water events
Three-Minute Kick Sampling		Kick/disturbing the substrate for three minutes while a partner collects the invertebrates/organisms that are dislodged with a fine mesh net
Time		The time that the assessment began
Transect		Every two calculated bankfull widths
Transect Spacing	m	Site bankfull width x 2
UTM Coordinates		GPS position of the HSI assessment location, described with Northings and Eastings, using a NAD83 projection
Vegetation Index		Multiplication factors are used for each vegetation type and added together to obtain an index value
Water Temperature	Celsius	Downstream water temperature
Watershed Area	km^2	Land that drains surface water to a common point
Watershed Code		Obtained through the Nova Scotia environment and allows sites in the same watershed to be grouped together
Wetted Depth	cm	The depth from the stream bottom to the current water level
Wetted Width	m	Width of the river that contains water at the time of the measurement

6.5   Habitat Suitability Index (HSI) Site Maps
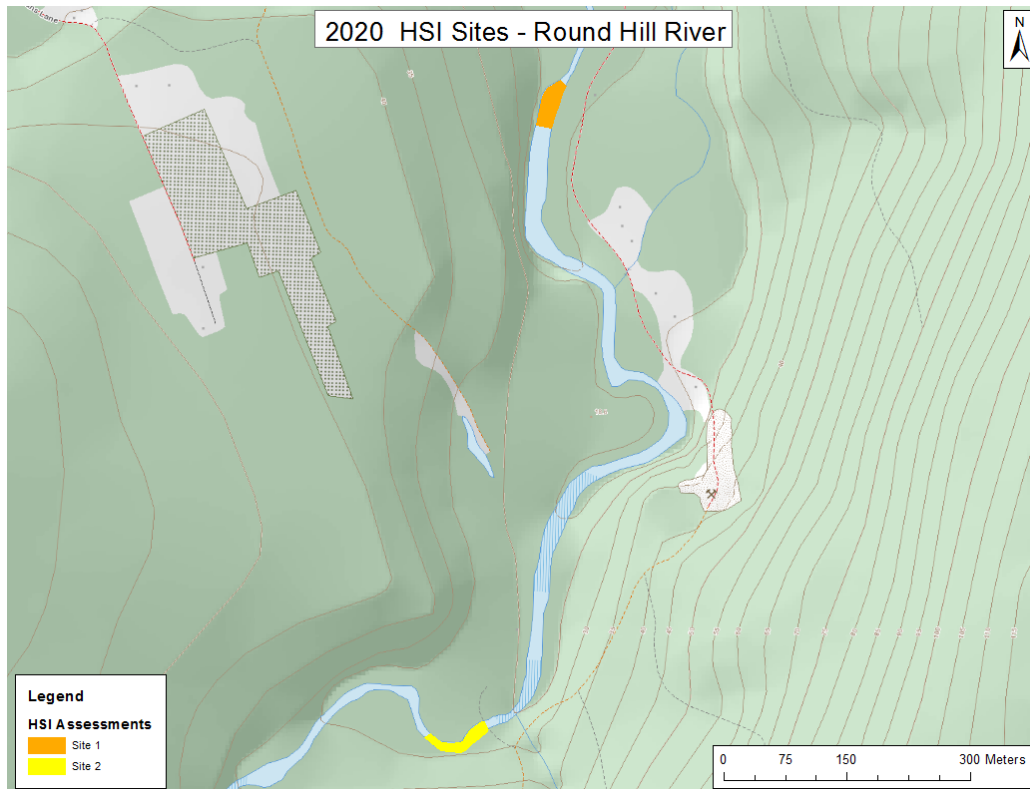

Figure 11. Site map of HSI sites 1 and 2 on the Round Hill River
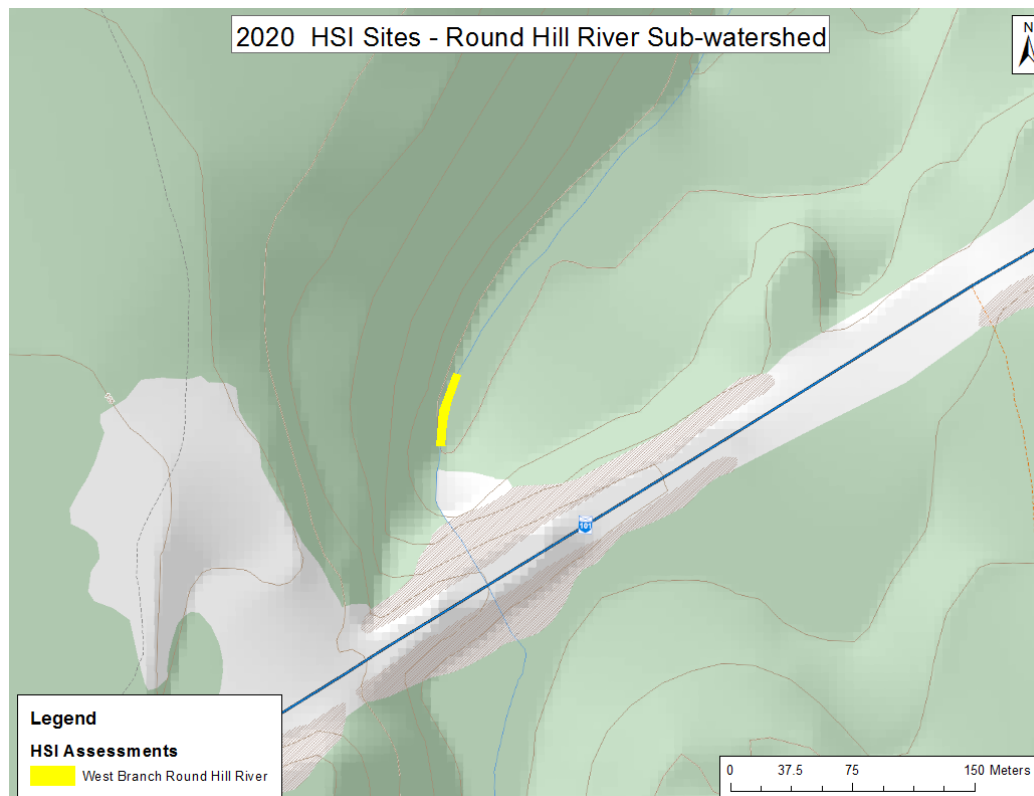

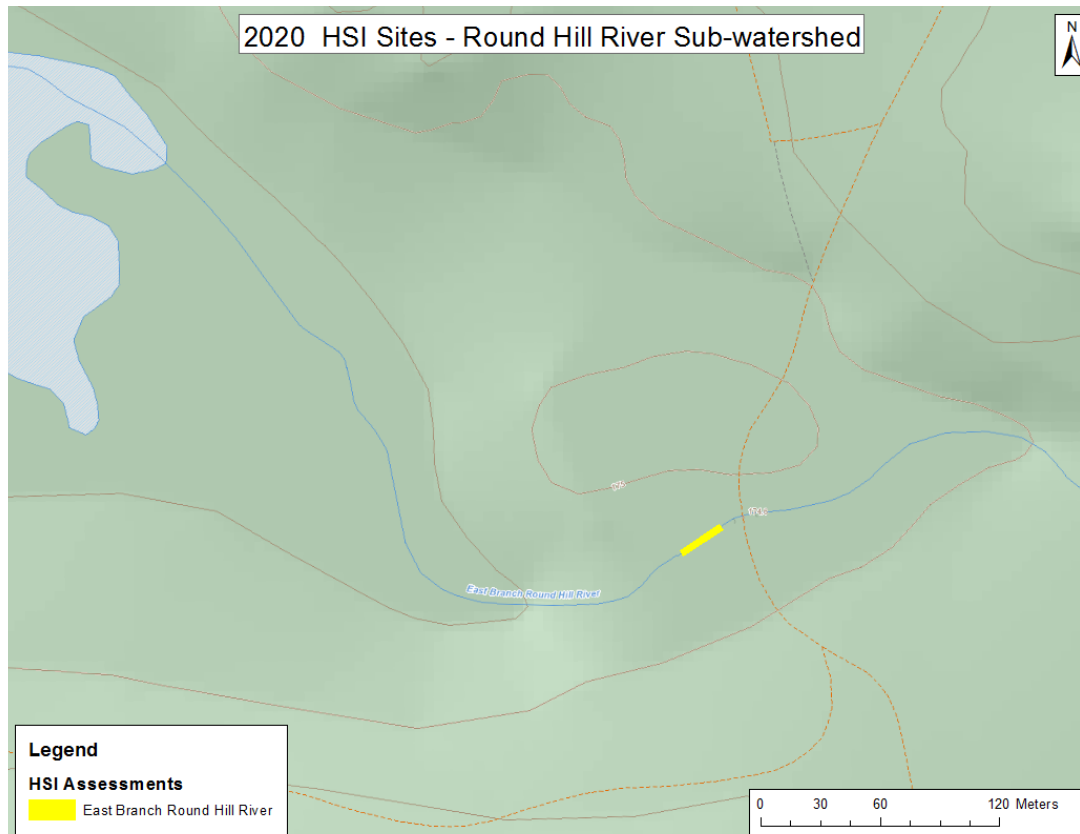Figure 12. Site map of HSI on the West Branch Round Hill River

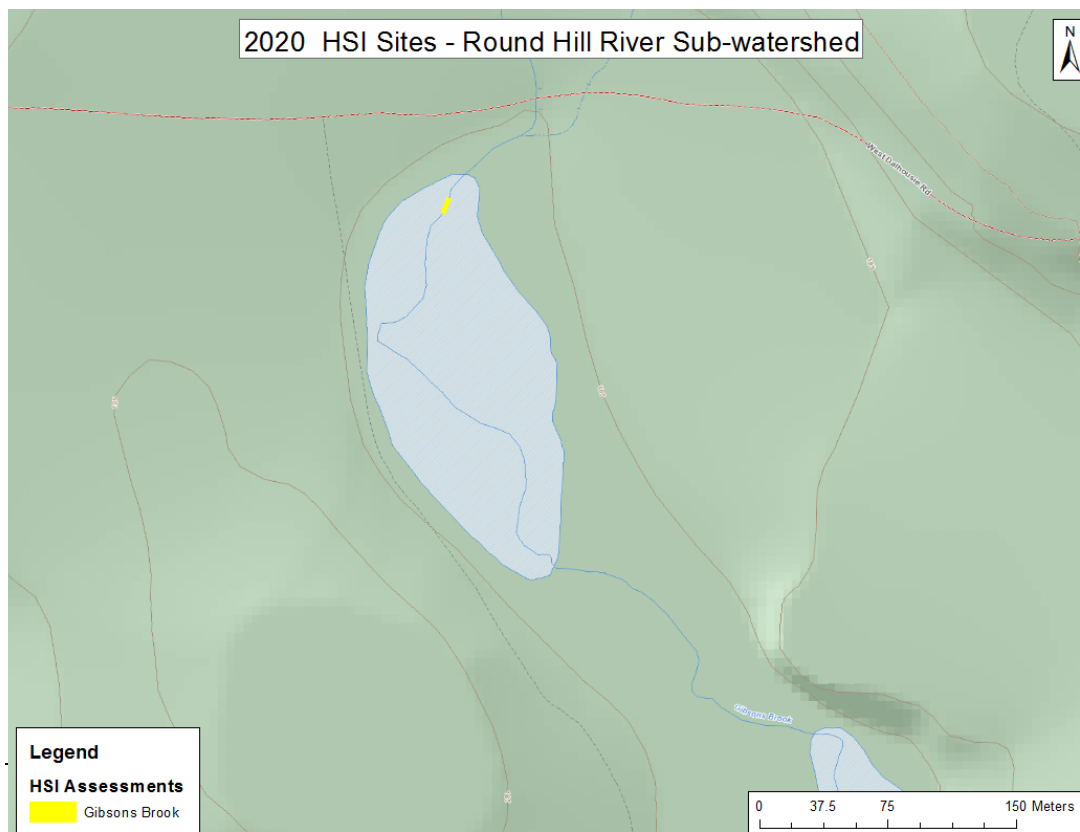Figure 13. Site map of HSI on the East Branch Round Hill River
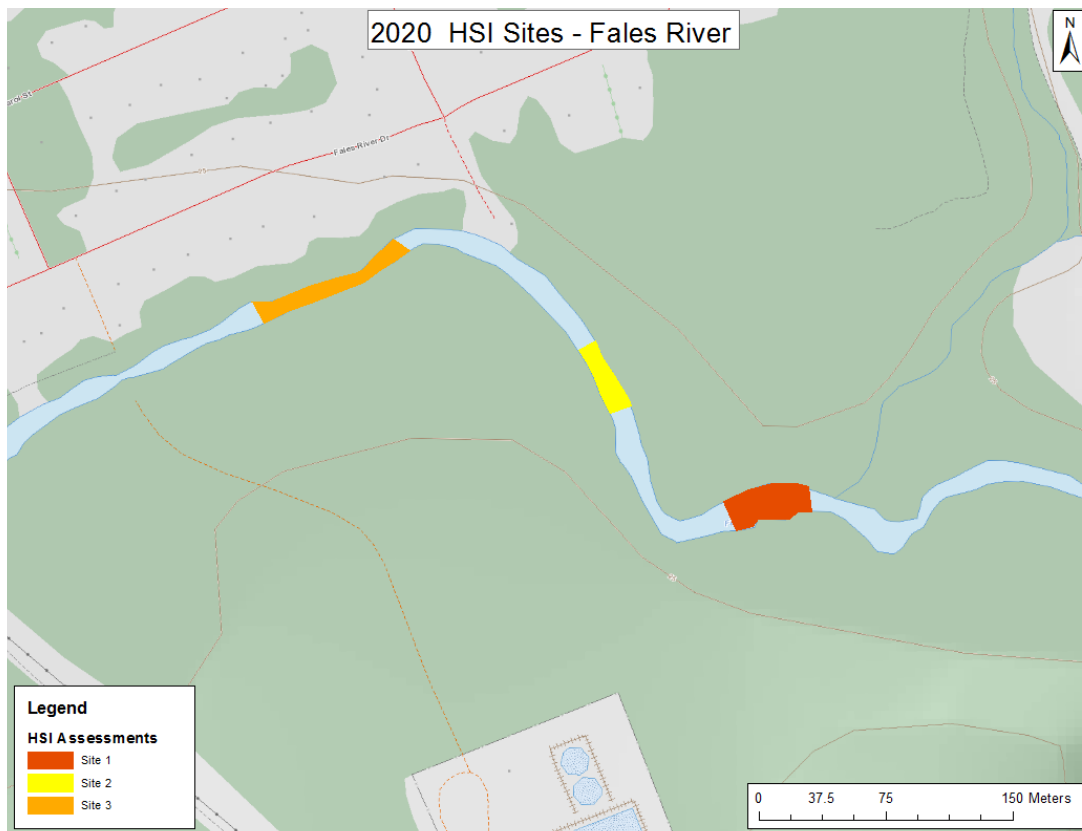

Figure 14. Site map of HSI on Gibsons Brook

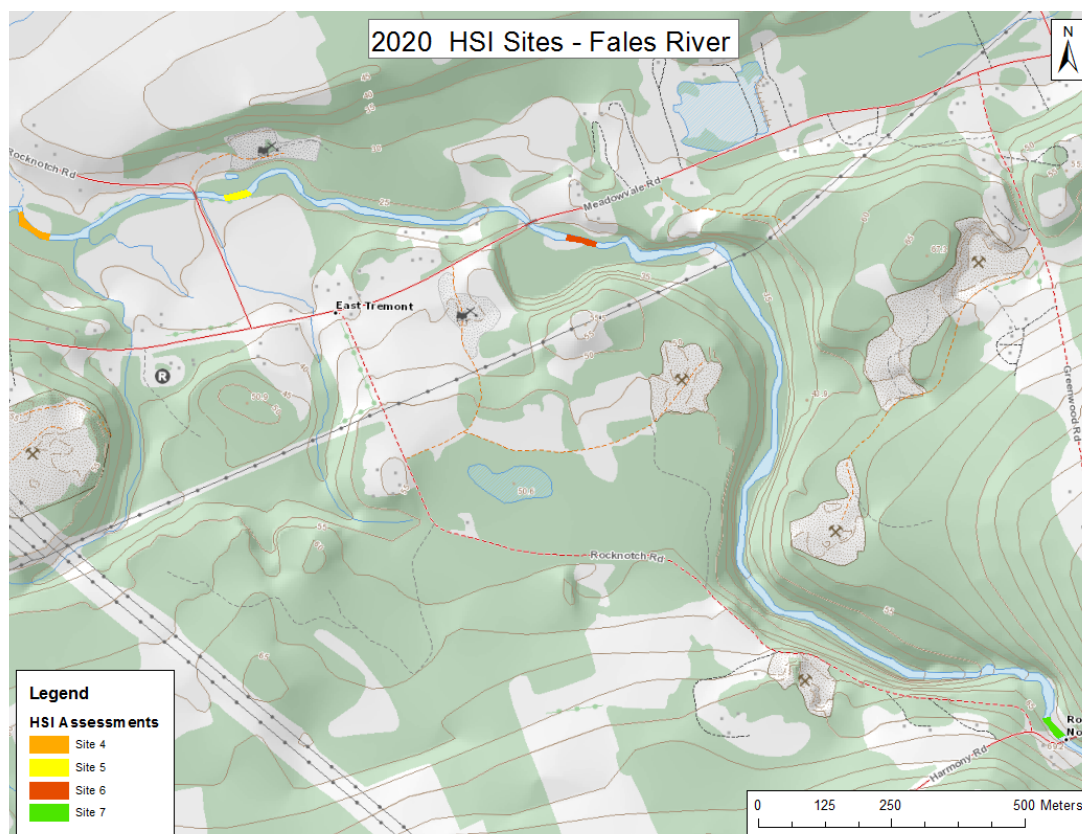Figure 16. Site map of HSI sites 1, 2, and 3 on the Fales River

Figure 15. Site map of HSI sites 4, 5, 6 and 7 on the Fales River

6.6 Habitat Suitability Index (HSI) Scores – NSFHAP

Table 10. HSI scores for brook trout

	Site Date	% Pools	Pool Class Rating	% In-stream Cover Juvenile	% In-stream Cover During Late Growing Season Adult	Dominant Substrate Type in Riffle-Run Areas	Average % Vegetation Along the Streambank	Average % Rooted Vegetation and Stable Rocky Ground Cover	Average Maximum Water Temperature	pH	Average Size of Substrate in Spawning Areas	% Fines in Spawning Areas	% Fines in Riffle-Run Areas	% Substrate Size Class for Winter Escape	Average Thalweg Depth During the Late Growing Season	% Stream Shade
Fales River	Site 1 2020/06/30	0.43	0.60	1.00	0.51	0.60	0.68	1.00	0.74	1.00	0.00	0.63	0.97	0.94	0.93	0.72
	Site 2 2020/06/30	0.41	0.60	0.83	0.07	0.60	0.61	0.77	0.68	1.00	0.00	0.08	0.99	1.00	0.41	1.00
	Site 3 2020/07/03	0.32	0.60	0.91	0.30	0.60	0.53	0.95	0.67	0.84	0.00	0.54	0.98	1.00	0.77	0.72
	Site 4 2020/10/15	0.43	0.60	0.68	0.08	0.60	0.92	1.00	1.00	0.77	0.00	0.00	0.92	1.00	0.98	0.72
	Site 5 2020/10/15	0.30	0.30	0.71	0.14	0.60	0.68	0.53	1.00	0.72	N/A	N/A	1.00	1.00	0.52	1.00
	Site 6 2020/10/15	0.34	0.30	1.00	0.57	1.00	0.73	1.00	1.00	0.76	N/A	N/A	1.00	1.00	0.70	0.81
	Site 7 2020/10/16	0.47	0.60	1.00	0.50	0.30	0.81	1.00	1.00	0.76	0.00	0.00	1.00	1.00	1.00	0.65
Round Hill River sub-	Site 1 2020/10/9	0.34	0.30	1.00	0.45	0.30	0.87	0.99	0.93	0.79	0.00	0.00	1.00	1.00	0.51	0.72
	Site 2 2020/10/13	0.36	0.60	1.00	0.94	0.30	0.56	0.88	0.70	0.96	0.00	0.00	1.00	1.00	0.97	0.93
	Gibson Brook 2020/10/13	0.53	0.30	1.00	0.44	0.60	1.00	0.97	0.91	0.65	N/A	N/A	0.94	0.67	0.22	0.33
	East Branch 2020/10/20	0.41	0.60	1.00	1.00	0.30	0.74	1.00	1.00	0.07	N/A	N/A	1.00	1.00	0.75	0.93

	Site Date	% Pools	Pool Class Rating	% In-stream Cover (Juveniles)	% In-stream Cover (Adults)	Dominant Substrate Type in Riffle-Run Areas	Average % Vegetation Along the Streambank	Average % Rooted Vegetation and Stable Rocky Ground Cover	Summer Rearing Temperature During Growing Season	pH	Substrate for Spawning and Incubation	% Fines in Spawning Areas	Fry Water Depth	Parr Water Depth	Stream Order	% Stream Shade
	West Branch 2020/10/20	0.38	0.60	1.00	1.00	0.30	0.73	1.00	1.00	0.77	N/A	N/A	1.00	1.00	0.96	1.00

Table 11. HSI scores for Atlantic salmon

	Site Date	% Pools	Pool Class Rating	% In-stream Cover (Juveniles)	% In-stream Cover (Adults)	Dominant Substrate Type in Riffle-Run Areas	Average % Vegetation Along the Streambank	Average % Rooted Vegetation and Stable Rocky Ground Cover	Summer Rearing Temperature During Growing Season	pH	Substrate for Spawning and Incubation	% Fines in Spawning Areas	Fry Water Depth	Parr Water Depth	Stream Order	% Stream Shade
Fales River	Site 1 2020/06/30	0.34	0.60	1.00	0.51	0.60	0.68	1.00	0.72	0.93	0.11	0.00	1.00	1.00	0.90	0.72
	Site 2 2020/06/30	0.30	0.60	0.83	0.07	0.60	0.61	0.77	0.65	0.99	0.14	0.00	1.00	1.00	0.90	1.00
	Site 3 2020/07/03	0.14	0.60	0.91	0.30	0.60	0.53	0.95	0.63	0.57	0.20	0.54	1.00	0.84	0.90	0.72
	Site 4 2020/10/15	0.33	0.60	0.68	0.08	0.60	0.92	1.00	0.51	0.83	0.70	0.00	1.00	1.00	0.90	0.72
	Site 5 2020/10/15	0.12	0.30	0.71	0.14	0.60	0.68	0.53	0.56	0.77	N/A	N/A	1.00	0.96	0.90	1.00
	Site 6 2020/10/15	0.18	0.30	1.00	0.57	1.00	0.73	1.00	0.66	0.81	N/A	N/A	1.00	1.00	0.90	0.81
	Site 7 2020/10/16	0.41	0.60	1.00	0.50	0.30	0.81	1.00	0.77	0.82	0.41	0.00	0.88	1.00	0.90	0.65
Round Hill River sub-watershed	Site 1 2020/10/9	0.18	0.30	1.00	0.45	0.30	0.87	0.99	0.31	0.85	0.78	0.54	1.00	1.00	0.90	0.72
	Site 2 2020/10/13	0.22	0.60	1.00	0.94	0.30	0.56	0.88	0.00	1.00	0.00	0.00	1.00	1.00	0.90	0.93
	Gibson Brook 2020/10/13	0.53	0.30	1.00	0.44	0.60	1.00	0.97	0.29	0.68	N/A	N/A	1.00	1.00	0.90	0.33
	East Branch 2020/10/20	0.30	0.60	1.00	1.00	0.30	0.74	1.00	0.56	0.00	N/A	N/A	1.00	1.00	0.50	0.93

West Branch 2020/10/20	0.24	0.60	1.00	1.00	0.30	0.73	1.00	0.84	0.82	N/A	N/A	1.00	1.00	0.90	1.00

*Scores with results listed as N/A, contain data that was not documented during the time of assessment and therefore their scores could not be computed.

6.7   Sediment Monitoring Methodology

Sediment Sampling:

1. Collect sediment samples from the thalweg of the river. When collecting the samples, dig your scoop/spoon/shovel down a few centimetres into the streambed, collect the sample, and carefully bring it out of the water not to lose any fine sediment.

2. Dry the samples in a drying oven or leave them out to air dry for a few days until all the water has evaporated from the samples.

3. Take the weight of each sample.

4. Sieve the samples, separating them into different substrate size classes. Our samples were separated into four size classes; coarse gravel (>16mm), fine gravel (16mm-2.8mm), sand (2.8mm-0.063mm) and silt/clay (<0.063mm).

5. Take the weight of the separate size classes to determine each percentage of the entire weight. Since the samples are all varying in weight the results are displayed in percentages to be made easily comparable.

6. Install sediment traps at the sites with the largest silt/clay content.

Sediment Traps:

1. Sediment traps are made out of PVC pipe and nylon netting.

2. Three sediment traps are installed at each location; one on the right, middle, and left sides of the channel. The traps are held in place with rebar, keeping them in an upright position and in line with the flow of the water

3. Collect the contents of the sediment traps weekly.

4. Dry the samples in a drying oven or leave them out to air dry for a few days until all the water has evaporated from the samples.

5. Take the weight of each sample. Results are displayed in grams.